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Abstract

The document considers the first Service Prototype created by 2-IMMERSE and evaluates both the experience itself and the generic platform that we used to support this service. The software platform is a micro service based platform that has provided the means to create a fully-fledged social inter-home multi-screen TV experience based around watching a theatre performance 'as-live'. The experience uses two devices, provides additional material and information, and allows people to communicate from different locations (video and chat based). The evaluation focusses on our experience with the platform but includes detailed finding from an extensive, highly situated user trial involving more than 35 people in more than 23 homes based on 12 distinct trials.

The document reports the method of evaluation the results and identifies a number of key findings and recommendations for future work that are reported as conclusion and plans. The fundamentals of the micro-service based approach to building the platform are very strong though more work is needed to improve robustness and to make it easy for producers to create new experiences. We also found that users would have like more ability to control the layout of the service as offered to them.

Target audience

Anyone interested in building or learning about new multi-screen experiences.

Impressum

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Executive summary

This document describes the evaluation of the Theatre At Home Experience, which is a prototype multi-screen social TV service based on watching a filmed live performance of Hamlet performed by the Royal Shakespeare Company.

The prototype service allows two households to share the experience of watching a theatre performance together with the production being presented on a TV screen. Each household has a second screen device, a tablet, and can use this to access synchronized information streams and communication resources directly from the provider of the broadcast. The experience is curated to mirror aspects of the ritualised nature of going to the theatre. The experience thus allows users to:

- Chat to each other (using video chat) before and after the performance and during the interval
- Receive warnings, as they do when they visit the theatre, that the performance was about to start.
- Access additional material related to the production, much as they would in a theatre programme
- Send messages to each other discretely during the performance using text chat

The prototype service, built using a micro service based software platform, became available in early January 2017 and the evaluation took place over the following months. The evaluation served to:

1. Evaluate the technology platform used to support the experience
2. Evaluate this specific experience
3. Provide more generic insights that should be valuable for subsequent prototypes being developed in 2-IMMERSE.

The technical performance of the platform was assessed, through a reflective process involving key stakeholders within the project such as: Platform developers; Application developers; and Cloud deployment specialists. We asked the stakeholders to reflect upon key aspects of the platform such as: extensibility, robustness, scalability, ease of deployment, ease of use and the feature set available.

The Theatre At Home experience itself was carried out through twelve trials, involving two households per trial with one to three people present at each household. Evaluations were based on questionnaires, qualitative semi-structured interviews with triallists and on analytics of application use based on instrumentation of the app we built.

In terms of the technical performance of the platform, we conclude that the micro-service approach that we adopted was very well suited to the deployment of distributed media applications across multiple screens and multiple locations. In terms of extensibility we believe that the micro service based architecture that we have chosen makes the platform naturally extensible. However, more work is required to give developers the confidence to extend the platform. To improve extensibility further we will consider creating client-side application architecture diagrams and further tutorials, documentation, and overviews to help developers understand and engage with the development of Distributed Media Applications (DMApps).

We have also recognized a large number of actions that we can take to further improve scalability, robustness, of the platform. Many of these are related to the particular challenges associated with building distributed applications. These actions are described in more detail in the Results and Conclusion sections.

The results from the user evaluation of the theatre At Home may well be generalizable beyond the particular Theatre At Home experience. The findings included the following:

1. Users appreciated the fact that the Theatre At Home experience echoed some of the ritualistic aspects of going to the theatre.
2. Users endorsed the producer's view that the play should be shown on the shared TV screen and not cluttered by additional content
3. Users were positive about the ability to share the experience through text and video chat
4. Users indicated that choice is important indicating they would like more control over the selection and placement of different features.
5. User responses confirmed a number of insights for multi-screen layout preferences
    a. the companion was the place for referencing and controlling;
    b. the shared TV was for shared features of primary interest –mainly the play (video-window), notifications, and socializing during the intervals;
    c. the presence of other features such as the script and social media was negotiated.

The findings will aid the orchestration of future multi-screen experiences.

The ability to manipulate features of the experience means the experience creators have to make decisions about the framework holding the experience together and how individual objects, that form the building blocks of the experience, behave (i.e., the rules and the models). For example, decisions have to be made about who should decide what goes where. These decisions are layered:

1. Decisions about the design of the overall experience concept –defining the format, phasing, and essential elements of the experience.
2. Decisions about which features of the experience are predefined and automated (so users have no control over when and where they appear); and features which are adaptable and can be manipulated by users.
3. Decisions on the degree of adaptability of features, and guidelines/rules on how users can manipulate them. E.g., ability to switch features on/off, ability to change the position of features (device/screen, layout), adaptable to change the appearance of features (palette, font, responsive sizing, etc.), responsive personalization of features (novice/expert).

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1 Introduction

This document describes the evaluation of the Theatre At Home Experience, which is a prototype multi-screen social TV service based on watching a filmed live performance of the Royal Shakespeare Company's Hamlet from 2015 starring Paapa Essiedu in the lead role.

The prototype service became available in early January 2017 and the evaluation took place over the following months. The evaluation is small scale and serves to:

4. Evaluate the technology platform used to support the experience
5. Evaluate this specific experience
6. Provide more generic insights that should be valuable for subsequent prototypes being developed in 2-IMMERSE.

As a reminder 2-IMMERSE is developing four prototype services. This deliverable includes a brief description of the Theatre At Home Service prototype but a more complete and rigorous description of the prototype service and its evolution can be read in the sister deliverable "D4.3. Prototype Service Descriptions - First Update."

The following text, which provides an overview of the four prototype services (for context) is taken from D4.3.

> "The four multi-screen service prototypes use the valuable and complementary content forms of live theatre and sport. The first two, 'Theatre at Home' and 'Theatre in Schools', describe experiences based on filmed performances by the Royal Shakespeare Company produced by John Wyver, who works for project partner Illuminations, that are designed for audiences at home and in schools. The 'MotoGP at home' service prototype creates personalised sports-related experiences using coverage of the MotoGP developed by Dorna Sports and distributed in the UK by BT. The final use-case takes coverage of the Emirates FA Cup (the oldest and best known football knockout cup in the world) for which both BT and the BBC (both project partners in 2-IMMERSE) have distribution rights. It develops enhanced multi-screen use cases to enrich and deepen the enjoyment of football fans watching in pubs and clubs across the UK.
>
> The four service prototypes will be evaluated in turn during the 3-year project lifetime.

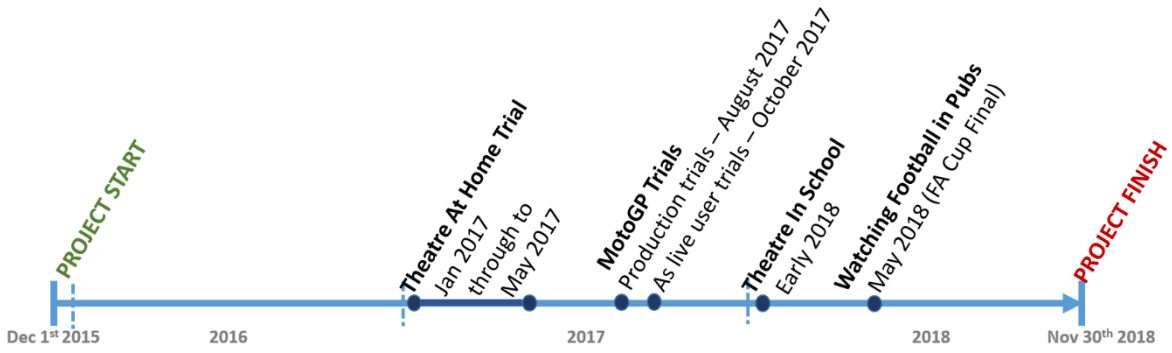


Figure 1 Timeline for the execution of the trials of the service innovation prototypes being developed in 2-IMMERSE

A description of the Theatre At Home Experience is provided in Section 2. Section 3 describes the purpose of the evaluation and Section 4 describes in some detail the methods we used. Section 5 provides the results of our evaluation of the platform and Section 6 reports the user evaluation of the Theatre At Home Experience. Section 7, 'Conclusions and plans' distils out some of the key findings from our work and identifies some of the future direction that the project is exploring based on the work completed to date.

2 The Experience

Watching Theatre At Home

This service innovation prototype is called Theatre at Home because it offers an enhanced social experience for users in a domestic context to watch a live or "as live" broadcast of a theatre performance. The user will have a second screen device that can access synchronized information streams directly from the provider of the broadcast and from the web through social media applications including Twitter but which can also, at times, feature audio and video chat with others who are watching.

The service innovation prototype will enable a user to watch a theatre production, shot with multiple cameras, as either a live or an 'as live' experience. Viewers will be able to contribute to and monitor different forms of feedback throughout the performance, and to discuss it with others who are watching at the same time, either in a different room or in a different home.

Owner: John Wyver (Illuminations) Rights Originator: Royal Shakespeare Company

The prototype service allows two households (Home A and Home B in Figure 2) to share the experience of watching a theatre performance together. User A and B each watch, on their TVs, a theatre production that was shot with multiple cameras. The production is being shown as a linear HD feed and is accompanied by a synchronised audio track. Viewer A is viewing the production simultaneously with User B who is watching in his own home. Each user has a second screen device, a tablet, and can use this to access synchronized information streams and communication resources directly from the provider of the broadcast. In the project's current configuration, the set-top box is a Mac Mini, the camera is a standard web cam and the tablet is an Android tablet. All these components were supplied by the project, and the Internet connection used was the connection found at each household.

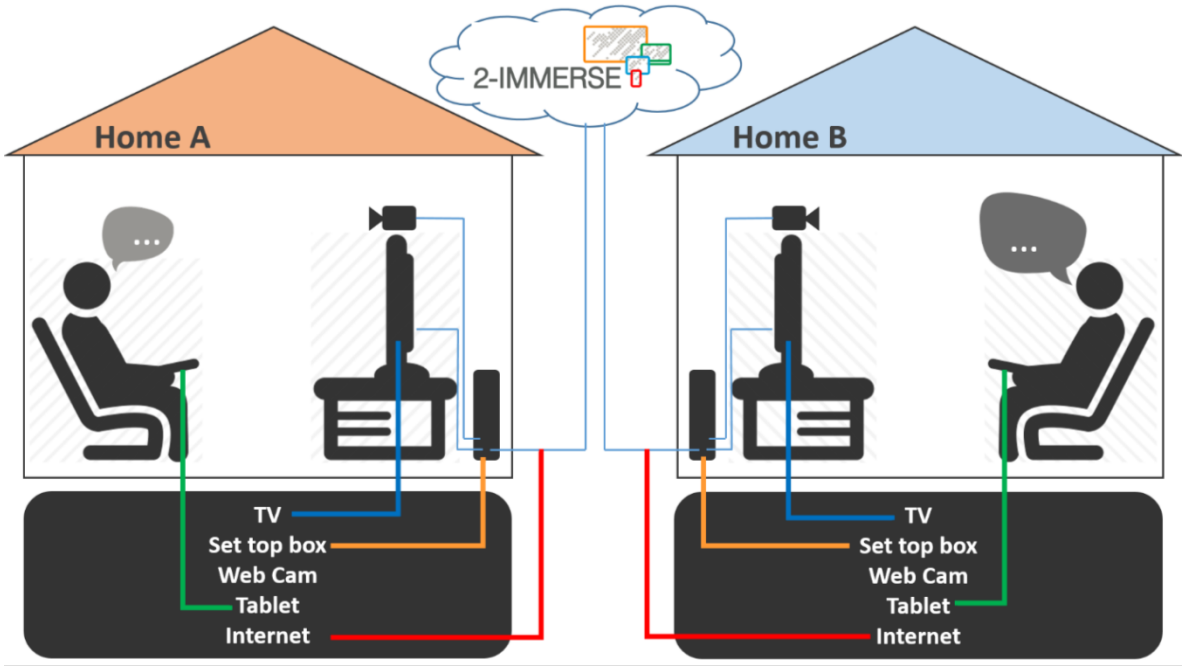


Figure 2 Schematic of the Theatre At Home Experience highlighting the key technical elements.

The experience is curated to mirror aspects of the ritualised nature of going to the theatre. The experience thus allows:

- Users to chat to each other (using video chat) before and after the performance and during the interval.
- Users to receive warnings, as they do when they visit the theatre, that the performance was about to start. This was effected using a countdown timer and on-screen messages.
- Users to access additional material related to the production, much as they would in a theatre programme, with these elements appearing on the large screen or the tablet. These elements include:
    - actor biographies
    - information about the cast and creatives
    - details about the play's development process including photographs of the rehearsals
- Users to message each other discretely during the performance using text chat – which shows on the screen.

In addition the presentation on the screen is augmented by a synchronized feed showing the script and thus allowing users to both read and hear Shakespeare's words.

This experience is a cut-down version of the experience that was envisaged in the early stage of the project. The rationale for, and the story behind the development of this experience is described in "D4.3. Prototype Service Descriptions - First Update."

Features that were not implemented included:

- Audience feedback (the 'like' button)
- Multiple Camera streams – to give users some choice over the point of view used to watch the performance
- Responsive layout – instead the layout was fixed
- On-boarding: sign-in and device set-up (and configuration) – instead the users received help from the technical team to get them to the point at which the experience began
- The ability for the user to control the different layouts for the content on the tablet and TV screens - instead layouts were predetermined using specific templates.
- Notifications and welcome/tutorial functions – instead users received brief training from the project team member who explained how to access the controls and functions on the tablet.

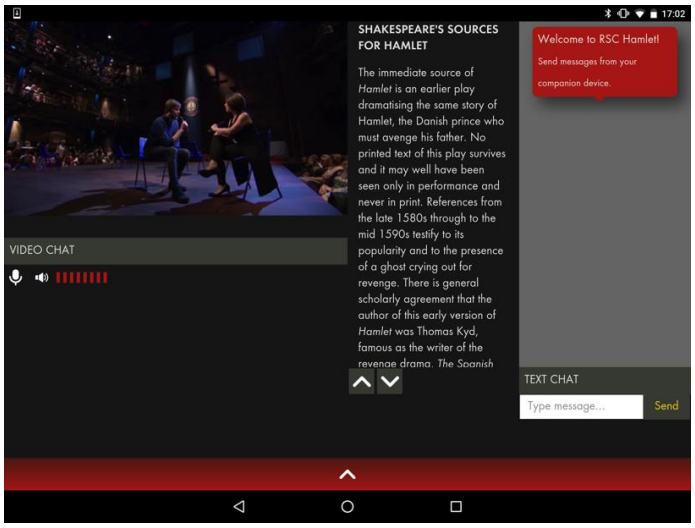
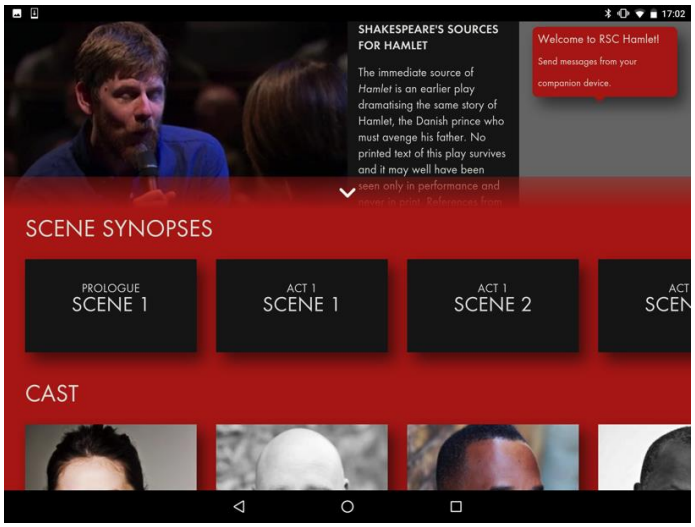
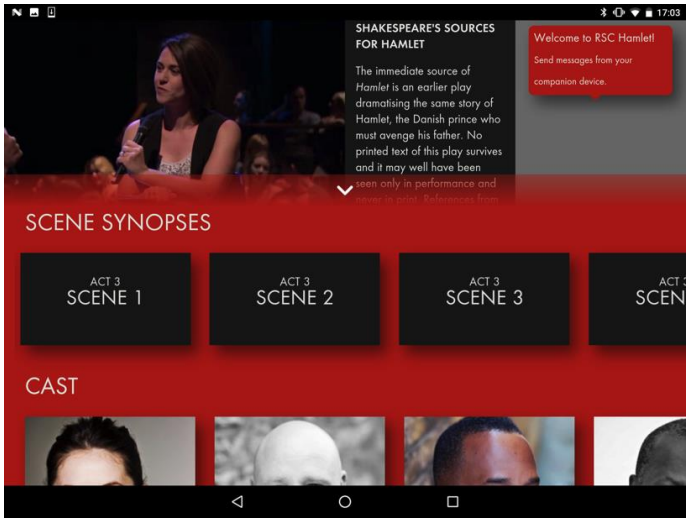
	Tablet views: The opening screen has a short recorded interview that takes place on the stage in the top left corner. Text chat is available in the right hand column. The central column containing text provides some introductory text about the play. The white arrow in the red bar towards the bottom draws up a sliding window… see below.
	The sliding window on the red background towards the bottom of the screen gives users access to resources such as scene synopses…
	…note the window is wider than the page so users can slide icons left and right to access synopses from the later stages of the play.

Table 1 First table showing screen shots from the tablet illustrating how users can access different resources

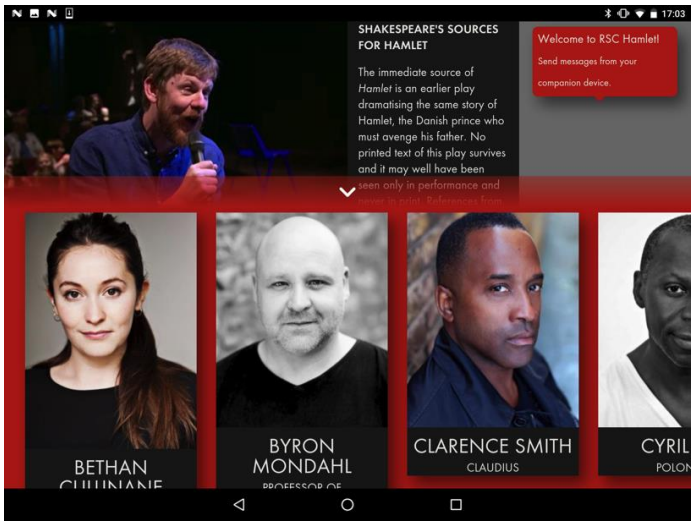
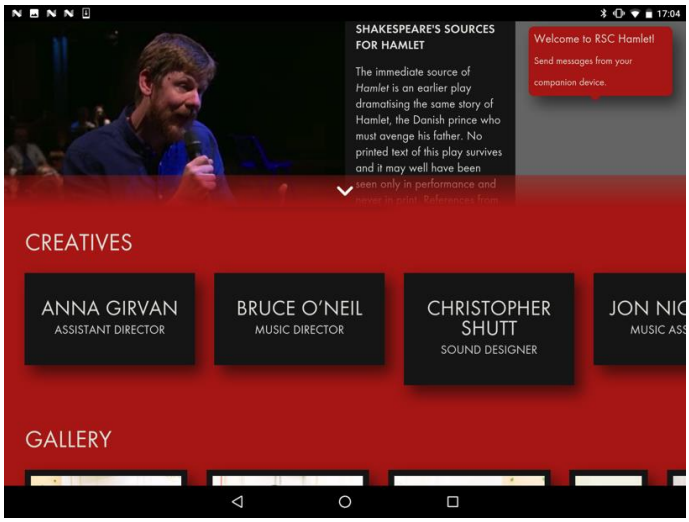
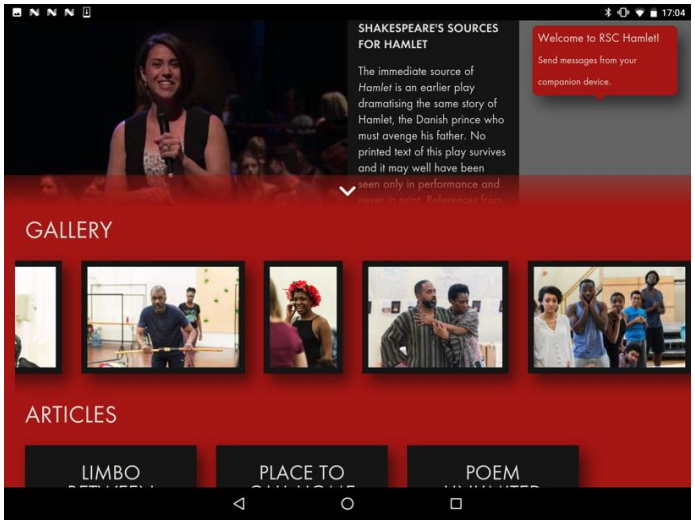
	The sliding window also affords access to biographies of the cast which can be accessed by selecting the appropriate image on the touch screen.
	Other resources available in the sliding window include biographies of the creatives.
	A gallery of photographs can be accessed by selecting a particular image. The image then appears on both the TV and the tablet.

Table 2 Second table showing screen shots from the tablet illustrating how users can access different resources.

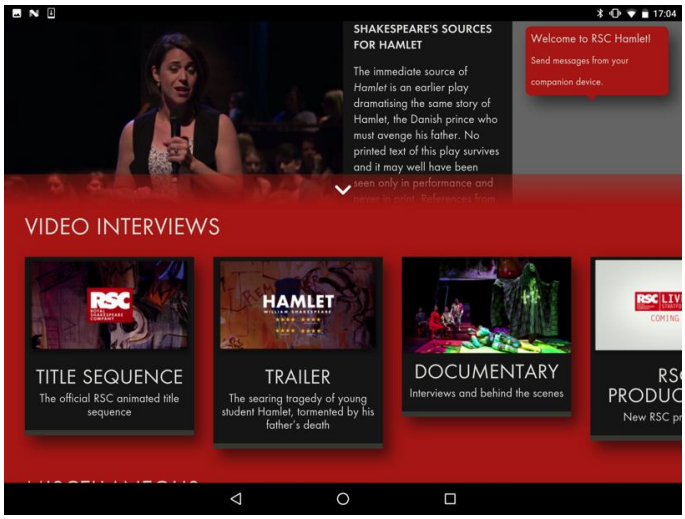
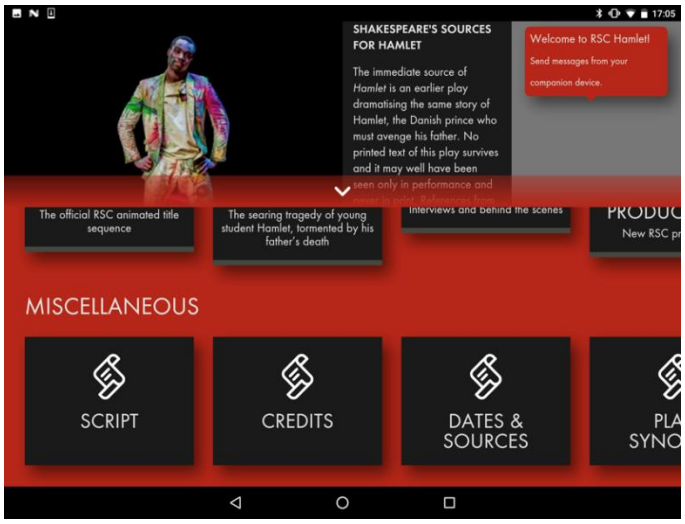
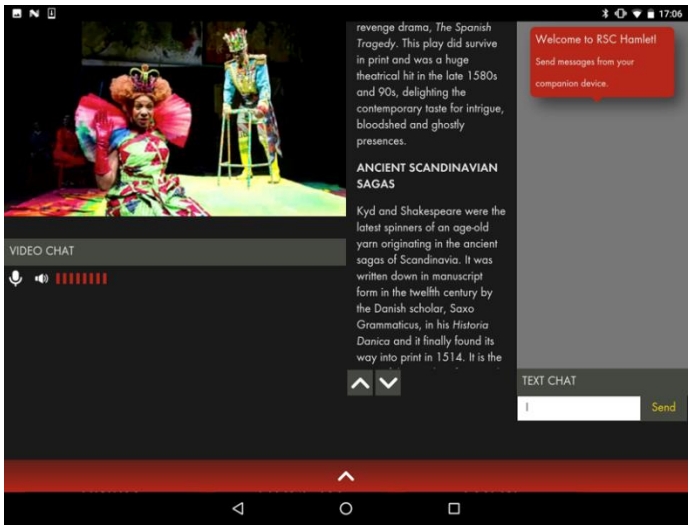
	Video interviews (which would display in the tablet window) are only available when the performance is not active.
	A Miscellaneous section features further articles including the script and the credits.
	Users can text chat with each other by touching the white text chat box. This brings up a keyboard (next image).

Table 3 Third table showing screen shots from the tablet illustrating how users can access different resources.

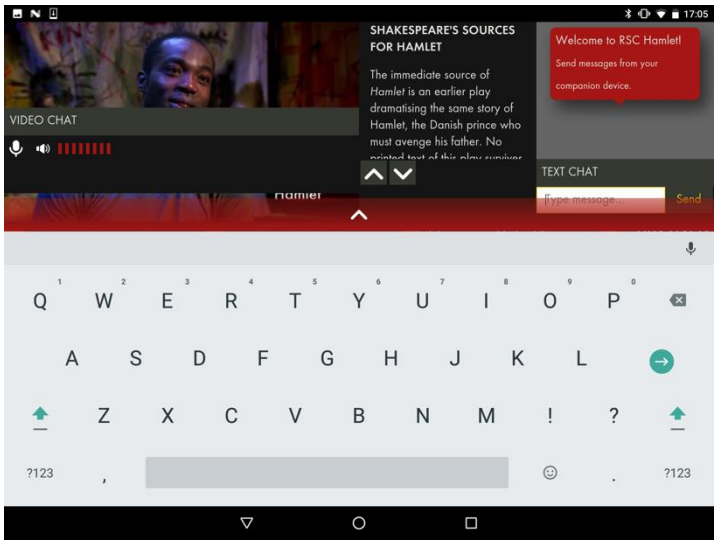
	Users can use the on-screen keyboard to compose messages and send them with the return key or by accessing the send button at the bottom of the text chat display window. Messages appear on the text chat window on the tablet and also on the TV.

Table 4 Fourth table showing screen shots from the tablet illustrating how users can access different resources.

3 Purpose of this evaluation

2-IMMERSE is developing a platform that will support multi-screen entertainment experiences. The platform is based on a constellation of cloud based micro-services and seeks to use available standards and specifications. The project seeks to understand whether the technological approach of employing micro-services has real merit and whether the standards framework exists to support their development; and also to provide insights that will help designers create compelling multi-screen experiences as well as to assess the Theatre At Home Experience designed and built within this project.

The evaluation of the Theatre At Home Experience thus has four goals which we state in order of their priority to the project:

1. To learn about the challenges, benefits and affordances that are associated with the micro-services approach to supporting synchronized, scalable, multi-screen experiences in a variety of scenarios.
2. To understand the degree to which standards, particularly those included under the HbbTV2.0 specification, enable (or limit) the development of multi-screen experiences.
3. To elicit insights that can inform the development of future multi-screen experiences. These insights may relate to the overall user experience, to aspects of the interaction design or to the orchestration and curation of content across screens.
4. To learn about how users receive, use and respond to the Theatre At Home experience.

Findings related to the lines of enquiry listed above will be used to inform and develop the 2-IMMERSE project across its lifetime by, for example, informing the technical design of the micro-services platform as it is developed for the final three prototype service demonstrations, but also by providing particular insights related to the design and implementation of future multi-screen services.

4 Method used for evaluation

There are two aspects of the evaluation: the evaluation of the platform as a technical entity and an evaluation of the Theatre At Home experience. The two aspects are both evaluated in a predominantly qualitative manner. The evaluation of the platform depends upon the responses of technical experts; the evaluation of the experience depends upon "normal users".

4.1 Method for evaluating the technology platform

Throughout the numerous meetings held to design, build and test the platform that runs the Theatre At Home Experience the team have debated different ideas and approaches, learned about the performance of the system as they built it and sought at all times to understand how they could make things better – or in the first instance, work at all.

Through that process the project team have gained insights that, were they to start the project again today, would make development process much faster. We tried to elicit this tacit knowledge by asking key members of the project team to reflect on their experience of the 2-IMMERSE platform that has been built. We deliberately sought perspectives from the key stakeholders, i.e.:

Producers

- Platform developers
- Application developers
- Cloud deployment specialists

We sought insights that relate to key aspects of the overall platform;

- Extensibility
- Robustness
- Scalability
- Ease of deployment
- Ease of use
- Feature set available

4.2 Method for evaluating the user experience

The project has adopted a design, build, deploy and evaluate methodology. The experience was designed in months 1-3, developed in months 4-12 and deployed and evaluated in months 12-18.

The evaluation being predominantly qualitative, it was not necessary to deploy the experience at very large scale; indeed we adopted the wisdom of Nielsen ("anything above 9 is good")[1]. We therefore sought to gain feedback through 12-15 experiments.

We were keen in evaluating the experience to conduct a highly situated experiment. That is, to have users evaluate the experience in the environment in which a proper service would run (i.e. their own homes). We felt this was important as the experience aimed to echo much of the ritual of attending the theatre and also because it was likely to take several hours. We wanted the user to have the best possible opportunity to relax into the experience and not to approach it as a technology trial.

[1] Nielsen is a user experience design guru. A significant author in the field he has published guidance that suggests there is a law of diminishing returns when collecting insights based on qualitative interviews; specifically he suggests you will receive 95% of the insights you are likely to receive from the first 9 set of responses.

Insights were sought through

- A pre-trial questionnaire
- A post-trial questionnaire
- A post-trial semi-structured interview
- Logs collected from the trial equipment

In some cases evidence was captured via two mechanisms, for example some aspects of the use of the system (e.g. the text chat) could be probed by asking users whether they used text chat but also by counting the number of text messages sent. We believed the objective measure would be useful and help to negate the very natural tendency for respondents to try to offer pleasing, positive answers.

4.2.1 Recruitment

Trialists were sought through three sources:

- By using the friend networks of 2-IMMERSE researchers in the BBC;
- By using the friend networks of 2-IMMERSE researchers in BT;
- By posting a message seeking trialists to a wide distribution mail list within BT.

We offered an incentive for taking part to the value of about €30, which we suggested would be received after completing the trial process. An example of the invitation to trialists is included in The Annex. We attempted to make clear the experimental nature of the work and that users would have to give up a few hours of time to watch a filmed performance of Shakespeare.

4.2.2 The pre-trial questionnaire

The pre-trial questionnaire was intended to allow us to better understand our users. It explored whether they were regular theatre-goers, how technologically literate they considered themselves to be, whether they were keen users of social networks, their age, gender etc. We asked these questions as we thought these factors might have a bearing on individual's propensity to enjoy the experience. The pre-trial questionnaire was completed only after the users had read a description of the trial and its purpose and had consented to the terms of involvement. The pre-trial survey was delivered online through Survey Monkey.

The full set of questions and the consent form statements are included in the annexes.

4.2.3 The post trial questionnaire

The questionnaire that was completed by participants after the experience (usually the following day) was, like the pre-trial questionnaire, delivered online via Survey Monkey. The questionnaire included questions that probed themes around:

- Users' experience to watching the event in a different place.
- The feature set: their utility, their ease of use and the completeness of the feature set.
- Rituals and the users' reaction to the mirroring of real world rituals in the multi-screen experience.
- The use of multi-screen: users' thoughts about how they distributed their attention between the screens.
- The value that users ascribed to the fact that the experience was shared.
- The curation and placement of content: users' opinions about which screens should be deployed to display the different components of the experience.

The complete set of questions used in the post-trial questionnaire is included in the annexes.

4.2.4 The post-trial semi-structured interview

A day or two after the trial we contacted the participants for a post-trial semi-structured phone interview to collect their thoughts and reflections. These interviews were recorded, transcribed and then analysed against the themes outlined, or against new themes that emerged.

The themes we attempted to address through the interviews included:

- Ease of use
- Look and feel
- Multiscreen
- Engagement
- Rituals
- Applause
- Phasing
- Mediation and curation of components and content
- Attention and automation
- Alternative camera content streams
- Social
- Social rules

The list of questions, with accompanying notes, that were used to guide the interviews are included in the annexes.

4.2.5 Logs collected from the trial equipment

Deliverable D2.3/D5.1 (Distributed Media Application Platform and Multi-Screen Experience Components: Description of First Release – Section 4.5) describes the logging and monitoring infrastructure which was implemented for the Theatre at Home trial, using the Elastic Stack instance provided within the Mantl platform. This infrastructure enables logs generated by all 2-IMMERSE services, as well as each Client Application (running on a TV emulator or companion device), to be time-stamped and aggregated using a single consistent logging format. Logs can be viewed, analysed and interpreted using the Kibana web application.

D2.3/D5.1 also describes plans to make use of Google Analytics as a complementary solution for logging of user interactions with DMApp Components. Unfortunately it was not possible to achieve this for the Theatre at Home trial, and instead information about the use of such components has been obtained through the post-trial interview described above. However, a user interaction logging solution will be implemented for subsequent trials, including MotoGP.

While the primary purpose of the Elastic Stack as a logging infrastructure was to facilitate debugging of the 2-IMMERSE platform and investigation of problems encountered during tests and trial runs, it was also employed to extract data on aspects of how the platform was used during each trial run. This data included:

- The progress of the experience, including the presence of each device in each household and the start times for each phase of the experience.
- The use of text chat within the experience. The text chat DMApp Components were available during all phases, and the logs indicate when text messages were sent. The content of the messages was not recorded.
- The use of video chat within the experience. The Video Chat DMApp Components were available during the Pre-show, Interval and Post-show phases, and the logs indicate speaker activity within each household (i.e. when the audio captured by the microphone rose above a certain threshold). The actual audio transmitted between households was not recorded or analysed.
- Orientation changes on the companion device. A change in orientation (e.g. from portrait to

landscape) of the companion device triggers the layout of the DMApp Components to be recalculated, and the logs record when this takes place. Such a log is perhaps of limited use, but could conceivably be used to indicate continued engagement with the companion device.

- Errors and warnings which indicate problems occurring in the home environment or its connection with 2-IMMERSE services in the cloud. These were used to indicate when a trial run stopped unexpectedly and why – for example the failure of the Wi-Fi connection to internet in one of the households.

This data was extracted and analysed within the Kibana web application using a set of visualisations and dashboards which were defined specifically for the Theatre at Home trial.

Figure 3 and

Figure 4 provide two examples which were used to obtain some of the results presented in Section 5 of this document.

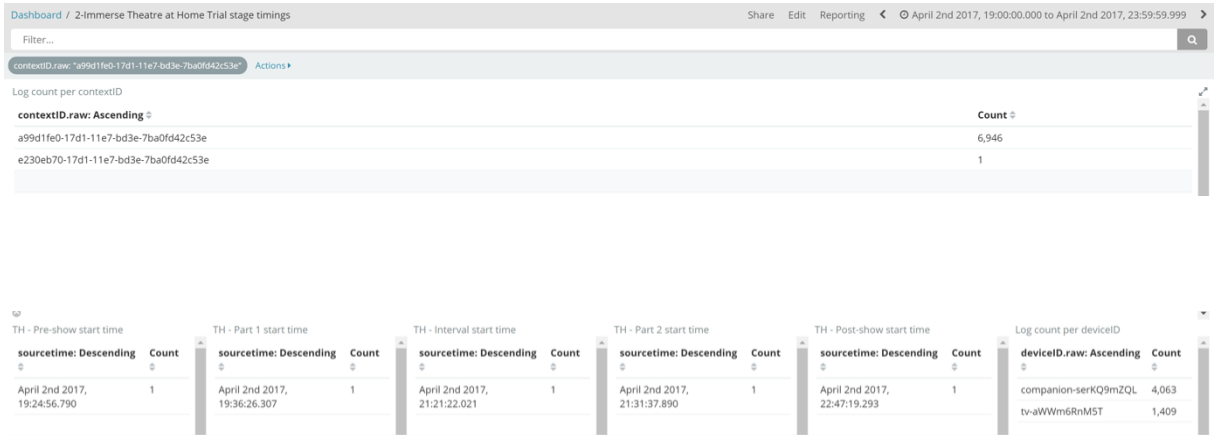


Figure 3: Screenshot of a Kibana dashboard used to extract the start times of each phase in the Theatre at Home trial. The context ID (representing a particular household) is selected at the top of the screen, and the start times are shown in each box at the bottom.

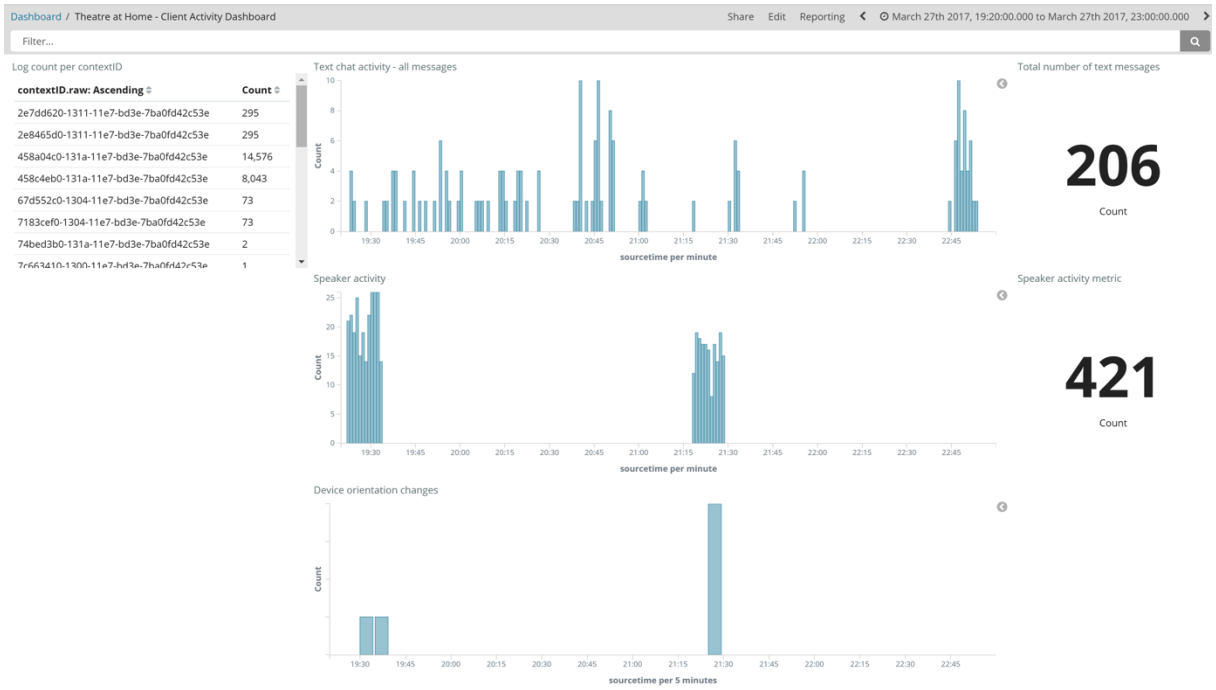


Figure 4: Screenshot of a Kibana dashboard showing client activity in the Theatre at Home trial. The context ID (representing a particular household) is selected at the top left of the screen. In the centre of the page, the graphs show text messages sent and received, speaker activity during video chat and orientation changes on the companion device.

4.3 Qualitative data: analysis method

The thematic analysis methodology of Braun and Clark [2] was used for the analysis of the data collected during the study.

The overall aim of the analysis is to capture, as a collection of 'themes', an understanding of what is really going on in the mass of qualitative-data captured in the open responses of the online questionnaire and the post-trial interview transcripts.

The interview transcriptions were loaded into Nvivo, a qualitative data analysis computer software package. An open coding procedure was used, during which the coding scheme was inductively defined and refined as the coding proceeded, very much in the spirit of Grounded Theory's constant comparative method (Glaser)[3].

A starting point for the analytic process was a set of themes identified to group questions (referred to as the Established Themes). For example, ease of use, utility, rituals of theatre, individual features, etc.

Items of the online questionnaire and interview data were considered in turn, and compared to the

[2] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3, 2 (jan 2006), 77–101. DOI: http://dx.doi.org/10.1191/1478088706qp063oa

[3] Barney G. Glaser. 1965. The Constant Comparative Method of Qualitative Analysis. Social Problems 12, 4 (apr 1965), 436–445. DOI: http://dx.doi.org/10.2307/798843

emerging coding scheme, to find existing codes that apply, to refine the definition of previously generated codes, or to produce new codes as appropriate.

Thus, while reading the text, 'nodes' (as they are termed in NVivo) or themes, were created as necessary and sentences assigned to them.

The nodes were created according to the judgement of the authors and refined and modified during the coding process. Subsequent words or sentences were allocated to the newly formed nodes, with new nodes created as and when the author felt they were needed.

5 Platform assessment results

The first trial of 2-IMMERSE has provided valuable knowledge that we summarize below. We focus on repurposing across scenarios; the expressivity of the platform; extensibility, deployment and scalability; and robustness. In summary, the first trial has provided us with a good set of requirements for the development of the production tools; the platform allows for repurposing; it is scalable and easy to deploy; but we need to continue to focus on robustness.

5.1 Repurposing across scenarios

The platform developed in the project aims to provide a core infrastructure that can easily be repurposed for different multi-screen experiences, as demonstrated by the variety of use cases considered in the project. To be 'easily repurposed', the system should be simple for 3rd parties to develop and include extra components for the intended experience.

The multi-screen experiences that 2-IMMERSE enables depend on a Distributed Media Application that is made from a set of components which we call DMApp components together with custom back-end services in the cloud. DMApp components are written using standard web technologies (JavaScript and HTML). Optionally components may use newer web features such as Web Components, which enable improved encapsulation and re-use. The design of the component interface is intended to allow wrapping of existing 3rd party User Interface (UI) components, and to be agnostic as to the technology and style choices used in the authoring of the component. This is to allow existing UI functionality to be easily imported into a 2-IMMERSE application. The component interface is designed such that common component functionality and standard behaviour is implemented without requiring additional effort on the part of component authors, yet can be overridden or amended where required by a component author.

Components used in the Theatre at Home trial include generic components written specifically for 2-IMMERSE and generic UI components which have been wrapped such that they can be used as DMApp components. Many of the components are data driven, permitting content and styling to be changed from one trial to another. For our second trial, we are reusing both generic and 2-IMMERSE specific components. We'll also implement MotoGP-specific components as defined by the stakeholder leveraging existing web developer talent. Such benefits flow from having made architectural decisions that enabled extensibility, as discussed below.

We have avoided committing ourselves to any particular application design methodology (e.g. Off-line first, mobile first, progressive etc.) and we haven't proposed an application structure (e.g. React-like, MVC, Meteor etc.). We permit application logic to run anywhere (cloud or client) and impose very few constraints on DMApp developers. Whilst this makes our platform very flexible and it doesn't tie developers to any particular implementation choice, we recognise that a layer of structure and constraints is a good thing to have especially in a distributed environment. Such a layer would promote consistency, performance and help developers concentrate on business logic instead of how to utilise the platform. This is a lesson we will be taking forward as we develop our other trials. An example is the provision of architectural support for executing application logic in the cloud.

5.2 Expressivity of the platform

The platform has provided the means to create a fully-fledged social inter-home multi-screen TV experience based around watching a theatre performance 'as-live'. The experience uses two devices, provides additional material and information, and allows people to communicate from different

locations (video and chat based). Some of the lessons learned during this process, which have now spawned further activity within the project, include:

1. The need for user-friendly tools to help media professionals to craft the experience. This insight is derived from requirements gathered from the producers and authors based on the experience of creating the Theatre at Home experience "manually".

2. The need for the platform to support a number of viewing "modes". This requires enabling the user to have access to greater levels of control over the layout and also to support more dynamic layout alternatives. This should make the experience adaptable to the expectations of the viewer. Such personalization capabilities have been taken into account for the follow-up scenario.

Based on the lessons learned during the first trial, the platform has substantially evolved. Dorna, exclusive commercial and television rights holder for MotoGP, sees commercial potential by enabling synchronized experiences across multiple devices, such as the TV/STB (Set-top Box) and tablet, extending their current offerings of synchronized multi-camera feeds within the App and website. The 2-IMMERSE platform, based on Object Based Broadcasting (OBB), provides opportunities for both cost savings and revenue generation for Dorna. For example, there are efficiency savings to be made in being able to easily regionalize content through rendering of on-screen graphics and branding later in the production workflow and delivery chain. Similarly, the ability to make on-screen graphics interactive when displayed on touch-screen devices opens up new possibilities for paid interaction (gaming, voting, competitions, etc.) and merchandising (purchase branded clothing, etc.).

In particular, Dorna are interested to explore multi-screen facilities combined with OBB, in order to support the provision of more personalized experiences for MotoGP viewers on both the TV and linked companion screen devices. Content can be orchestrated to match the interest and experience level of individual viewers. Newcomers to the sport, for example, could be provided with a guided introduction, while long standing fans would be offered more detailed statistics and analysis.

5.3 Extensibility, deployment and scalability: micro services and Mantl

The 2-IMMERSE platform is designed to be a cost-effective means of making and delivering multi-screen experiences in volume. We want to leave behind a plausible foundation for others to reuse and build on. The platform was designed to integrate with existing broadcast infrastructure. This requires it to be highly modular with components that are decoupled in such a way that they can be used standalone, extended or easily replaced. Consequently, we adopted a micro-service approach that is characterized by:

- Services that are: "Small, focused and that do one thing very well", and
- A supporting ecosystem and authoring capability for new micro services

We learned that we needed a very clear separation of concerns between micro services and the supporting infrastructure. Micro service developers do not need to worry about authentication, logging, data storage, message brokering, communications, Application Programme Interface (API) management, caching, load-balancing and service discovery. These are features that should be provided by the platform. They should allow the developer to concentrate on the business logic of their service.

Early on in the project we adopted mantl.io[4] as the foundation of our service platform. Mantl is an integrated set of industry-standard open-source components. It is cloud infrastructure provider agnostic.

We found it fairly straightforward to deploy Mantl; our initial deployment was to a private cloud platform based on OpenStack[5], and we were able to get a deployment up and running in a couple of days, with Dockerised[6] test applications deployed through Marathon and available to use. More recently, we needed to migrate the platform to AWS (Amazon Web Services)[7], and similarly found the deployment to AWS to be relatively straightforward, and had something up and running relatively quickly. In both cases we have been able to put together a Continuous Integration Continuous Delivery (CI/CD)[8] pipeline to make deployment of the 2-IMMERSE service straightforward. In the first instance this was using a Jenkins[9] Virtual Machine; in the most recent platform this is integrated with the project GitLab repo[10], and actually uses the Mantl container platform to run the build processes themselves. The use of Elastic Stack[11] for logging and analyzing platform issues has generally worked well and been invaluable for uncovering and resolving platform issues.

Using Mantl has been overall a good decision, even though we found some challenges like the fragile deployment of add-ons (such as Kong[12] and Elastic Stack), the static cluster management through Terraform, and periodic issues with long-term cluster stability which have required manual interventions. For the last of these concerns, we have added extra instrumentation to the platform, and developed an operational dashboard that brings together relevant indicators of platform and service status to a single screen. We have also implemented a system of e-mail alerts triggered by Mantl healthcheck failures. Nevertheless, our 2-IMMERSE service dependencies on Mantl are relatively light, being Docker, Consul for service discovery and Marathon for orchestration (which is itself easy to replace). On that basis, migrating to an alternative container platform ought to be straightforward, should it be required. Most of the effort here would be related to configuration of infrastructure around the container platform, e.g. API gateways, logging etc. (although we would reuse what we can e.g. the Elastic Stack). We have established a way of using Docker containers, and the infrastructure that they use that could be implemented within a range of container platforms. This is a design pattern that gives us portability.

[4] Mantl is a software platform that makes it easy to rapidly deploying globally distributed services. Mantl brings together arrange of different software capabilities from a variety of vendors to help with service discovery, resource management, load balancing and range of other common but diverse capabilities required to manage distributed services.

[5] OpenStack is a free and open-source software platform for cloud computing.

[6] Docker is an open-source project that automates the deployment of software applications.

[7] AWS, Amazon Web Services provide on-demand cloud computing platforms to both individuals, companies and governments. The technology allows subscribers to have at their disposal a fully-fledged virtual cluster of computers, available 24/7/365, through the internet.

[8] Continuous Integration/Continuous Delivery is a software strategy that enables organizations to deliver new features to users as fast and efficiently as possible. The core idea of CD is to create a repeatable, reliable and incrementally improving process for taking software from concept to customer.

[9] Jenkins is an open source automation server that helps to automate the software development process.

[10] GitLab Repository is a version control system used for tracking changes in computer files and coordinating work on those files among multiple people.

[11] Elastic Stack is an Open Source software system that claims to allow users to take data from any source, in any format, and to search, analyze, and visualize it in real time.

[12] Kong is a scalable, open source API Gateway/Middleware. Every request made that requires an API on the 2-IMMERSE platform will hit Kong first, and then it will be proxied to the final API. In between requests and responses Kong will execute any plugin that you decided to install. Kong effectively becomes the entry point for every API request.

5.3.1 Extensibility

In terms of extensibility, the architectural decisions make the platform naturally extensible. However, more work is required to give developers the confidence to extend the platform, by providing them with well-defined protocols, architecture diagrams and API specifications for services wishing to interact with the supporting platform. We could, for example, create client-side application architecture diagrams and further tutorials, documentation, and overviews to help developers understand and engage with the development of Distributed Media Applications (DMApps).

In planning for the MotoGP trial and Football trials we recognize that we need to consider carefully how to structure the applications. The design of single device applications is well understood, but there are many more options when the application is distributed over multiple devices and partly into the cloud. The Football and MotoGP trials include features such as tutorials that require sequences of user interaction and the ability to personalise the application behaviour according to user preferences. This requires the orchestration of activities (modes of user interaction) and the orchestration of application behaviour across multiple devices, not just layout orchestration. It isn't clear where such high-level application logic should reside (on the device or in the cloud for example) because there are many possible strategies.

5.3.2 Deployability

We are satisfied that the platform is easy to deploy based on the fact that it is built using modern architectural and deployment paradigms using micro services isolated in containers orchestrated and managed in several layers. The platform has been hosted on both OpenStack and on AWS cloud infrastructure and the move from one cloud deployment to another was completed with few issues. Once running it's straightforward to deploy the 2-IMMERSE services using Marathon.

5.3.3 Scalability

Our initial implementation effort has not been on scalability, even though we had scalability in mind when taking architectural and technology decisions. Thanks to the first trial, we have identified several issues that should be tackled to improve the scalability of the platform. It is not clear whether our planned trials will be limited by the current scalability performance of the platform but in any case we will consider addressing these issues.

- The way the layout service persists and accesses data in Redis[13] can be improved to minimise the need to lock data accesses.
- The core layout calculation engine in the layout service could be partitioned into a separate micro-service that can be scaled independently of the remaining (context and DMApp management functionality) in the layout service.
- We have implemented a Redis adapter for the websocket service that allows us to run multiple websocket service instances although these have to load-balanced using sticky sessions.
- Externalise timeline service state to enable scaling up service instances.
- Explore moving away from REST APIs for inter-service communication and instead use websockets, or a message bus directly.

[13] Redis is an in-memory database open-source software project implementing a networked, in-memory key-value store with optional durability. Redis supports different kinds of abstract data structures, such as strings, lists, maps, sets, sorted sets, hyperlog logs, bitmaps and spatial indexes.

5.3.4 Robustness: product quality

Robustness has been the major challenge faced by the technical team for smooth running of the Theatre at Home trial. This is in part due to the complexities of a distributed system and the uncontrolled environments in which they run. The trial has been very useful in identifying the main problems with the robustness of our platform.

Selecting devices for running the trials was a complex task, which required extensive investigation and discussions.

For our TV Emulator, we had hoped to use a low-cost single-board computer platform (the Odroid C2) which has similar processing capabilities to a high-end set-top box or HbbTV device, but unfortunately the platform's USB interface did not provide sufficiently reliable support for Wi-Fi connectivity and the external webcam which was required for the Theatre at Home trial. By switching to a Mac Mini desktop-grade computer instead, we were able to improve stability and mitigate some home network connectivity issues by providing a dedicated local Wi-Fi access point for the companion device. The MacOS platform presented its own challenges, including management of the startup process and controlling operating system features.

For the companion device, we provided Android tablets with the 2-IMMERSE app pre-installed in order to mitigate the risk of installation problems on trialists' own devices.

Given our experience with the Theatre at Home trial the technical team are investigating the following for the MotoGP trial:

- Changing the TV Emulator operating system to enable tighter control of the setup and on-boarding process;
- Enabling app support for both iOS and Android operating systems, and providing a range of different companion devices to trialists so that the platform's ability to adapt the experience can be properly tested;
- Investigating how to host compute-intensive operations, such as video compositing and multiple video decode into the cloud as a way of targeting devices and homes with poorer bandwidth and/or compute capability.

The quality of home networks had a significant impact on the robustness of the platform. We found that even homes that exceeded our minimum expected broadband upload and download transfer rates were prone to serious Wi-Fi issues. In many homes, the signal strength of the Wi-Fi was inadequate and packet loss or interference would cause client devices to occasionally lose a connection. Such connection loss issues are made all the more likely when you consider the duration of the trials, each of which lasts approximately four hours. One important consequence is that the current inter-home synchronization architecture effectively propagates the connectivity issues from the home acting as master to the home(s) acting as slaves. As a result, a connectivity failure in one home can cause the experience to fail in all synchronized homes. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for the MotoGP trial:

- Modifying the on-boarding process so that it permits 4G connections and supports Wi-Fi access points that lock down visibility of other networked devices (typically done for public access points). This may improve bandwidth to the home and provide an alternative to environments with poor domestic Wi-Fi;
- Changing the architecture so that the master timeline and state authority are moved to the cloud. This will improve robustness in the event that clients drop out whilst also allowing late joining to an experience. This will also facilitate the media seeking requirements of the MotoGP trial. These mechanisms can then be harnessed to recover an experience in the event of network connection problems.

During the trial, we observed a number of issues in the way that software on different devices utilized the available network bandwidth, affecting the quality and robustness of the experience. We learned that the clients were doing a lot of work to fix-up the system state by reordering messages being sent via multiple routes with different latencies, between multiple servers and clients. This has resulted in a revised plan to consolidate on using a pub-sub backbone for service-to-service communications and the Websocket Service for the majority of client-service communications. We also discovered potential problems when DASH[14] video player components and WebRTC[15] video chat components compete for available Internet connection bandwidth, possibly resulting in players being starved of data or video chat sessions being progressively degraded in quality. Overall, the lesson is that bandwidth coordination between devices is essential in a distributed multi-device environment. If each device is in competition with others, the results are highly unpredictable and the quality of experience can suffer. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for the MotoGP trial:

- Exploring MPEG-SAND and other coordinated bandwidth management strategies for multi-device ecosystems;
- Investigating the use of bandwidth budgets and constraints when computing DMApp component layout;
- Investigating how to amortize the cost of pre-emptive content caching or otherwise throttle the network bandwidth for such activities;
- Developing a better QA process, which includes finer control over the segregation of deployments, improved versioning and more regimented workflows;
- Introducing simulation of packet loss and connection dropout into our testing and QA process to harden the stability and robustness of the system;
- Simplifying messaging within the 2-IMMERSE platform to reduce the complexity of the client and the potential for inconsistent state between the micro services and clients;
- Introducing an API for subscribing/publishing system-wide error notifications and messages to help DMApp authors with better signposting.

In order to focus on a functional platform, on-boarding and user notifications were descoped in our first implementation. Perhaps because of this connection errors and partial connectivity were not reported in a way that enabled the user to understand the behaviour of the experience, and we learned that more research is required to find the best way of notifying users of error conditions. For example, a notification that the TV device is suffering Internet connectivity issues should be displayed on all devices, not just the TV. The users need to be informed if network performance is poor so that they can diagnose and resolve the problem for themselves.

Inevitably, issues arose from a lack of user understanding about the setup. We learned that on-boarding is an opportunity to evaluate and diagnose network performance, run tutorials and help successfully connect multiple devices to the network, the platform and the instance of the experience. This will improve the robustness of the trials. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for subsequent trials:

- Streamlining the on-boarding process for trial participants to reduce the need for project engineers to intervene with equipment setup. This will permit more trials to be conducted for the MotoGP, Football and Theatre in Schools service trials, whilst making it easier to run them

[14] DASH (Dynamic Adaptive Streaming over HTTP) is an adaptive bitrate streaming technique that enables high quality streaming of media content over the Internet delivered from conventional HTTP web servers.

[15] WebRTC ("Web Real-Time Communication") is a collection of communications protocols and application programming interfaces that enable real-time communication over peer-to-peer connections. This allows web browsers to not only request resources from backend servers, but also real-time information from browsers of other users.

simultaneously;
- Improving visibility of network issues within the user interface of our experiences so that participants are kept informed and can equate the behaviour of the experience to particular issues;
- Improving the assessment of the home network environment during the selection process for trial participants.

6 User experience results

6.1 Trials - overview

Tables 5 and 6 below provide a technical summary of each of the 12 Theatre at Home trial runs. Each trial run, apart from one, involved two groups of individuals taking part in the experience together and watching the play 'as live' in synchrony. As well as indicating the date and location(s) of each trial run, the tables contain the following information:

Home Environment: This row indicates the method used to connect the trial equipment to Internet within the home. Initially, both the TV emulator and the companion devices were connected via Wi-Fi and in some environments this proved reliable. However, to provide a more robust experience, an alternative configuration was developed in which the TV emulator was connected via an Ethernet cable and a software bridge set up on the emulator so that it could act as a local Wi-Fi access point for the companion device.

Start Time: For each phase of the experience which was presented to the trial households, the start time (as recorded by the TV emulator) is provided.

Video Chat: During the Pre-show, Interval and Post-show phases, the platform recorded when speech was detected at each endpoint. The two numbers shown represent the amount of speaker activity at each endpoint. They can be compared between endpoints and trial runs to give an indication of the relative intensity of the conversation.

Text chat: Throughout the experience, the participants could send text messages to each other using the companion device. Messages were shown on both the TV and the companion. The number shown is the total number of text messages sent by both endpoints during each phase.

Environmental issues: At the bottom of the table, this indicates where problems experienced with the home environment (including the home network and the TV provided) were responsible for degradation in the experience and/or the abandonment of the trial run before completion.

Platform issues: Similarly, this indicates where software bugs or platform faults were responsible for degradation in the experience and/or the abandonment of the trial run before completion.

As can be seen from the tables below, most of the trial runs were subject to a combination of platform and environmental issues. This trial was technically complex: a successful experience relied upon the synchronous orchestration of media on four different devices connected to arbitrary consumer TV sets and running over best-efforts and highly varied home and access network infrastructure. As a first trial for the project and the 2-IMMERSE platform, the issues experienced have provided essential learning for the technical team and have enabled significant improvements to be made, and in some cases tested, along the way. They have also highlighted the issues relevant to domestic environments, such as:

- It is not always possible to identify and address all the foibles that a home network may exhibit over a 4 hour experience in the time available to set up the system (usually less than half an hour. Sometimes network failures can occur (just as they do for commercial over-the-top services), and these are more likely to be detrimental to an experience which relies on synchronized playback at two locations.
- That domestic equipment can also be unpredictable. The HDMI interface between a source and sink device can cause intermittent problems, for example due to specification differences between older and newer devices.

	Trial Run 1	Trial Run 2	Trial Run 3	Trial Run 4	Trial Run 5	Trial Run 6
Date	6th February	13th February	6th March	27th March	1st April	2nd April
Location	Sudbury, Suffolk	Trimley and Ufford, Suffolk	Manchester and Ramsbottom	Ipswich and Stowmarket, Suffolk	London (2 adjacent homes)	London (only one household)
Home Environment	Wi-Fi to all devices	Wi-Fi to all devices	Wi-Fi to all devices	TV emulator wired with Wi-Fi bridge	Wi-Fi to all devices	Wi-Fi to all devices
Pre-show						
Start time	7.19pm	7.30pm	Not available	7.22pm	2.26pm	7.24pm
Video chat	98/127	1/1	Not available	151/84	No video chat	No video chat
Text chat	2	6	Not available	4	3	No text chat
Part 1						
Start time	7.31pm	7.42pm	Not available	7.33pm	2.37pm	7.36pm
Text chat	115	29	Not available	67	27	No text chat
Interval						
Start time	9.15pm		Not available	9.18pm	4.22pm	9.21pm
Video chat	121/113		Not available	109/36	No video chat	No video chat
Text chat	0		Not available	0	14	No text chat
Part 2						
Start time	9.26pm			9.28pm	4.33pm	9.31pm
Text chat	44			31	30	No text chat
Post-show						
Start time					5.48pm	10.47pm
Video chat					No video chat	No video chat
Text chat					1	No text chat
Performance comments						
Environmental issues	None	Home Wi-Fi failure prevented Part 1 from completing.	Home Wi-Fi failure prevented Interval from completing.	None	Home networking problems prevented synchronous video chat from taking place.	None
Platform issues	Video playback problem caused Part 2 to repeat instead of proceeding to Post-show.	None	Server issue prevented logs from being retained.	Video playback problem caused experience to finish at the end of Part 2 without proceeding to Post-show.	None	None

Table 5: Technical data for Trial Runs 1 to 6

	Trial Run 7	Trial Run 8	Trial Run 9	Trial Run 10	Trial Run 11	Trial Run 12
Date	5th April	6th April	16th May	16th May	19th May	21st May
Location	London	London	Northampton	Northampton	London	Stowmarket and Needham Market, Suffolk
Home Environment	One TV wired, One via Wi-Fi to 4G	TV emulator wired with Wi-Fi bridge	TV emulator wired with Wi-Fi bridge	TV emulator wired with Wi-Fi bridge	Wi-Fi to all devices	TV emulator wired with Wi-Fi bridge
Pre-show						
Start time	9.05pm	7.31pm	6.07pm	7.05pm	2.33pm	6.42pm
Video chat	110/120	115/51	Not available	Not available	119/27	160/65
Text chat	4	8	Not available	Not available	3	0
Part 1						
Start time	9.16pm	7.42pm	Not available	Not available	2.44pm	6.53pm
Text chat	5	67	Not available	Not available	39	94
Interval						
Start time		9.27pm				8.49pm
Video chat		87/105				0/0
Text chat		0				0
Part 2						
Start time		9.37pm				
Text chat		11				
Post-show						
Start time		10.53pm				
Video chat		No video chat				
Text chat		No text chat				
Performance comments						
Environmental issues	Participants chose to finish the experience at 9.51pm	One household chose to shut down their TV at the end of Part 2 (10.53pm).	None	None	Home Wi-Fi failure at 3.12pm prevented Part 1 from completing.	Intermittent audio on TV in one household resulted in abandonment at the Interval. Suspected HDMI interface fault as the TV was old.
Platform issues	None	None	Platform configuration issue caused the experience to stop at 7.39pm (during Part 1). Server issue prevented logs from being retained.	Platform configuration issue caused the experience to stop at 7.49pm (during Part 1). Server issue prevented logs from being retained.	None	None

Table 6: Technical data for Trial Runs 6 to 12

6.1.1 Recruitment method

	Long list (individuals)	Completed (household pairs)
BBC friend networks	9	8
BT friend networks	2	1
BT distribution list	14	3

Table 7 Summary of the way the triallists were recruited

The BT posting to an intranet site and inclusion in a broadcast email reached several thousand potential readers – though actual readership of these broadcast emails is not known. Fourteen respondents were recruited in this way though only three trial pairs made it to actual trial. Recruiting trialists for this experiment encountered some specific difficulties. In particular we found the requirement to agree a mutually convenient time was awkward – often requiring several rearrangements and in some cases just proving impossible, either because respondents failed to find a partner who could watch the play with them or because respondents could not agree on a mutually convenient time.

6.1.2 Pre-trial demographic questionnaire summary

All but one of the participants had some level of previous experience with theatre, indicating that they go to the theatre "a little", with 2 participants indicating that they go very often. Barriers to going to the theatre more often were sourced in the post-trial interviews and included obstacles such as time, money, distance and convenience, all of were cited in the interviews.

The Theatre at Home experience involved incorporating social networking and video conferencing technologies into traditional theatre broadcasting. Participants were asked to report on their previous experience with such types of technologies in the pre-trial questionnaire. There was a wide disparity among regularity of social media use, with 3 participants indicating that they never use social networking sites such as Facebook, with 4 noting Facebook use extremely often. Use of video conferring was also very disparate with participants either using services very often, or extremely infrequently. Despite the moderate experience with video conferencing and social networking services, participants generally considered themselves competent in their use of technology devices. All participants were confident in connecting a computer to Internet, and all but one reported similar confidence in connecting a TV set-top box and connecting a phone to a wireless speaker. These were specific competency questions asked in the pre-trial demographic form. Participants were also asked to reflect on their habits of watching television whilst using a second device. This was identified as a very common behaviour for the majority of participants with only 3 participants indicating that they do not engage in this behaviour.

Participants were asked to indicate the prevalence of technological devices that were present in their home. The average home for participants in the trial contain an infrastructure of 2 (1.58) tablets, 3 (2.72) smartphones, 2 (2.3) televisions and 3 (2.8) laptops or desktop computing devices. 1 participant indicated having over 5 smartphones and televisions while 3 participants cited the presence of over 5 laptops/computers in their home.

6.1.3 Post-trial questionnaire, logging and interview: findings

After experiencing the Theatre at Home prototype participants were asked to complete an online survey and a semi-structured interview. In this section we present the findings from these post-trial evaluations, combined with data-logs of user interface activity, to give an overview of participants' responses to the Theatre at Home experience.

19 households took part in the post-trial interviews. This included 5 couples interviewed together, with the remaining as individuals who spoke on behalf of their family and friends.

6.1.3.1 Overview

Participants were asked to respond to a series of statements outlining their overall responses to the Theatre at Home experience.

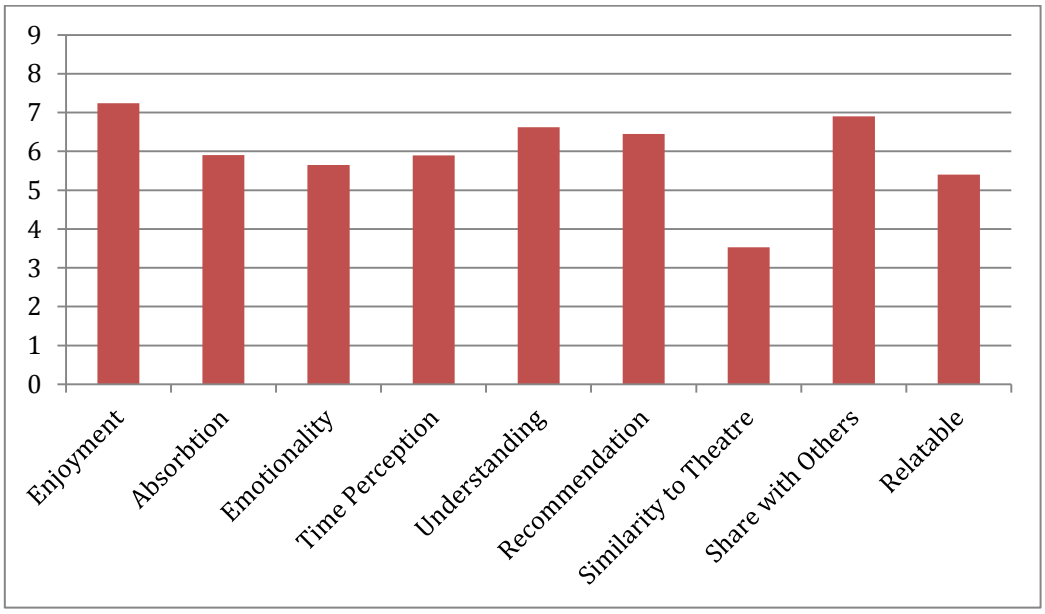


Figure 5 Average scores for aspects of the Theatre at Home experience (scale 0-9)

Category	Overall scoring (scale 0-9)
Enjoyment	**How much did you enjoy the performance?** 7.2av 7med (6-9)
Absorption	**How much did you feel absorbed in the performance?** 5.9av 7med (2-9)
Emotion	**Did you feel an emotional response to the play?** 5.7av 5.5med (3-9)
Time perception	**How quick or slow did time seem to pass?** 5.9av 6med (3-9)
Understanding	**How easy did you find it to follow the plot?** 6.6av 7med (3-9)

Category	Overall scoring (scale 0-9)
Recommend	**Based on the event, I would recommend this experience to other people** 6.5av 6.5med (2-9)
Similarity to Theatre	**How much did you think it was like going to the theatre** 3.5av 3med (0-9) - Participants did not consider it the same as going to the theatre.
Share with others	**After the play, I wanted to talk to people about what I'd seen.** On a scale of 0-9, participants scored 6.9av 7.5med (3-9)
Relatable	**I could relate to, or feel a bond with the performers**. 5.4av 5med (2-9). - Participants didn't feel the same bond with the performers as they did in the theatre.

Table 8 Summary of responses from 21 respondents

6.2 Features - summary

The Theatre at Home experience encompassed a range of features to accompany a 'live' video-stream from the theatre.

Some features were automatically selected and opened as part of the predefined experience, designed by the producer.

Other features were manually selected. Features were available to the user from the 'component switcher', a menu on the companion screen, which the user accesses with a click on the white arrow to open the drawer from the bottom of the screen.

Figure 6 Trial demo: 'component switcher' drawer, navigated via up/down, right/left movements.

The availability of features within the component switcher menu, were dictated by the experience producer, who scripted when features would be available to the user.

In the *Theatre at Home* trial all features within the Component Switcher could be selected all the time. However, where they were presented changed. For example, during the performance photos of the cast could only be shown on the companion screen, and not on the shared TV screen.

6.2.1 Feature use - summary

In the post-trial questionnaire, participants were asked to reflect on their use of the features available to them in the multiscreen theatre experience. All but two of the participants made use of the synopsis feature making this the most popular feature. Similarly, the text chat, scrolling script and background information materials also had high engagement. As well as learning which features were used, the questionnaire also asked respondents to share reasons that they may have stopped using certain features.

- 6 participants did not give up on any features that were available to them and interacted with the full experience.
- 11 participants however were not able to use all the features available to them, citing that it was due to the feature not working correctly. For example, the video chat feature was unavailable post-performance to many of the participants. However in post-trial interviews, despite disappointment about its malfunction, participants indicated positive feelings towards its potential use, mentioning it would have added to their experience.

(A full description of feature use and logs can be found in Section 4.2.5, and a technical summary of the trials including feature failure in section 6.1.)

2 participants said that they gave up on features because they interfered with watching of the play. One participant reflected this insight in their questionnaire, mentioning that they *"would like to switch off some features during the play so not to interrupt"*.

This requirement for user-mediated control of features is further highlighted by participant's mixed response over their preference of what device the features, such as video chat, should be housed, split between shared TV screen and the companion screen. (This is discussed in the following sections in more detail.)

6.2.2 Feature usefulness - summary

In the post-trial online questionnaire participants were asked how useful they found the various features/components of the Theatre at Home experience, on a scale of 0-9. The average scores on the chart above indicate that all features were considered useful, but the synopsis was the most useful. (This is discussed further in the 'Synopsis' section below.)

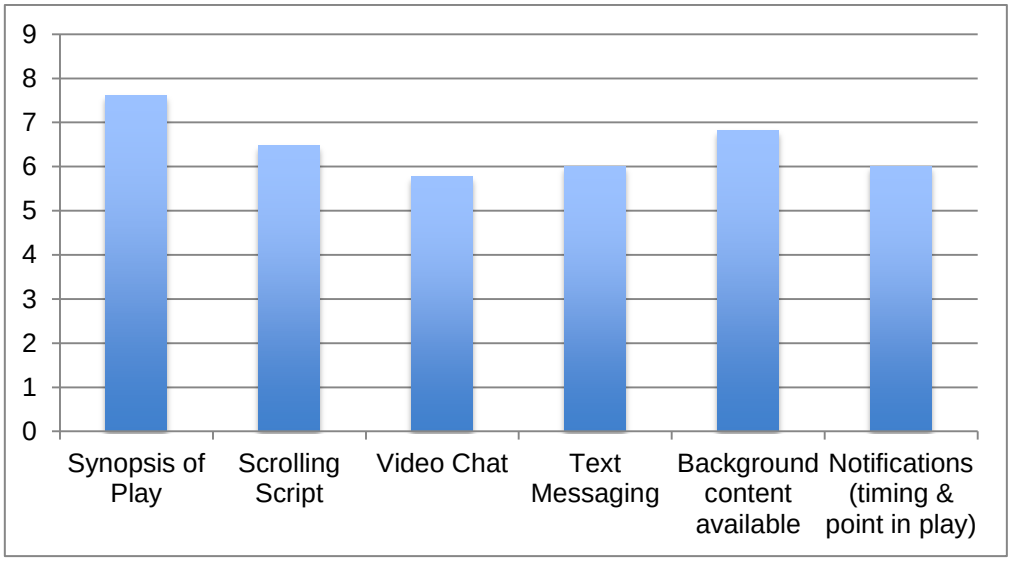


Figure 7 Useful features of the Theatre at Home experience, average scores.

6.3 Reflection on use of specific features

In the post-trial interview and questionnaire trialists were invited to reflect on the features in the Theatre at Home Experience. The following sections summarise these reflections.

6.4 Video stream - reflections

The video stream of the play, from the editor/director (mixed from the 5 camera streams in the theatre) appears in the main video window, on the top left of the shared screen. All participants used the video-window, and understood that this was the area where the live performance was presented.

All households discussed the video-window in the post-trial interviews, and their feedback can be clustered into three themes.

6.4.1 The video window needs to be as big as possible

The video window was maintained at a fixed ratio with other windows on the screen that additional contained content such as the scrolling script and the text chat.

> *Once the play loaded I wanted to make it full screen immediately.* [ID302]
>
> *I would have preferred to have the option and maybe this is something that you plan to do longer term. In just having the play fill the screen. And then bring in the other elements as and when required. And I would imagine that, erm, I probably wouldn't have brought in the other elements if I was doing that because I would want to just watch the drama unfold,* [ID701]

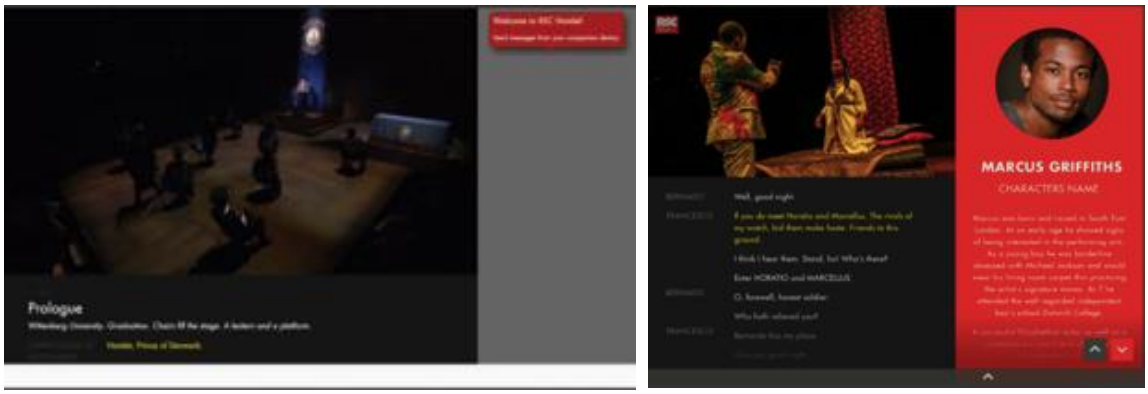


Figure 8 Video-window in the Trial demo on the shared TV screen (left) and the original user interface design treatment (right).

6.4.2 Overlays are needed

To achieve the participant's requirements of a dedicated full-screen video-window, on the shared TV screen, dedicated to the video-window, any additional information (such as the scrolling script, and text chat, or the synopsis) would have to appear as an overlay on the video-window (i.e., as subtitles appear on films/TV, or data-tables appear over sports programmes).

> *…if it could overlay over the TV image it would be better. So you would still get the full screen enjoyment and then the text would appear like an overlay, like a picture in picture if you like on top of the main screen.* [ID01 couple]

> *I'd like the script overlaid on the video stream so the video window can be larger and we can see more detail.* [Online Survey]

6.4.3 Supporting information on the companion screen

There was some debate as to whether the supporting information should be on the companion screen, rather than presenting it as overlays.

> *…more like TV, which you can kind of give focus to. So it is quite like, you know, if there was a desire to have the extra information on, you could have that as an extra overlay that you could dismiss, but I would happily have the extra information on the tablet and nothing else on the television.* [ID302]

Much research has been done on the problems of directing attention across two screens. Although our participants had suggested this as an option, more exploration is needed to define the nuances at play here. For example, if content which is not synched or time dependant, it can be referenced and orchestrated easily be the user, and can be displayed on a companion screen without cognitive load; while content that is time dependent/closely synched to content on the shared TV screen it increase the cognitive load considerably.

(N.B. Choreographing attention across two screens is discussed in more detail in section 6.6.3.)

6.5 Background information - reflections

A selection of background information, such as articles, biographies, photos and videos was available to participants throughout the trial. Some of these you would find in a traditional theatre programme, such as the actor's and crew member's biographies, presented as articles. Other information could be found on the RSC website, such as 'Behind the scenes' videos, interviews and trailers.

"Before, during and after the performance participants will be able to access relevant text, image, audio and video resources about the play, the production, the cast and crew.

This information is made available by the producer so that the experience and appreciation of the broadcast can be enriched and made more compelling." 2-IMMERSE D4.1

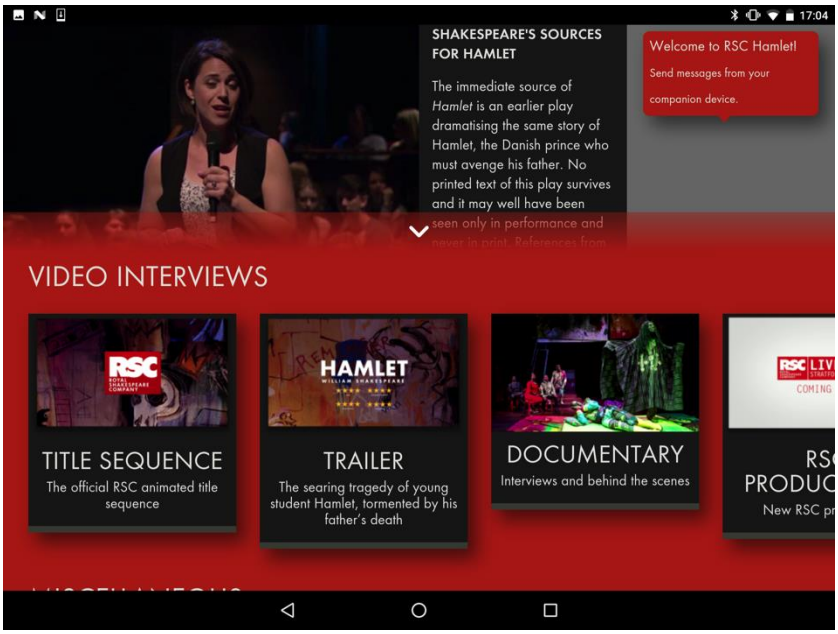


Figure 9 Trial demo: background information components menu

Participants felt that the background information features were useful, and easy to use.

Background materials available	Scale of 0-9
Ease of Use	7.8
Usefulness	6.8

Table 9 User evaluation scores for background materials

All background content was available to select and browse, (i.e., access to actor's biographies, crew information, photo galleries of rehearsals), except for a small selection of video clips (i.e., *Behind the scenes* footage, and interviews with cast and crew videos), which were 'placeholders'.

Participants were pleased to see the range of content that could be on offer in the Theatre at Home experience.

I did use the feature allowing you to check on the actor biographies etc., as this filled the same function as glancing through a programme bought in the theatre and provided very useful info, particularly as I didn't know the actors in this particular production at all. [ID702]

In the post-trial interviews 10 households discussed their expectations and use of background information in depth..

The actor's biographies were popular among trial participants, and something they expected. They talked about regularly using IMDB and other 3rd party apps/services to reference actors and film information while watching regular TV.

Figure 10 User Interface design treatment (left) and Trial demo cast and crew components (right)

6.5.1 More than a theatre programme

Although the background information was well received, many participants emphasised a requirement for a selection of appropriate, unique content to be available.

> *The information on the tablet was very good because it was proper information, and sort of edited and filtered and appropriate for what we were watching.* [ID201]

Participants wanted the same volume of information they would find in a theatre programme, some found the selection of content in the demo too small.

> *… when there wasn't enough supplementary information I'd go on internet and look up some of the actors –you know when you recognise someone's face and your sure you've seen them in another play and your curious? So, I did read what was available on the tablet and then I did some more research on my own.* [ID602]

One participant wanted something beyond traditional theatre programme content. For example, using content in different media formats (i.e., video), or adaptive/responsive content, that might be revealed over time or depend on the level of experience of the user (i.e., Shakespeare novice or Shakespeare expert).

6.5.2 Organised appropriately

The background information should be organised appropriately, taking influence from theatre programmes, and it should be editorially correct.

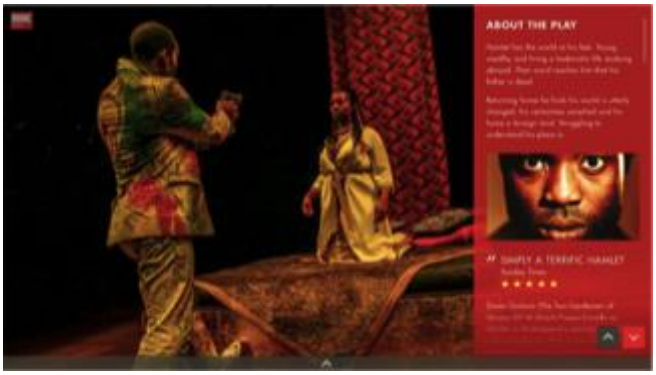


Figure 11. User Interface design treatment: background information on shared TV screen.

> *The content was not laid out in the same manner as a theatre programme, making it more difficult to find the biog of Hamlet, say. The actor's biographies, or the creatives, were not presented in order of appearance, cast ranking or alphabetical order, but randomly. In other words it should match the credits as scrolled at the end.* [Online Survey]

6.5.3 Should be on the companion screen

Participants talked about viewing background information primarily on the companion screen, and not on the shared TV screen. They often reflected on its use being similar to using a theatre programme during the performance:

> *If you wanted to reference something you look down at your programme for that, and I think in a similar way that the tablet was good for that, wasn't it. If we wanted to re-read the synopsis or we wanted to re-read the notes on a particular scene, just to remind ourselves what was happening that. It was very similar to looking at a programme, so that worked really well for us* [ID01 couple]

The project team are interested in exploring how people responded to the more seamless presentation of consistent content between screens (e.g. images/articles moving from the shared TV to the companion, depending on which stage in the experience you're at). These findings suggest that access to background information on the companion screen during a performance is appropriate for the user.

The positioning of background information in the periods outside the performance is less clear, and is dependent on the preferences of the participants. Many suggest that content should be initially accessed and placed-on companion screens. A move to the shared TV screen needs to be negotiated by all participants. However, this needs more exploration.

The type of background also has relevance. For example, if content has an audio track, negotiations are required to alleviate conflicting audio – from shared and companion devices – unless headphones are used.

(This is discussed further in the Sharing content section.)

6.5.4 Exploring Background Information during different 'phases' of the experience

Access to background information varied through the phases of the experience.

This was due to the demands/timeliness of the production, and/or the pressures of social interaction. Background information needs to be present throughout the experience, so participants can choreograph access to it in their own way and in their own time.

6.6 Scrolling synchronised script - reflections

A scrolling synchronised script is available on the shared TV screen during performances, as a default setting. Current lines are highlighted in yellow text.

> *During the broadcast I want to be able to view synchronised sub-titles for the production, either on a second-screen device or overlaid on the main performance feed. If I am hard-of-hearing I want to do this to enjoy the broadcast fully; and if my hearing is good I may want to do this if I find the language of the playwright (e.g. Shakespeare) unfamiliar and a bar to achieving a satisfying understanding. 2-IMMERSE D4.1.*

Pre and post-performance, and during the interval, the whole script is available from the component switcher drawer, for the user to select manually.

Figure 12 User Interface design for scrolling script on the shared TV screen (left) and the trial version on the companion screen (right)

Most of the participants used the scrolling script. Only four households talked about not referencing it or requiring it during the performance.

Scrolling Script	Scale of 0-9
Ease of Use	6.7
Usefulness	6.5

Table 10 Reported ease of use and usefulness for the scrolling script

Initially participants were split over the presence of a synchronised scrolling script. As the experience progressed, they amalgamated over their appreciation of the script, as an aid to understanding the narrative and characters.

> *When it first started off we thought, we don't really want the scrolling script. We thought it was like subtitles initially, and then we thought, well how do we turn the subtitles off because obviously it's in English, we can hear it, we don't need English subtitles, erm, and initially it frustrated us that we couldn't turn it off. But then later on we found that actually we needed a little bit of support and we became a little bit dependent on the scrolling script for remembering which character was which, because we are not super theatre goers or anything.* [ID01 couple]

6.6.1 Turn-off/turn-on options

As with other components, there was a standard requirement to have an option to turn the script on and off.

> *I found the scrolling script somewhat of a distraction from focussing on the play. It would be good to have the option to hide or deselect that particular feature. This would also enable the section of the screen dedicated to showing the performance to be bigger.* [ID702]

> *I would like to be able to hide that and just have the screen dedicated to the performance itself with options to bring up text if needed, if you wanted, but not have it there as a default*. [ID801]

6.6.2 Overlay or presented in a separate window?

For the time when the synchronised script remains on the screen, participants discussed presentation options –the most popular request was for the script to be presented as an overlay within the video window (i.e., similar to subtitles on traditional TV). There were some requests for the script to be presented within a separate window underneath (or alongside) the video window or presented on the companion (and not presented on the shared TV screen).

6.6.3 Cognitive load

Participants discussed the value of presenting the script on the companion screen, but the close connection between the script and the video window (on the shared TV screen) required a high level attention switching, which was not always appropriate for a successful experience.

Familiarity with the content affects the cognitive load - whether the content is on the shared TV screen or the companion. If the participants were familiar with the script already, they did not need it in close physical proximity to the video-window, and could orchestrate their attention between devices at a relaxed pace.

One participant talked about the use of the audio channel –and familiarity of language.

> *Again I think that is due to the language. I think if it had been a modern day play, I would have been able to follow along just by listening, but because you have to have a bit more consciousness to really know what is going on...* [ID301]

Other forms of information, such as actors' biographies and the synopsis, were not so tightly coupled with the video window, and therefore did not require high levels of attention switching. Therefore they could be positioned on the companion screen, because the orchestration of attention between shared TV screen and companion screen was more manageable for participants.

6.6.3.1 Design and layout of the scrolling script

The font, font size, and palette of the scrolling script were adequate for participants, although some adaptation requirements were surfaced by individuals. For example, a preference for larger text. Another couple of comments were related to unusual characters embedded within the script, such as '*a question mark and a diamond shape'.*

A 'smooth scrolling mechanism', and making the script and other supporting features 'less bold' were other requirements.

6.6.3.2 As a timeline to manage activities

Many participants talked about using the script, and other components such as the synopsis, to understand where they were in the play, and from that, they could manage their time.

> *I kept taking the tablet off him, it was nice to check where we were on the script as well to know when was the best time to nip to the loo and grab a drink. It was quite nice to know where you were in the script so you could go and do it.* [ID502 couple]

(N.B. The synopsis was also used as a timeline, to manage activities. The participants discussed their requirements for a timeline in the 'Suggestions' section.)

6.6.4 Feature reflections - social

The ability to enjoy a live theatre as a social experience with family/friends was an important part of the trial, particularly during the interval and pre/post-experience.

> *Before, during and after the performance I want to see and be seen, hear and be heard, by others within the group who I have chosen, and to be able to exchange private and group text messages within this group, so that we can enjoy each other's company with the performance as a focus, and to exchange ideas and reactions prompted by the play.* 2-IMMERSE Deliverable D4.1

In the post-trial online questionnaire participants were asked to what extent did they agree with the statement: *After the play, I wanted to talk to people about what I'd seen.* On a scale of 0-9, participants scored 6.9av 7.5med (9-3), that they did want to talk to others about the experience, supporting the requirement, and use of social features.

Two social features (were offered in the Theatre at Home experience: text chat and video chat.

11 households discussed the social features in the Theatre in the home experience in the post-trial interview in depth.

6.7 Social: text chat - reflections

Text chat was available throughout the *Theatre at Home* experience. Users enter text via a keyboard on their companion screen, and posted messages appeared on the shared TV screen and companion screens. The text chat messages from both houses were presented, and remained, on all screens throughout the performance.

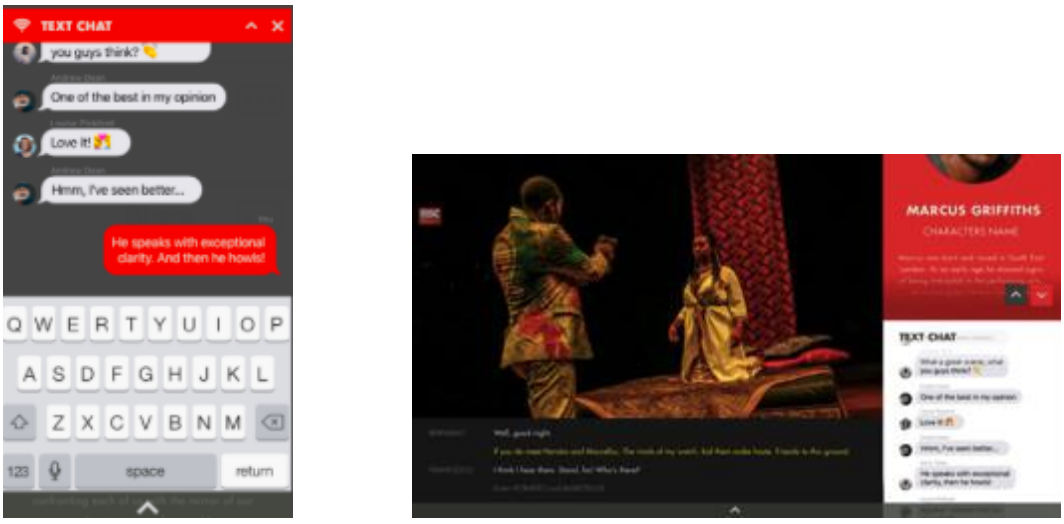


Figure 13 User Interface Designs for text chat, portrait orientation on a mobile device (left) and on a shared TV screen (right).

All participants used the text chat, and considered it useful and easy to use.

Text chat	Scale of 0-9
Ease of use	**7.4**
Usefulness	6

Table 11 Users' assessment of the text chat feature

The post-trial interviews surfaced how the participants used text chat, and their thoughts on related issues.

6.7.1 Frequency and phasing

Participants all used text chat, for a variety of reasons, such as asking questions, for explaining the plot, for pointing out something of interest, and in some cases it was used to discuss technical difficulties that may have arose.

It allowed participants to socialise without distracting sounds being emitted.

> *Yep, very good. We were able to say things like "Ophelia is rocking it' when she goes insane, because she did really go bonkers and it was really good. [ID502 Couple]*
>
> *That was useful actually yes, part of the chat that we had between the houses was, was he in so and so, on TV? The good thing about text is that it doesn't affect the sound. [ID701]*

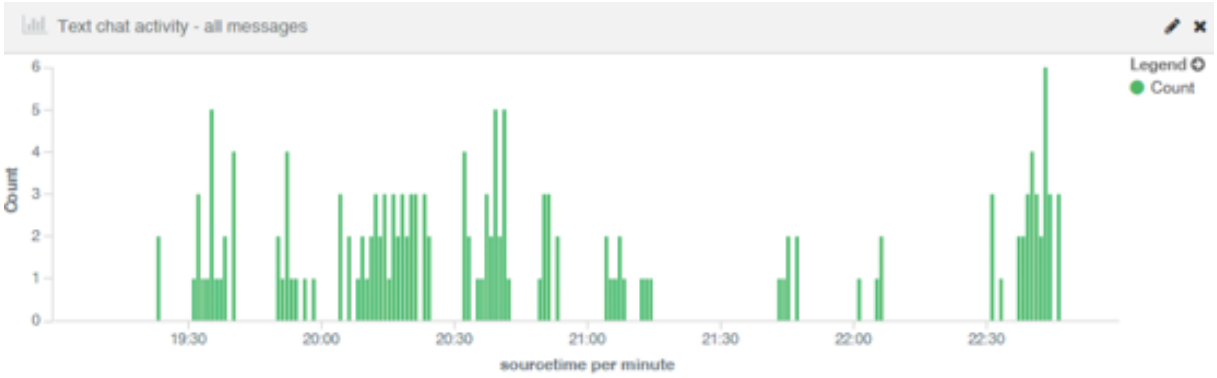


Figure 14 Example of text chat activity, a count of 160 throughout the Theatre at Home experience.

The use of the text chat featured throughout the phases of the experience.

> *I mean the frequency of messages tended to reduce during the play, unless there was a specific event that we wanted to comment on.* [ID01 Couple]
>
> *And you become more engrossed in the story telling. And also I suppose you don't want to… you are aware that people are on the other side of town watching the same thing that you are and you don't want to affect their enjoyment by continually messaging.* [ID701]

The graph (

Figure 15) and Table (below illustrate data to the end of Part 2 of the performance, in households where the social communications did not fail.

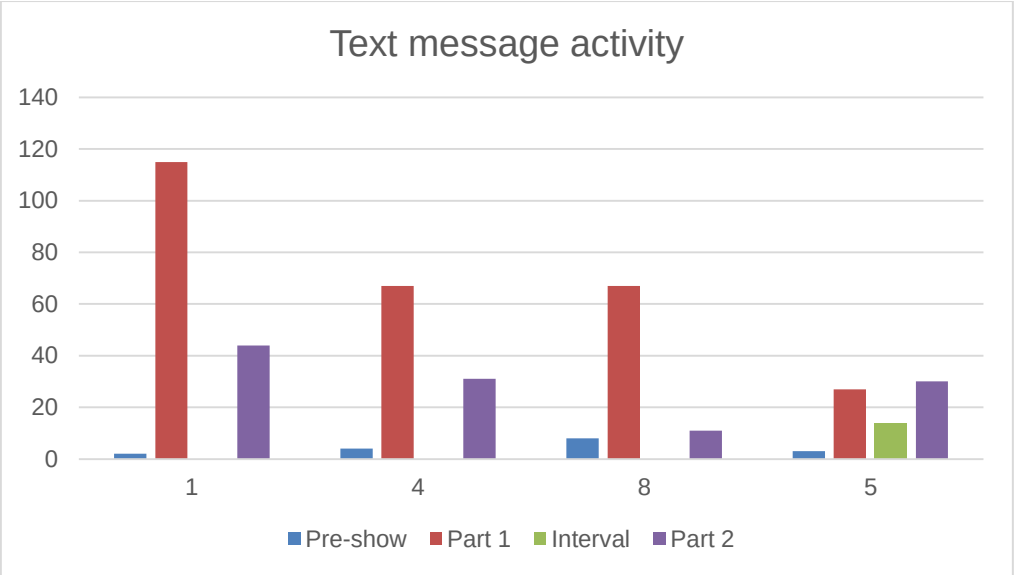


Figure 15 Text message activity to the end of Part 2 of the performance, in households where the social communications did not fail.

Number of text message sent	Trial 1	Trial 4	Trial 8	Trial 5
Pre show	2	4	8	3
Part 1	115	67	67	27
Interval	0	0	0	14
Part 2	44	31	11	30

Table 12 The number of text messages sent during different phases of the show

6.7.2 Temporary overlays

All the participants had expressed a preference to see the video-window (showing the play) full-screen, so discussion emerged on how additional information, such as the script and the text chat, might be presented on the same screen as the video-window.

Overlaying the text chat, temporarily, within the video-window was a popular idea expressed by participants.

6.7.3 Text chat activity and distraction

Sharing activities on the shared TV screen, with others in the room, can be distracting if their intentions differ.

> *So, it took me a while to get zoned into just that screen, because I could, out of the corner of my eye, see these two keep putting up comments and mucking about a bit. So I found it, from my point of view, I found it a little bit distracting from my own enjoyment of the play because every so often you'd see Colin pop up and write something, then Jeff would reply and so on.* [ID102 couple]

An option to control the text chat feature, by switching it on and off at the users discretion was requirement from nearly all participants.

This was a recurring theme throughout the evaluation, with frequent requests for other features in the *Theatre at Home* experience to be manually controlled 'switch-on/off' options.

6.7.4 Permanent record on companion screen

Concerns about 'cluttering the shared TV screen' led some users to suggest that the companion screen seemed a natural place to write and read text chat.

It was proposed that a default position would be a permanent record of the text chat on the companion device, while a copy of the most recent postings were displayed on the shared TV screen (as a notification) and are then 'timed-out'.

But the option to display the text chat on the shared TV screen should be at the user's discretion.

> *No, I personally would want it on the tablet. The more screen presence of the actual production the better.*
>
> *Well, the chat would be better on the tablet than on the television I would think*
>
> *You'd probably need the alerts to come up on the TV if there is a chat.*
>
> *Or, if someone does type on the tablet, it actually starts to appear on the screen after you've posted, for 5 seconds, and disappears again.*

Like a notification on the shared screen, with a permanent record on your tablet. [ID05 Couples]

All participants supported the idea of text chat having temporary presence on the shared TV screen to reduce the chance of distraction. Once a text message was received and read, it was no longer useful, and the text chat bubbles should time-out/fade-out.

6.7.5 3rd party social media raises cognitive load

A few participants spoke about using 3rd party social media on individual devices, during the trial**.** However**,** it distracted the participant's attention from the video-window (on the shared TV screen) and the experience, and they stopped using it.

> *With our friends, for a little while, we started texting using a third party thing on our phone. Because we said, well we could just text each other, and I think we used WhatsApp or something like that. But then after doing that for a little while I realised that now I was no longer paying any attention to the play so all my attention had gone to my phone. So I said to Jeff, "look I'm going to go back to texting on the TV because I'm missing it". And then when we went back to texting on the screen it was a lot better because there was a focus on the screen.* [ID01 Couple]

6.7.6 Design and layout of text chat

Aesthetic suggestions to improve the presentation of the text chat were made. Such as identifying individual contributions by colour and/or user name; reducing the size of the text chat panel.

6.7.7 Text chat and user ID

Participants speculated on how the text chat might work with multiple users, and if all text chat should be replicated on the shared screen. Again it was suggested that text chat should default to the companion device, with an explicit decision to mirror conversation on the shared screen temporarily.

6.7.8 Text chat and age, genre, or the purpose of taking part

Two households discussed how the use of text chat may vary with age of user, citing that younger people might consider social features an important aspect of the Theatre at Home experience.

Participants speculated on how text chat features might be used across a range of genres, and reflecting on the purpose of the group of users taking part in the experience. For example text chat would support banter throughout sports programming, or discussion in a study group.

> *C: If this concept were used for football or rugby or a sporting match, then you'd quite welcome the banter of being able to see it in the texting, down the side. So I think, there could be an instance where that would really work well, to see all the comments.*
>
> *J: Like, if it was a musical concert you might to share. In the theatre you might want it off, but in the football it would definitely add.* [ID102 couple]

6.8 Social: video chat - reflections

Video chat was an automated feature available outside the performance, which allowed connected homes to socially interact. Video chat was available on the shared TV screen.

The controls for video chat audio (microphone mute and volume level) were provided on the companion device, but participant's feedback did not contain any information about whether they used these controls.

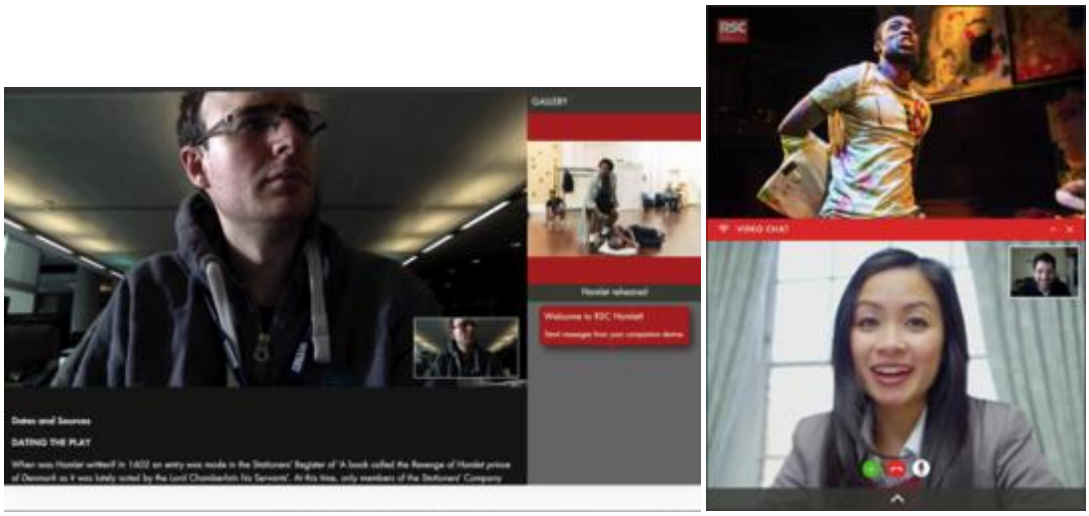


Figure 16 Trial demo video chat on the shared screen (left) and User interface design treatment for video chat on mobile phones in portrait orientation (right)

All participants used the video chat, and understood where in the experience it would be available, and how would be automatically be presented on the shared TV screen.

Video chat	Scale 0-9
Ease of use	6.2 (7.8 when removing broken trials)
Usefulness	5.8 (6.8 when removing broken trials)

Table 13 Results of user assessment of video chat

Participants acted naturally with video chat, and used it as a vehicle for normal social interaction, and an opportunity to re-connecting with family members.

> *We loved the video link. You know, being able to talk to Colin and Susie, and obviously, then we were talking to their daughter about her friend and that. And that was so nice to have that interaction. We absolutely loved that bit as well didn't we?* [ID102 couple]
>
> *I think it is the sort of thing I would chose to have with people that I know well, because you know, you are literally in their living room, it's their space. So I can really see it as an experience to have with close friends and family. You know that would be great, particularly for me with family in France and scattered around the country, sharing an experience with them, that would be lovely.* [ID801]

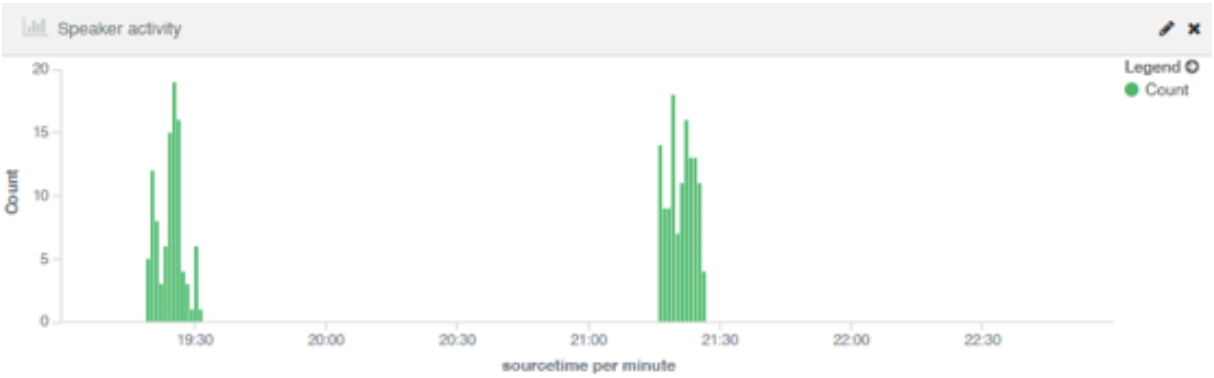


Figure 17 Example of video chat activity outside the performance phases, a count of 224 instances of speaker activity.

The graphs and figures below illustrate data to the end of Part 2 of the performance, in households where the social communications did not fail.

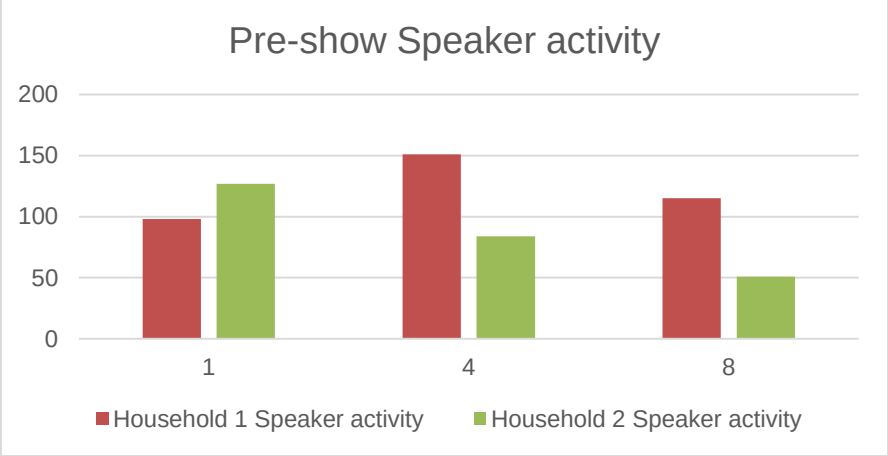


Figure 18 Pre show speaker activity in households where social communications did not fail

Voice/speaker activity	Trial 1	Trial 4	Trial 8
Pre-show			
Household 1 Speaker activity	98	151	115
Household 2 Speaker activity	127	84	51
Interval			
Household 1 Speaker activity	121	109	87
Household 2 Speaker activity	113	36	105

Table 14 Speaker activity in households where social communications did not fail

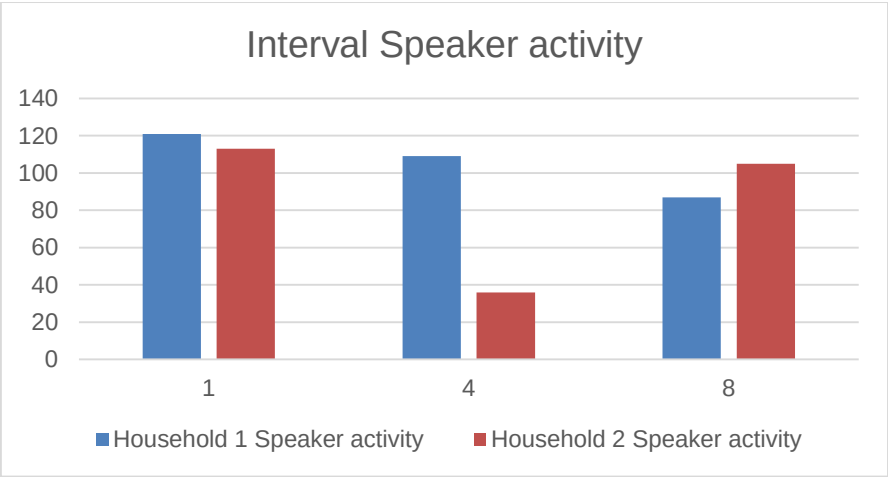


Figure 19 Interval speaker activity in households where social communications did not fail

This data, combined with participant's qualitative feedback from the post-trial interviews, suggests that:

- Video chat seemed equally popular in the interval as it was in the Pre-show phase.
- Text chat was little used during the Pre-show and Interval phases (being supplanted by Video Chat), and was used most during Part 1. Usage appears to tail off during Part 2, although our data isn't statistically significant.

6.8.1 Video chat during performance would be distracting

Video chat wasn't available during the performance. So, participants were asked '*Would you want video chat on all of the time?*' All participants suggested that they would need time out, and it would not be reflective of the experience in a real Theatre if video chat was available throughout the experience. Participants said it would be distracting from the performance, and cause extraneous noise.

> *We used the interval section to talk on the webcam, that was really good actually, it really did feel like an interval at the theatre where you spend 2 or 3mins discussing what you've just seen and then you just get into a normal conversation, normal chit chat, and I think that felt very natural and how your experience at the theatre might be.* [ID902]

> *I think because of the nature of what we were watching I wouldn't have wanted the video chat during the performance. It is the sort of show or performance that merits your whole attention, so I wouldn't have wanted the video chat during the performance.* [ID801]

6.8.2 Failure did not put users off

The video chat features failed in a number of the trials (see section 5), failing part way through 3 of the 12 sessions (due to network issues).

However, all participants had an insight into its use, and all participants thought it was a valuable asset in the *Theatre in the Home* experience.

> *J: There was a fault with the set-up, so when it got to the end it went straight back and started the second half again. We didn't have a return to the video, which was upsetting.*

> *C: Yeah, that was the only disappointing part of the evening was that we didn't get a chance to chat to Colin and Susie at the end, but we Skyped them anyway, didn't we?* [ID102 couple]

> *We thought about restarting the experience, to use video chat, but carried on without it, and the social side worked fine via text chat. I did miss the video chat though!* [Online questionnaire]

6.9 Synopsis

A synopsis was available, outlining the narrative of the play by scene and act.

The whole synopsis could be referred to at any point in the Theatre at Home experience, and the current location could be manually controlled.

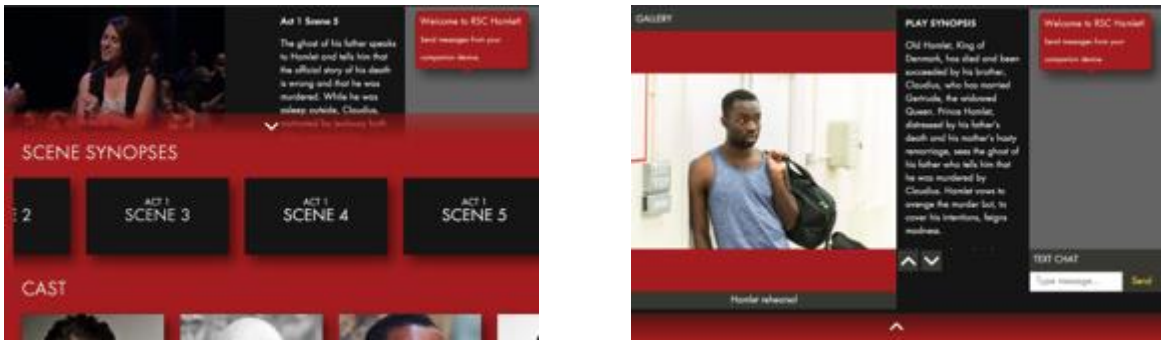


Figure 20 Trial demo synopsis components menu (left) and synopsis displayed with other background information on companion screen (right)

All participants used the synopsis, and understood how to select it from the component switcher.

Use of Synopses	Scale 0-9
Ease of use	7.7
Usefulness	7.6

Table 15 Users' assessment of the Synopses

They synopsis was used by all participants, and they wove the use of the synopsis into their viewing of the play, using it to aid their understanding of the play, and identify where they were in the play.

> *We sort of got into a habit of reading the notes for each act and scene as it was about to change.* [ID101 couple]

> *I think the synopsis obviously helped because Jeff's obviously not a great Shakespeare (fan) so I sort of read through the plot for him and explained what he was going to see as the acts went through, and then we both looked at the actors and what they had done previously and looked at that. But I think the synopsis part of it was probably the most useful for us.* [ID102 couple]

The synopsis tended to be used on the companion screen and read out or passed around, in a similar way to a theatre programme, because it was usually referenced during the performance, which meant it defaulted to the companion screen.

> *If we wanted to re-read the synopsis or we wanted to re-read the notes on a particular scene, just to remind ourselves what was happening, that was very similar to looking at a programme, so that worked really well for us.* [ID101 couple]

> *I know Hamlet quite well because I've studied it quite a few times during my education, but if I needed it to refresh my memory, to work out where we were and which act and scene we were in, and that was one of the most useful parts, to look on the tablet and think yeah that's happening at the moment, because sometimes Shakespeare can be a bit complex can't it?* [ID902]

6.10 Time keeping: notifications/'the bell'.

A time-keeping function within the *Theatre at Home* experience was designed to reflect the (bar) bell in a Theatre, which notifies the audience about when the play is about to start/commence. The 'bell' count-down notification is pushed to the shared TV screen, informing users *'1 minute to the start of the performance'*; *'30 seconds to the start of the performance''*; and '*5 seconds to the start of the performance''*.

All participants liked the bell, and understood its meaning, indeed some felt the 'sense of anticipation' surrounding a live theatre visit.

> *The timer was useful and I liked it. You do get a sense of anticipation from it. When you are in your own home and you have the opportunity to come and go as you please, but there's something about watching a shared experience, that's particularly at the interval where you do just want to sit and wait for it to begin. That's something that is quite special about the theatre. That you take your seat and then you're waiting to go back into that world that you've just left, and so I quite liked the idea of preparing yourself mentally for that 5minute, the 1 minute, the 30seconds countdown, and I find that to be quite effective in the trial.* [ID602]

In the post-trial online questionnaire participants suggested that it was a useful feature, but they didn't find it easy to use.

Notification	Scale of 0-9
Ease of use	**4.8**
Usefulness	6

Table 16 Users' assessment of the notification functions

The post-trial interview feedback gave an insight into why the bell got lower scores and ways to improve the feature.

6.10.1 A longer countdown window

Participants liked the bell, but they wanted a little more warning, similar to the timings used in the theatre.

> *Yeah, I think a clearer timer beforehand and during the interval, then you could sort of know how long you've got to get drinks and rush around during the break. Once we had that timer pop up at 30 seconds we said 'quick, quick, quick'. So we told our friends to rush back.* [ID01 couple]

Having a little more time would allow the users to manage their time more efficiently.

Two participants asked for adaptations to the bell, such as an audio notification (such as a bell sound) to complement the visual notification.

Requests for more time prompts and notifications, to help organise time and activities was a recurring theme during the trials. The addition of a 'timeline' or time-indicator was request by some participants.

6.10.2 Option to pause

The option to 'pause' the performance was another recurring theme in the trial for a few. Ten (10) participants, who wanted to manage time and activities outside the Theatre at Home experience.

> *…with such a long production, I would have liked to have made a negotiation with the other house that I was watching with, how about we have half an hour interval and I can go and cook dinner. And then we can eat dinner while we watch the second half. So that is kind of the opposite of making it like theatre. Making it feel like home.* [ID302]

This proposal takes elements of theatre, mixed with the conveniences of watching theatre in the home, to offer something unique.

There was considerable debate (amongst the project team) about including a 'pause' function, and not making it a feature was a deliberate decision at the request of the producer because the inclusion of 'pause' moves the experience towards VOD rather than an 'as live' event – which was a very different concept.

Participants discussed the value of pause in the context of other 'live' events, such as football, and how the detrimental effect of the qualities of live-ness and spoilers, and the negotiations and inconvenience for the adjoining household. Participants suggested that a simultaneous pause would be acceptable, or even to run the experience a few minutes out of sync –which still allowed some time for video chat in the interval.

There was much discussion on the realisation of adding a pause function,

(N.B. 'Pause' is included in the 'suggestions' section.)

6.10.3 Other types of notification

Other types of notification were suggested during the Theatre at Home trial, particularly notifications displayed on the shared screen, to alert users to new content.

For example, alerting users to new social media activity that might be available on their companion screens only.

(N.B. A related discussion for this can be found in the 'Cognitive load' section of this document, when participants discussed how attention could be directed across two or more screens. Notifications have been suggested as a prompt to alert users to new content.)

6.11 Phasing

The Theatre at Home experience was broken into phases, to mirror the phases of a theatre visit:

1. **Pre-performance** – opportunity to socialise, opportunity to review supporting materials, and make preparations before the performance starts.
2. **Performance: Part I** – focus on the performance, orchestrated opportunities to review/reference supporting materials, limited opportunity to interact with fellow audience members.
3. **Interval** –- opportunity to socialise, opportunity to review supporting materials, and make preparations before the performance starts.
4. **Performance: Part II** – focus on the performance, orchestrated opportunities to review/reference supporting materials, limited opportunity to interact with fellow audience members.
5. **After-show/Post-performance** –- opportunity to socialise, opportunity to review supporting materials.

Most of the features were available throughout the experience, such the script, the synopsis, text chat, and back ground information (actors and crew biographies).

The video stream, from the stage in the theatre was only available during the performance.

However, the video chat component was only available outside the performance, to reflect the reduction of social interaction allowable during live theatre. Background video's, such as interviews with actors and crew, and 'behind-the-scenes' footage, were only available outside the performance.

(N.B. The features available within each phase are described in section 4.2.5)

The post-trial questionnaire and interviews, revealed that all households were aware of the phases of the Theatre at Home experience, and the (automated) availability of features such as video chat, and they all felt comfortable with that. When asked *Did you find it useful for the video chat to automatically shut down during the performance?* They responded positively, giving it a score of 7.5 on a scale of 0-9.

When asked, '*Would you rather have things like the video chat available all the time?'* participants unanimously agreed that some components might be distracting and detrimental to the experience if they were available and in use all the time.

6.11.1 Behaviours change through the phases

Participants were aware of changes in their behaviour during the phases of the experience.

Particularly how the frequency of social interaction reduced during the performance, and picked up again between performance phases.

> *I mean the frequency of messages tended to reduce during the play, unless there was a specific event that we wanted to comment on.*
>
> *Texting…..we found that detracted from, took our attention away from the play to be honest.* [ID101 couple]
>
> *Generally, I feel that Shakespeare or theatre more generally doesn't lend itself too well to interacting with content or others while watching the performance, but rather interaction is normally left to the interval or after the play*. [ID702]

However, the availability of features did not control participants' behaviours. When asked *Do you think phasing the availability of the video chat made you more absorbed in the performance?* Participants scored 5.6 on a scale of 0-9, suggesting participants could direct the attention appropriately.

> *Once we'd sort of familiarised ourselves with everything and could settle down we actually then zoned into the play and it worked really well. I think if we could do it again we'd definitely ask for more time at the beginning to familiarise ourselves before the play starts.* [ID102 couple]

Once the participants were familiar with the phases of the experience they could organise their attention, time and activities more appropriately.

6.11.2 Different experiences would have different phase patterns

Some participants reflected phasing in other multi-screen live experiences, and reflected on how the activities would be organised.

> *So for this type of show I wouldn't have used the text during, particularly. If it would have been something different like strictly come dancing or something like that which is very interactive with the audience then I could see the text option being used during the show, something like that. Probably not so much for Shakespeare.* [ID801]

6.12 Easy to use and control

Participants were asked to measure how easy the Theatre at Home experience features were to use, on a scale of 0-9. All features were considered 'easy to use', with the synopsis scoring well, alongside the supporting background information and text chat.

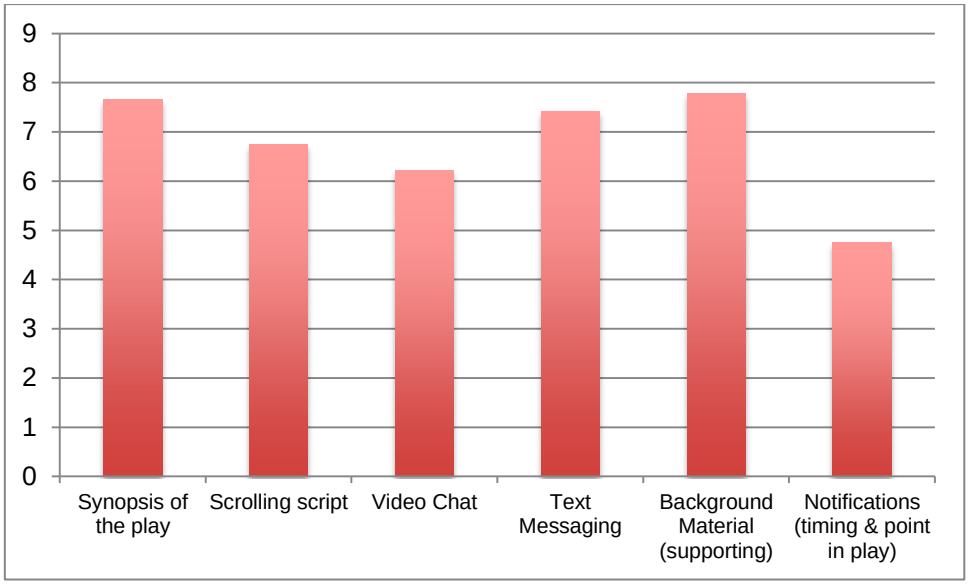


Figure 21 Features of the Theatre at Home experience, and their average 'ease of use' scores.

The Notification features scored low, as participants required a longer count-down period to indicate when the performance was commencing. They also required some indication of where they were within the experience.

(N.B. This is discussed further in the Notifications section.)

Little interaction was needed on behalf of the user in the trial experience. Features, once selected, would position themselves on a screen. Some appeared and were removed automatically – to coincide with the phases of the experience. Although this automation did frustrate some users, it also took control out of their hands and afforded an easier experience.

> *For me personally, if it was pre-fixed, that wouldn't worry me as much. I didn't want to touch too much of it to be honest, in case I lost things. Yeah, it might depend on how confident you are with the hardware, do you know what I mean?* [ID01 couple]

We cannot compare these findings with how users might respond to a hypothetical 'fully-responsive' experience –which would require more orchestration and decision-making on behalf of the user.

Some simple adaptations, such as the ability to switch features on and off, were discussed throughout the trials, and participants considered this simple enough to manipulate.

6.12.1 'Ease of use' aided by familiar structures and framework

The inclusion of familiar features, aids 'ease of use'. For example, a suggestion to present information in a structure from theatre literature; presenting content in a consistent default layout;

> *So the screen is going to be top left window most of the TV and then the text box down the side and then the scrolling script along the bottom.* [ID01 couple]

> *The content was not laid out in the same manner as a theatre programme, making it more difficult to find the biography of Hamlet, say. The actors' biographies, nor the creatives' were not presented in order of appearance, cast ranking or alphabetical order, but randomly. In other words it should match the credits as scrolled at the end.* [Online Survey]

(N.B. These issues are also covered in the Aesthetics and Layouts section)

6.12.2 Closely matched content should be on the same screen

The ease of attending to content across two screens was discussed. Participants were in agreement that distributing 'closely matched' content, (such as the live video stream and the scrolling script) across two screens, was not appropriate. While content that was not closely matched (or sync'd) made it easier for users to orchestrate their attention.

(N.B. This is reviewed in the Cognitive Load: attention/distraction section.)

6.13 Exploring

Some aspects of the Theatre at Home experience were automated. Users had no control of the appearance or removal of components such as the video window, the script and the video chat/text chat. However, they did have control of the features available in the component switcher, and when they appeared on the companion screen.

Ten (10) households discussed 'exploring the content' of the Theatre at Home trial in the post-trial interviews, such as how comfortable they felt exploring, when they explored, and when they felt they could not or should not explore.

Participants explored content throughout the experience, but usage levels coincided with the phases of the experience. During the performance participants tended to reference the synopsis, and occasionally actors' biographies, while the wider range of content was explored outside the performance phases.

6.13.1 Exploring content enhances the experience

The ability to explore content makes the experience appealing.

> *I kept taking the tablet off him, because I wanted to know who was who and what they had played in, when the actors really stood out, it was nice to check where they were and also on where we were on the script.* [ID05 Couple]

> *I think if it had been just a normal broadcast on television I think we're less likely to have watched it. But with the ability to interact and have a programme and have that sort of stuff at home I think that definitely would encourage us to do it more for sure.* [ID01 Couple]

Participants expressed disappointment when they could not explore content they had expected, such as the place-holder video features in the component switcher.

For the majority of users the information available within the experience was adequate, but sometimes it formed a jumping off point to explore beyond the experience.

> *… when there wasn't enough supplementary information I'd go on internet and look up some of the actors –you know when you recognise someone's face and your sure you've seen them in another play and your curious? So, I did read what was available on the tablet and then I did some more research on my own.* [ID602]

6.13.2 More control over selection and presentation to aid exploration

Understanding the layout of information on the screens aided exploration. So, adopting a familiar layout and structure of information can short-cut the process.

> *If you wanted to reference something you look down at your programme for that, and I think, in a similar way, that the tablet was good for that, wasn't it. If we wanted to re-read the synopsis or we wanted to re-read the notes on a particular scene, just to remind ourselves what was happening that was very similar to looking at a programme, so that worked really well for us.* [ID01 Couple]

All users expressed a requirement to have more control over the selection and presentation of content, to aid exploration.

6.14 Cognitive load (attention / distraction)

Attending to multiple content streams, especially across multiple screens increases the users cognitive load. The point at which cognitive load is exceeded varies from person to person, and depends on the types of content being presented and consumed.

Maintaining 'simplicity' in user interface and user interaction is a general rules of thumb, to reduce cognitive loading in an individual experience, but within a connected multi-user/multi-household experience there are other considerations to bear in mind too, such as an awareness of fellow participants and how one's activities may impact on their experience.

Responses in the post-trial online questionnaire, revealed aspects of cognitive loading. *Having media available across two screens* enhanced users' experience of the performance (6.35 on a scale of 0-9). Participants indicated that it *was easy to navigate and use the content across the different devices* (7.15 on scale 0-9)

Concerns and discussion about cognitive loading arose spontaneously with 10 households in the post-trial interviews, which was discussed in depth. Generally, while viewing the performance on the shared TV screen, attention to the companion screen reduced. If content on the shared screen could be followed by an audio channel only, participants could attend to their companion screen, if they wanted to.

6.14.1 Ability to remove features/content to ease cognitive load

Automating the presentation and removal of features also reduces cognitive overload, especially with those related to social media that are no longer in use, such as text chat bubbles on the shared TV screen.

The ability to manually switch features and content on and off was a popular spontaneous suggestion from all participants, and this would ease cognitive loading. This was linked to personal preferences. For example, two households found the scrolling script slightly distracting.

> *I found that [script] distracting. Because it is something else that attracts the eye while you are trying to focus on the portion of the screen where the performance is happening. I think it is a useful tool if you miss sometimes what somebody has said, then I think that as an option is great. I would like to be able to hide that and just have the screen dedicated to the performance itself with options to bring up text if needed, if you wanted, but not have it there as a default. [ID802]*
>
> *We were nodding off because of that [scrolling script on TV]. You're sitting there and you're concentrating so much on the screen there's this thing happening underneath that you are*

> *constantly… The fact that it would be nice, if you could, turn the subtitles off, if you wanted to. So we blocked the subtitles. We put something in front of the television so we couldn't see them. It was just this square black box with this white scrolling text. It is very in your face. I'm not a big fan of watching foreign films because of having to look at subtitles. [ID05 couple]*

6.14.2 Directing attention between screens, to new features and content.

As mentioned above, while viewing the performance on the shared TV screen, attention to the companion screen reduced.

Participants suggested that subtle notifications or the presentation of new content on the shared TV screen would direct their attention to the companion screen.

For example, the treatment of text chat was the source of much debate, especially in relation to minimizing the presence of text chat on the shared TV screen.

> *I think there were periods where something exciting was happening, I'd be engaged in the TV and not really paying attention [to the CS]. I guess on one hand that was quite good having it on the [TV] screen, because when it popped up to say Jasmine said something [in text chat] I might have missed it if I wasn't paying attention to the tablet. But I think it would have probably have been better to just have like a little notification pop out and then quickly pop away again [on the TV], rather than constantly have the thing [text chat] there.* [ID301]

> *I think it is right to have the complementary stuff on the tablet rather than, maybe have something pop up every now and again. "would you like to know more?, it's on your tablet now"* [ID1001]

6.14.3 Learning to direct attention

Some participants initially struggled with choice (and cognitive overload). However they quickly learned to deal with how and where to direct their attention.

> *Once we'd sort of familiarised ourselves with everything and could settle down we actually then zoned into the play and it worked really well. I think if we could do it again we'd definitely ask for more time at the beginning to familiarise ourselves before the play starts.* [ID01 couple]

If the experience contains features that suit and support the requirements of the user, then cognitive load is overcome. However, if components are unnecessary they become a distraction.

> *From my point of view, I found it a little bit distracting, from my own enjoyment of the play because every so often you'd see Colin pop up and write something, then Jeff would reply and so on.* [ID102]

When features are being shared they can become distracting to others, so negotiation was necessary about how to deal with that. Indeed, there was much debate about where features should be presented, on the shared TV screen or the individual companion screen, and how that affects the user's attention, and their cognitive load.

6.14.4 Positioning of features

Preferences emerged about the features participants expected to see on the shared TV screen, and features they expected on the companion screen.

Participants expected the video-window (the play), the script/subtitles, and notifications to be presented on the shared TV screen; and reference materials, such as the biographies, the synopsis and control features (e.g., text chat keyboard) to be presented on the companion screen.

> *So I think it is important that you are watching the TV as much as possible, and that most of the interaction is on the TV. Like you're in a theatre and you've got a programme. I you wanted to reference something you look down at your programme for that, and I think in a similar way that the tablet was good for that, wasn't it. If we wanted to re-read the synopsis or we wanted to re-read the notes on a particular scene, just to remind ourselves what was happening, that was very similar to looking at a programme, so that worked really well for us.* [ID01 couple]

However, many also requested the ability to adapt these rules-of-thumb, when they wanted to share something of interest, or reduce distraction.

6.14.5 Complex content and cognitive load

Two participants spoke about the use of the scrolling script to reinforce the dialogue, and how it maintained their attention, and eased cognitive load.

> *…so you kind of want to be watching the action and following the dialogue at the same time, during a really long soliloquy for example, so you'd gage a sense of what's going on and then checking the text at the same time, so having the option to switch on a subtitle function could be brilliant and then having the options for a scrolling script on the tablet would also be great.* [ID602]

6.14.6 Orchestration of attention varies with genre and format

Some genres incorporate orchestrating attention as part of their format –it can be threaded through the narrative –with cues and pauses crafted as part of the experience, allowing time to re-direct attention to different screens and features, and time for the user to re-orientate themselves.

> *I can think of other scenarios of other things to show which may work better than a Shakespeare play with that style of thing which would encourage, where you could encourage to comment next and video content and all the rest of it. And that is some sort of, either sport of some sort or an entertainment show like strictly or something like that which I can imagine can work a lot better than doing a Shakespeare play.* [ID701]

This is linked to the design of the phasing of the experience. Different formats/genres should have different phasing.

6.15 Sharing content (on the shared TV screens)

In the *Theatre at Home* experience, participants could not control where features and content were displayed.

6 households discussed their opinions on how and when features should be shared with their friends and family on the shared TV screen and they gave the following insights:

Features/content on the shared TV screen gave the experience a 'focus point'.

Participants enjoyed sharing features/content on the TV screen, and using the companion screens for personal reference.

> *Its like you're in a theatre and you've got a programme. If you wanted to reference something you look down at your programme for that, and I think in a similar way that the tablet was good for that, wasn't it. If we wanted to re-read the synopsis or we wanted to re-read the notes on a particular scene, just to remind ourselves what was happening. That was very similar to looking at a programme, so that worked really well for us.* [ID01 couples]

Participants preferred features/content, which was not of interest to everyone in the room, to be displayed on the companion screen/s, so their friend's experience was not interrupted.

There was some debate over which content/feature should be pushed by the experience provider, and which features/content should be pushed by the users.

If content is pushed to the shared screen (or other companion screens) it should be negotiated first.

6.16 Reflections on aesthetics and layout

Participants in the trial were asked to give feedback on the visual design and layout of the user interface, and interaction design.

(They were made aware of adaptations that had been made to the GUI design, as part of the prototyping and development process.)

Conversations about the appearance and layout of the *Theatre at Home* experience arose spontaneously during all of the post-trail interviews. 8 households had significant things to say beyond an initial agreement that the general 'look-n-feel' was appropriate.

The participants' responses fell into 3 areas:

- **Use of colour**: All participants could all read text based information. However, there were some requests about the use of colour to differentiate individual contributions, and how users would welcome the ability to adapt font size and colour.
- **Responsive and adaptive layout:** There was much discussion on the use of solid panel backgrounds, with a preference for presenting some text based information as overlays, and suggestions about options to remove of components, and options to define where information should be displayed (CS or shared screen). There were some individual preferences to consider, regarding the distraction/tolerance for the scrolling script and text chat, and a feature to allow users to choose how text is presented (i.e., scrolling or static, selecting the number of lines visible).
- **Interaction behaviours:** Participants often reflected and compared interface behaviours with those they were already familiar with, on their personal mobile devices (iPhones, Android devices, etc). For example, swipe motions to open and close the component switcher, the automatic closure of menu panels once a component had been selected, if a component was presented within a menu they participant expected it to be active, the ability to adjust and resize the position and size of the panels.

6.17 Proposed features: feedback like applause

The project team had originally planned for feedback features to be available in the Theatre at Home experience, so users could express their appreciation or bookmark their favourite scenes. Participants were asked if this would be a feature they would be interested in, and 7 households gave their feedback.

Figure 22 Design ideas for showing audience appreciation as a response graph overlaid on the video

6.17.1 'Live' feedback

All participants discussed the natural urge to applause when sharing an experience with a circle of friends, and the importance of a 'live' performance for feedback to feel relevant.

However, in the post-trial online questionnaire participants seemed indifferent to offering applause and feedback, had this experience been live (4.7 on a scale of 0-9).

> *Yeah, we were applauding at home. If you could tie messages to say congratulations or well done, or those sorts of things, like a response of twitter feedback to the theatre or to the actors. Certainly a closing message back to the theatre would be good.* [ID102]
>
> *The actor and the producer and the director, I think it is more for the benefit of them than me particularly.* [ID801]

An ability to adapt the depth and range of feedback was discussed by a few participants. For example, to see reactions from the people that you have chosen to share the experience with, or to see the more general response from everyone who is involved with a Theatre at Home experience.

6.17.2 Social media for feedback

Participants discussed the use of social media as a natural channel for feedback, and questioned the use of Theatre at Home to do the same thing. We found that using 3rd party apps on personal devices during the experience was often too distracting, and participants wanted the ability to communicate via a feature within the experience – so it is easier to find and orchestrate with other activities.

Participants also spoke about social media as a requirement, and expectation, for younger people, and how its inclusion within the experience would positively affect the cohesion of the group of users.

6.18 Proposed features: multiple camera angles

The project team had originally planned for multiple camera streams to be available in the Theatre in Home experience, so users could switch camera angles.

Figure 23 design ideas showing selection of different camera angles

Participants were asked if this would be a feature they would be interested in, as part of a future Theatre in the Home experience, all households responded positively, and 8 households had additional feedback.

> *I like the idea of the option of being able to view the play from different angles as well. That is a bonus you get over sitting in a theatre seat. You see it from where you are. You can't decide 'I wouldn't mind seeing it from another angle where that actor is.* [ID801]

> *A feature allowing you to select different camera angles is I feel a bonus compared to being in a theatre, as you are able to see the play from different points of view (which you can't do sitting in an auditorium).* [ID702]

Participants would appreciate multiple camera views. However they also wanted to retain the director's/editor's 'view' as a default, which could then be chosen manually alongside other alternative views.

6.19 Retaining the director's view/edit

Participants speculated on the long-term use of multiple-camera angles, and suggested that they would use the director's/editor's view/edit as a default in case they missed something important while watching an alternative stream.

Some participants went on to debate the usefulness of multiple-camera streams, such as directing a friend's attention to interesting things, and its use for other genres of experience, including sports events, which thought would be particularly appropriate.

6.19.1 Incorporating a 360-video stream

There was an aspirational project aim to include a live 360-video stream from the foyer between before and after the performance.

However, other development needs and some concerns about the permissions that might be required persuaded us to deprioritise this feature.

There have been some early conversations about how 360-video would be incorporated within the user experience. 360-video could appear on, and be controlled by, the companion device. The companion device could also be inserted into a headset. A copy of the 360-video stream would be on visible the shared screen, if that option is chosen by the user.

6.20 Rituals of the theatre

A hypothesis driving the Theatre at Home experience concerns the value that incorporating theatre rituals. The implementation of theatre rituals was realized through features such as socializing in the foyer, the 'live-ness' of the experience expressed through notifications (such as the bell) and the 'phasing' of the experience, and the inclusion of supporting materials found in theatre programmes (and websites).

8 of the households had interesting feedback regarding the rituals of theatre in the post-trial interviews.

6.20.1 Social

Socialising in the foyer and other public areas in the theatre was simulated through the use of a video chat feature, available outside performance times (pre and post production, and at the interval).

6.20.2 Live-ness - the (bar) bell and sense of anticipation

The bell alerting the audience that the performance is about to start/continue was adopted as part of the experience, and for participants it conveyed a sense of anticipation that accompanies a live performance.

> *The timer was useful and I liked it, you do get a sense of anticipation from it. When you are in your own home and you have the opportunity to come and go as you please, but there's is something about watching a shared experience that's particularly post an interval where you do just want to sit and wait for it to begin.* [ID602]

6.20.3 The programme: supplementary information

Information that an audience would expect to find in the theatre programme was available to participants.

The key strength of the programme is that the collection of information has been specifically curated around this instance of the play, it should not require the user to rely on other information sources (unless they have a very specific area of interest). However, the demo did not contain a full set of content, so the full benefits of this attribute were not visible to all participants.

One participant questioned what more could be done to enhance the programme feature, and reflected on a responsive programme features that could reveal information to the user over time.

6.20.4 Comparison to the theatre

Although the experience contained elements of the Theatre, which had a similar effect on participants as a visit to the real theatre, the overall effect was not the same, but a hybrid, a new experience.

6.21 Theatre at Home concept

The overall concept of Theatre at Home was discussed with participants.

All participants agree it was a good valuable unique concept.

Participants enjoyed the experience and compared the experience to watching (plays on) TV, and visits to the theatre.

In the online survey participants were asked about the similarity of the experience to going to the Theatre: *How much did you think it was like going to the theatre?* 3.7av 3med (9-0). Participants did not consider it the same as going to the theatre.

6.21.1 A unique hybrid

They concluded that the Theatre at Home experience offered a unique hybrid of the two activities; different from anything they had done before.

> *I enjoyed it. An unusual experience, nothing that I've done before, as an idea or a concept. It was fun. I've seen a lot of theatre and this was a good representation. I haven't been to any of those 'live from the theatre' events at the cinema, but I imagine it's quite comparable to that, but in your own home.* [ID602]

6.21.2 Similarities and differences

Participants picked-up on the similarities, and differences, between the Theatre at Home experience and going to the theatre.

Participants talked about the relaxed nature of the experience, there were no formalities about dress or seating; and they felt they were able to socialize more than they could in the theatre; yet it still retained and evoked feelings of being at the theatre (the anticipation, the shared experience).

> *I think the build-up part was more like the theatre, the fact that it is all in sync. The fact that you have the interval where you can chat to each other about what has happened was quite like the theatre. Just the fact of watching a play on TV rather than a drama made for TV obviously made it more like the theatre.* [ID301]

6.22 Benefits and value

Participants discussed types of audience that the Theatre at Home experience might benefit.

Benefits included: accessibility to theatre that might otherwise be physically or financially out of reach; as an aid to support an educational activity; those nervous and unfamiliar with theatre, no distraction from people you do not know (rustling sweet bags, being restless in their seats), multiple camera angles (compared to only one view in the theatre).

> *I suppose in the way that you watch a live concert on the telly and watching a concert there is a whole crowd atmosphere which you can't quite re-create when you are not there physically. On the other side, It gives you a chance to see a play that may have possibly sold out, gives the chance to see a live play that is too far away from where you live. So, the practical side of things is obviously there and you might not have a neighbour who is eating next to you, eating popcorn who is making a lot of noise as a distraction. So there is a plus and a minus of being there for real. You don't get the same sort of communication of feelings with the actors when you are not there in the flesh, but again, the bonus of being able to see the play from different angles that is a bonus compared to the theatre in the theatre.* [ID801]

Participants touched on aspects that were missed: the atmosphere of a theatre visit cannot be replicated, and you don't get the communication of feeling with the actors.

In the online survey participants were asked about how relatable the experience was: by responding to the statement: *I could relate to, or feel a bond with the performers*. On a scale of 0-9 participants were positive about the relatability of the experience, but not strongly giving the statement a score of 5.4av 5med (9-2).

> *O: But does it add to it or not? I don't think it does add. Nothing adds to what is on the stage. Actually, it [being there] probably detracts from it [the performance] because you're worried about the person's head that is bobbing around and can't see, so it takes away all of that kind of hassle as well. I would opt for it over the theatre.*
>
> *M: Whereas I wouldn't. I like the buzz of going to the theatre and experiencing it all, because I, unfortunately unlike you, you don't like going to the cinema, whereas I love it.*
>
> *O: Yeah, I'd much rather sit and watch it in my own home.* [ID05 couples]

6.23 Theatre at Home: social aspects and choice

The Theatre at Home experience offered a variety of features, which would appeal to the requirements of a varied audience. So, choices could be made depending on users mood, energy levels, etc.

> *I think having the chat is the USP of why I would chose to, if I wanted to see a play, I can chose between seeing it live and that is great because you know you have the feeling of being there and that is great and all that. Or choosing to stay at home because I then get the opportunity to chat with my friends. So I can see why I would choose one over the other in different circumstances.* [ID301]
>
> *Watching as a family, there were different features for different members of the family. So, the tablet would have the synopsis, and the faces buttons, and the text chat, and we each got something. We each chose bits of those which makes sitting down as a family group work better -were as a six year old would have left after the first act or scene if there wasn't something for her, with the information on the connected tablet and the text down the side. So, it made it more accessible to watch as a family group, whereas we would have left, all of us just watching it on our own, it gives us something to look forward, or switch off. If you had multiple views of the thing, suggesting information, then yes that would be good. We think we got more from that, than we did from the linking up with the group, but my daughter got a lot from wanting to chat with her friends. Their children were also plugged in.* [ID201]

6.23.1 Theatre at Home: live or VoD?

Again the debate about whether the Theatre at Home experience should have a 'pause' function arose. Most of these requests were related to time management, in order to carry out other activities (related or not): to take comfort breaks; read the synopsis; get food.

6.24 Suggestions for a future Theatre at Home experience

During the trial, participants made suggestions about what they'd like to see in the *Theatre in the Home* experience and other multi-screen experiences, and improvements they'd like to make.

- **Ability to manipulate the size of the component 'windows'.** All participants wanted the ability to manipulate the size of the component 'windows'. In particular they all stressed the importance of making the video window (in which the editors/directors view was displayed) as large as possible on the shared TV screen.

- **Ability to overlay components.** All participants wanted the ability to overlay components.
- **Ability to manipulate which components are available, and when they are selected.** All participants wanted the ability to control when components were available, and when they could be selected. On the other hand, some participants also recognised that initially they wouldn't have chosen to see the text chat/script components on the shared-screen, but later they were glad it was 'imposed-upon them'. The creators of such experience should know when components should be initiated –and when users should have the ability to remove them.
- **Ability to manipulate where components are presented or a semi-automated decision? (companion screen or shared screen)** But there are always some participants who'd rather have an automated system…Looking ahead, one participant reflected on how multiple users might use text chat, and how preference should be given to the companion screen as a default place for it.
- **Ability to control when components appear -** 'timing-out' components when they are not being used
- **Ability to request 'timed-out' notifications on the shared screens, to alert users to new content on their companion screen.**
  Some components should act as notifications –such as text chat contributions, perhaps appearing on the shared screen to alert user's attention to new text chat content on the companion screen.
  Feedback needs to be live
- **Ability to select from multiple camera streams, might benefit some genres more than others.** The ability to pick from multiple camera streams was wanted by all participants, but there was an understanding that ultimately the directors/editors view be the primary source of content. The benefits of multiple camera stream options were recognised for other genres.
- **Social aspects** of the experience might be suited to entertainment based genres rather than drama…..
- **Ability to differentiate between contributors**
- **Ability to adapt the size and volume of content**
- **Synchronised script and synopsis, or adding a timeline** – for current position and time management. All participants talked about mechanism they used to, or would like to use, to organise their time. Some used the synopsis and synchronised script to make a judgement on where they were in the play, while other talked about adding a timeline component.
- **A 'pause' function**
- **Components adaptable to individual user requirements (expert/novice) -** There was much discussion within the project team, and with participants during the trial, about the benefits of offering an experience that would appeal to all users, and abilities. Offering components as separate entities allow users to adapt the experience to their own requirements. …which could support families/groups with different ages and interests. ..which could support the genre/format of experience
- **More than just a theatre programme -** Two participants talked about providing something more/different to a theatre programme or experience you could get elsewhere… 'Pulling in stuff from the internet'? Embracing the affordance of an online experience…

6.25 Outstanding project aims, not covered in this trial

There were some project aims that were not achieved in this trial, due to development prioritizations. But these aims should be achieved in later trials.

For reference, here are project aims related to the user experience:

Accessibility features

- Access **synchronised audio description** for the production.

Feedback and ratings

- **A graphical display of how many other home viewers are watching at any moment** during the broadcast, to appreciate and enjoy being part of a simultaneous communal experience.
- **Rate on a scale of 1 to 10 my current assessment of the production**, to express responses and contribute to a communal assessment.
- **An aggregated total of the ratings of all those who are watching simultaneously**, so as to monitor and assess the responses of the audience and to measure users responses against the broader view.
- **Feedback to the producer about any and all aspects of the production**, and to know that feedback has been communicated, so that users have an involvement in the shared experience of the production.

'As Live'

- **Access an "as live" recording of the broadcast with the functionality** of many of the URs already specified. This will allow the user to recreate many of its elements at a time that is convenient.

On-boarding

- **Invite friends/family to share the experience** of watching the performance.
- **Receive invitations to watch with others**, and to accept or decline these.
- Use my credit card or PayPal to purchase access to the production and its enhanced features, so as to be able to participate in the experience.

7 Conclusions and plans

We have built a generic platform designed to support multi-screen experiences. We have used this platform to deploy and evaluate a thorough trial of a social synchronized multi-screen experience based on the viewing of an as-live theatre performance. We report conclusions related to the platform and to the particular experience of Watching Theatre At Home separately.

7.1 2-IMMERSE platform – conclusions and plans

The micro service based platform has provided the means to create a fully-fledged social inter-home multi-screen TV experience based around watching a theatre performance 'as-live'. The experience uses two devices, provides additional material and information, and allows people to communicate from different locations (video and chat based). Some of the lessons learned during this process, which have now spawned further activity within the project, include:

1. The need for user-friendly tools to help media professionals to craft the experience. This insight is derived from requirements gathered from the producers and authors based on the experience of creating the Theatre at Home experience "manually".
2. The need for the platform to support a number of viewing "modes". This requires enabling the user to have access to greater levels of control over the layout and also to support more dynamic layout alternatives. This should make the experience adaptable to the expectations of the viewer. Such personalization capabilities have been taken into account for the follow-up scenario.

The micro-service approach that we adopted was very well suited to the deployment of distributed media applications across multiple screens and multiple locations. We learned that we needed a very clear separation of concerns between micro services and the supporting infrastructure. Micro service developers should not need to worry about authentication, logging, data storage, message brokering, communications, Application Programme Interface (API) management, caching, load-balancing and service discovery. These are features that should be provided by the platform. They should allow the developer to concentrate on the business logic of their service. In this regard basing our deployment on the Mantl platform was a good decision. (Note that we presume alternative equivalent constellations of software capability under an equivalent service wrap would be good too and that migrating from Mantl to another platform would not be that problematic given the large commonality of software between similar services.)

7.1.1 Extensibility – conclusions and plans

We believe that the micro service based architecture that we have chosen makes the platform naturally extensible. However, more work is required to give developers the confidence to extend the platform.

To improve extensibility further we will consider creating client-side application architecture diagrams and further tutorials, documentation, and overviews to help developers understand and engage with the development of Distributed Media Applications (DMApps).

In addition we recognize the importance of structure in distributed applications and how constraints help DMApp developers harness the platform efficiently. This is something we will be taking forward as we develop our other DMApp use cases. An example is the provision of architectural support for executing application logic in the cloud.

7.1.2 Deployability – conclusions and plans

Regarding deployment, the platform is built using modern architectural and deployment paradigms using micro services isolated in containers orchestrated and managed in several layers. The platform has been hosted on both an OpenStack cloud service and on Amazon Web Service and the move from one cloud host to another was completed with few issues. Once hosted it's straightforward to deploy the 2-IMMERSE services using a container orchestration platform like marathon.

7.1.3 Scalability

Our initial implementation effort has not been focused on scalability, though we had scalability in mind when taking architectural and technology decisions. We have identified several issues that should be addressed to improve the scalability of the platform. These include:

- The way the layout service persists and accesses data
- The core layout calculation engine in the layout service could be partitioned into a separate micro-service that can be scaled independently of the remaining (context and DMApp management) functionality in the layout service.
- Implementing a way to run multiple websocket service instances that can be load-balanced
- Externalise timeline service state to enable scaling up service instances.
- Explore moving away from REST APIs for inter-service communication and instead use Websockets, or a message bus directly.

7.1.4 Robustness: product quality

Robustness has been the major challenge faced by the technical team for smooth running of the Theatre at Home trial. This is in part due to the complexities of a distributed system and the uncontrolled environments in which they run. The trial has been very useful in identifying the main problems with the robustness of our platform.

Given our experience with the Theatre at Home trial the technical team are investigating the following for the MotoGP trial:

- Changing the TV Emulator operating system to enable tighter control of the setup and on-boarding process;
- Enabling app support for both iOS and Android operating systems, and providing a range of different companion devices to trialists so that the platform's ability to adapt the experience can be properly tested;
- Investigating how to host compute-intensive operations, such as video compositing and multiple video decode into the cloud as a way of targeting devices and homes with poorer bandwidth and/or compute capability.

The quality of home networks had a significant impact on the robustness of the platform. We found that even homes that exceeded our minimum expected broadband upload and download transfer rates were prone to serious Wi-Fi issues. In many homes, the signal strength of the Wi-Fi was inadequate and packet loss or interference would cause client devices to occasionally lose a connection. Such connection loss issues are made all the more likely when you consider the duration of the trials, each of which lasts approximately four hours. One important consequence is that the current inter-home synchronization architecture can propagate issues from the home acting as master to the home(s) acting as slaves. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for the MotoGP trial:

- Modifying the on-boarding process so that it permits 4G connections and supports Wi-Fi access points that lock down visibility of other networked devices (typically done for public

access points). This may improve bandwidth to the home and provide an alternative to environments with poor domestic Wi-Fi;
- Changing the architecture so that the master timeline, state authority and synchronisation functions are moved to the cloud. This will improve robustness in the event that clients drop out whilst also allowing late joining to an experience. This will also facilitate the media seeking requirements of the MotoGP trial. These mechanisms can then be harnessed to recover an experience in the event of network connection problems.

During the trial, we observed a number of issues in the way that software on different devices utilized the available network bandwidth, affecting the quality and robustness of the experience. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for the MotoGP trial:

- Exploring MPEG-SAND and other coordinated bandwidth management strategies for multi-device ecosystems;
- Investigating the use of bandwidth budgets and constraints when computing DMApp component layout;
- Investigating how to amortize the cost of pre-emptive content caching or otherwise throttle the network bandwidth for such activities;
- Developing a better QA process, which includes finer control over the segregation of deployments, improved versioning and more regimented workflows;
- Introducing simulation of packet loss and connection dropout into our testing and QA process to harden the stability and robustness of the system;
- Simplifying messaging within the 2-IMMERSE platform to reduce the complexity of the client and the potential for inconsistent state between the micro services and clients;
- Introducing an API for subscribing/publishing system-wide error notifications and messages to help DMApp authors with better signposting.

Connection errors and partial connectivity were not reported in a way that enabled the user to understand the behaviour of the experience. Based on our experience from the Theatre at Home trial, the technical team are investigating the following for subsequent trials:

- Streamlining the on-boarding process for trial participants to reduce the need for project engineers to intervene with equipment setup. This will permit more trials to be conducted for the MotoGP, Football and Theatre in Schools service trials, whilst making it easier to run them simultaneously;
- Improving visibility of network issues within the user interface of our experiences so that participants are kept informed and can equate the behaviour of the experience to particular issues;
- Improving the assessment of the home network environment during the selection process for trial participants.

7.2 Theatre at Home experience evaluation

The results from the user evaluation of the theatre At Home Experience trial are rich and varied, and intertwined. However, they can be distilled into the following key points which we believe may well be generalizable beyond the particular Theatre At Home experience.

6. Theatre ritual was important to the participants (i.e., timing of features, notifications, interval, material available and layout –adopting the same order as cast list, and theatre programme-style layout).

7. The producer's view that the play should be on the shared TV screen and uncluttered was echoed by the participants (informing the balance of curation across the value chain).
8. Sharing the experience through video chat was a big hit with participants (as was texting, but the former was a bigger risk a priori and harder work to integrate).
9. Choice is important when it comes to which feature is where (i.e., shared TV screen, companion screen) and for how long. A desire for adaptable and responsive options, to reflect the users' preferences and requirements, arose spontaneously throughout the trial, but based on a core experience defined by producers as a default.
10. Some user experience insights for multi-screen layout preferences emerged (confirming earlier studies – attention, distraction, notification, peer to peer vs broadcast messaging on tablet vs TV):
    a. the companion was the place for referencing and controlling;
    b. the shared TV was for shared features of primary interest –mainly the play (video-window), notifications, and socializing during the intervals;
    c. the presence of other features such as the script and social media was negotiated.

    The findings will aid the orchestration of future multi-screen experiences.
11. Theatre at Home unique selling points - participants wanted features within the experience to offer something beyond what they could use/access otherwise –e.g., 3rd party social media, content archives (e.g., IMDB, Wikipedia). The availability of a synchronised script, and a 'curated' selection of content, and the ability to socialise while watching live theatre was unique.
12. Participants did not consider Theatre at Home the same as going to the theatre. Instead it offered something different (a hybrid), that they had not experienced before, and about which they were broadly positive. They saw great potential in the concept, not only for theatre but also for other genres and formats; and as a means to reach-out to underserved – and potentially new - audiences.

7.3 Conclusions in the context of the hypotheses, and areas of interest driving the project

A hypothesis driving the Theatre at Home project was the value of theatre ritual. By adopting features such as the 'live-ness' and anticipation of a theatre performance, the availability of supporting information and the social aspects, would all enhance the user experience, creating a concept beyond and stronger than just a 'live' video-stream from theatre to the home.

The rituals of theatre were realized through the features described earlier in this document, and evoked the following responses:

- Live-ness – timing/availability of features and notifications/the bell –evoked a sense of anticipation in participants that usually accompanies a live event. Notifications/timelines would help users manage their time.
- Phasing – a recognized framework defining the rhythm of the experience –aided participants understanding what to expect and their purpose.
- Social - the integration of video chat and text messaging for sharing was a key feature (as opposed to separate texting – i.e.WhatsApp which had high cognitive loading); the 'buzz' of a shared live experience took a different form from that felt in the theatre, but was still relevant.

- Supplementary information – offering an experience beyond a standard theatre programme was expected (a mix of media, access to content otherwise unavailable)

7.4 Object based production approach

An object based broadcasting approach allows choice, because OB broadcasting enables the experience creators to give curation/composition/layout choice across the value chain from producers, broadcasters, venue owners to audiences.

The responses in the trial indicate that there is an appetite for choice of layout in multi-screen environments amongst audiences. A recurring theme was the ability to adapt and manipulate the experience to suit the requirements/needs of the participants.

The ability to manipulate features of the experience means the experience creators have to make decisions about the framework holding the experience together and how individual objects, that form the building blocks of the experience, behave (i.e., the rules and the models). For example, decisions have to be made about who should decide what goes where? These decisions are layered:

4. Decisions about the design of the overall experience concept –defining the format, phasing, and essential elements of the experience.
5. Decisions about which features of the experience are predefined and automated (so users have no control over when and where they appear); and features which are adaptable and can be manipulated by users.
6. Decisions on the degree of adaptability of features, and guidelines/rules on how users can manipulate them. E.g., ability to switch features on/off, ability to change the position of features (device/screen, layout), adaptable to change the appearance of features (palette, font, responsive sizing, etc.), responsive personalization of features (novice/expert).

Annex A **Recruitment text**

The advert that was posted on the BT Intranet set inviting volunteers is pasted below.

Volunteers to Share Shakespeare?

BT Research are looking for volunteers to help in a social TV experiment as part of our ongoing investigations into ways in which we can evolve our TV services.

We are looking for volunteers in the Ipswich area to arrange with a friend to each spend a few hours at home watching a recording of the Royal Shakespeare Company's recent production of *Hamlet*, with the award-winning Paapa Essiedu in the leading role. We are still working on the technology but we will be able to help with the set up – you'll need to be comfortable using, and preferably own, both a TV and a smartphone and or a tablet.

Those completing the trial will be rewarded with vouchers for a Cinema of their choice as well as a chance to win 2 tickets see an RSC Theatre production in either London or Stratford upon Avon.

The trials are planned for early December. If you think you could some hours helping us out, please contact doug.williams@bt.com

Thank you

Annex B **Consent and pre-trial questionnaire**

All participants are asked to complete an online pre-trial consent form which invited the respondents to read the following information and to provide consent as required

- *"I understand that this research is being conducted by the 2-IMMERSE project consortium, and the conducted research is part of the European research project 2-IMMERSE.*
- *I/we understand that my/our participation in this research study is voluntary.*
- *I/we may choose not to participate and may withdraw my/our consent to participate at any time.*
- *I/we voluntarily agree to use the provided software/apps and hardware relating to the Theatre in the Home experience, to participate in a pre-study and post-study online survey, to discuss the research in a short informal interview.*
- *I/we understand that our participation in the study will be video and/or audio recorded, I give my consent for:*
    - *written notes to be taken throughout the experiment, and*
    - *audio and video recordings to be made during the chat sessions and the informal interview at the end.*
- *I/we agree to the 2-IMMERSE project team using the contributions and information*
- *I/we supply, and any video or audio recordings, for statistical/summary and research purposes only. The 2-IMMERSE project team will ensure that my/my child's personal details will not be associated with any contribution made in any recording.*
- *The 2-IMMERSE project team may make the results of this study publicly available, but no personal data relating to me/my child nor any video or audio material involving me/my child will be made publicly available.*
- *The 2-IMMERSE project team will not use my/our personal details for any purpose other than this study, nor will the 2-IMMERSE project team pass any personal details to any third party.*
- *I agree that, save as publicly announced by the 2-IMMERSE project team, any information relating to this study is confidential and that all information collected by the 2-IMMERSE project team concerning my/our participation in this study is confidential, and will be held securely in password protected files/folders in a secure location.*

I have read the description of the study and agree that I will participate on the terms set out above.

This survey will take about 10 minutes to complete. For the questions, unless instructed otherwise, please indicate your response by clicking on the scale where your response would lie given the criteria. You DO NOT have to click and drag your response for each question, simply click."

Once consent has been given participants are complete the pre-trial questionnaire.

Pre trial: https://www.surveymonkey.co.uk/r/D55R3DQ

- Please type in the participant number we gave you
- How often do you use video conferencing services such as Skype and FaceTime?

  Not at all / Very Often
- How often do you use social networking sites such as Facebook?

  Not at all / Very often
- How many of the following devices (do you own/are) in your household?
  - Tablets (1 2 3 4 5+)
  - Phones (1 2 3 4 5+)
  - Televisions (1 2 3 4 5+)
  - Laptops/Computers (1 2 3 4 5+)
- How often do you go to the theatre?
  - Never go
  - A little
  - Very Often
- How competent do you consider yourself to be with technology/devices?

  Not at all competent / Very Competent
- Would you consider yourself comfortable in doing the following things: (check all that apply)
  - Connecting a TV to a set-top box
  - Connecting a computer to internet
  - Connecting a phone to a wireless speaker
- Do you often watch television whilst using another device with a screen

  Not at all / Very Often

Annex C **Post trial questionnaire**

The first batch of questions are based on watching an event in a different place.

- How much did you enjoy the performance?
  - I did not enjoy it / I enjoyed it very much
- How much did you feel absorbed in the performance?
  - I was not absorbed / I was totally absorbed
- Did you feel an emotional response to the play?
  - Not at all / I felt a strong emotional response to the play
- How quick or slow did time seem to pass?
  - Time seemed to pass very Slowly / Time seemed to pass very quickly
- How easy did you find it to follow the plot?
  - Could not follow it / It was very easy to follow
- Based on the event, I would recommend this experience to other people
  - Would not recommend / I would definitely recommend
- How much do you think it was like going to the theatre?
  - Not at all like attending the Theatre / As good as attending the theatre
- After the play, I wanted to talk to people about what I'd seen
  - Not at all / Very much
- I could relate to, or feel a bond with the performers
  - I could not relate at all / I felt a strong bond with the performers
- Are you more likely to go to the theatre after seeing this?
  - Yes / No
- Are you more likely to go to a cinema screening of theatre?
  - Yes / No
- Are you more likely to watch future broadcasts of theatre at home?
  - Yes / No

The second set of questions are 'Feature Feedback'

"Please indicate by selecting from the list below, which features you used during the experience, and of these features you used, could you please indicate how easy they were to use, and how useful they were on impacting on your experience."

Feature:

- Synopsis of the play
- Scrolling script
- Alternative camera view
- Video chat
- Text messaging
- Background material (supporting)
- Notifications (timing and point in play)

Of the features you used, how easy to use were they?

- Synopsis of the play
  - Impossible to use / Easy to use
- Scrolling script
  - Impossible to use / Easy to use
- Alternative Camera View

    - Impossible to use / Easy to use
- Video Chat
    - Impossible to use / Easy to use
- Text Messaging
    - Impossible to use / Easy to use
- Background Material (supporting)
    - Impossible to use / Easy to use
- Notifications (timing and point in play)
    - Impossible to use / Easy to use

Of the features you used, how useful were they?

- Synopsis of Play
    - Not at all useful / Indispensable
- Scrolling Script
    - Not at all useful / Indispensable
- Alternative camera views
    - Not at all useful / Indispensable
- Video Chat
    - Not at all useful / Indispensable
- Text Messaging
    - Not at all useful / Indispensable
- Background content available
    - Not at all useful / Indispensable
- Notifications (Play starting, timing and point in play)
    - Not at all useful / Indispensable

Other (please specify)

Were there any features **you** wanted to use, but gave up on, and if so, why?

- No, I didn't give up on any
- They didn't work correctly
- Were too complicated
- Interfered with watching the play
- I never use things like this
- I didn't understand the instructions

Other (please specify)

The next set of questions are about 'Adopting Rituals of Theatre'

"We tried to make it feel like you are at the theatre, so we used some of the things you'd find there. For example, we only allowed the video chat at the beginning, the interval and at the end, but you could have been talking at any during the play, or doing other things, so..."

- Did you find it useful for the video chat to automatically shut down during the performance?
  - No really annoying / Yes Very useful
- Do you think phasing the availability of the video chat made you more absorbed in the performance?
  - No it did not / I felt more absorbed
- If the performance was broadcast live, do you think you would enjoy it more if you could feedback your responses to the actors? (e.g. applaud/like/laugh)
  - No not at all / Yes very much

The next set of questions were about 'Multiscreens'

- How much did having content available on more than one screen enhance your experience?
  - Not at all / Very much
- How easy was it to make use of content presented across your TV/Phone/Tablet
  - Not very easy / Very easy

The next two questions explored the value of sharing the experience

- Would you prefer the video chat function to be available all the time?
  - Yes / No
- How much was the experience enhanced by watching the performance with friends and family from another home?
  - Not at all / Greatly enhanced my enjoyment of the experience

These questions explore users' opinions about which screens should be used to display different aspects of the experience.

- Would you prefer the video chat to be available on the TV (at the side of the play) or separate on a screen (phone or tablet)?
  - TV
  - Tablet
  - Phone
- Would you like to be able to decide what content gets where? (E.g. what goes on the TV, what goes on the phone or the tablet).
  - Yes / No

Annex D **Post experience semi structured interview**

Ease of Use

- How did you like the layout of the interface on the second screen?
- Were all the components on the screen useful and easy to use?
- Would you like to be able to change positioning of where things are located on the wireframe/UI?

Look and Feel

- Did you like the appearance of the interface?
- Does this look like other apps that you use?

Multiscreen

- Do you have any regular TV protocols, and if so did you follow them in this scenario?
- How did you find it having another screen whilst watching the television?
- Was it practical to have to follow two screen inputs at the same time?
- Did you find yourself distracted with content happening on the second screen?
- Where there any occasions where you attended to the second screen to either if check content had appeared, say something etc.
- Did you forget there was a second screen available at any point during the
- performance?

Engagement

- Which features of this experience contributed most to the development of an experience that is positive differentiated over just watching television with a twitter feed
- What features of the experience enhanced this experience?
- What features do you feel detracted from the experience compared to just watching TV, if any?

Rituals

- Did you notice any similarity from this experience to a visit to the theatre?
- What did you think about the bell?
- Did you notice this occur to call for the end of the interval?
- Was this a useful prompt in your opinion (if noticed)/would it have been more useful if this signal were made clearer?

Applause

- How did you feel at the end of the performance?
- Did you find yourself voicing an opinion about the performance?
- At the end of the performance did you feel an impulse to clap?
- Would you like to have been able to make your response to the performance be more widely recognised?
- In what was would you like it to be shared?

Phasing

- Did you notice the video chat was only available at certain times of the production?
- Were there instances where you went to use a feature (such as video chat) and subsequently realised it was not available?
- Did you like the fact that the video chat was automatically phased in and out?
- Was this useful?
- Would you have preferred to decide this yourself?
- Would you rather have all the components available all the time?

Mediation and Curation of Components and Content

- What did you think of the positioning of the different content available?
- Do you have any observations of the overall content that you were exposed to, such as availability and appearance of images and sounds?
- Would you have liked to decide the position of the content at your disposal?

Attention and automation

- Did you find your attention was being pulled to different devices at any point?
- Did you feel in control of where you were looking and what content you were engaging with?

Alt camera content streams

- Did you use the alternative camera views available?
- Did this have a positive effect on your experience?
- Have you ever watched anything before from multiple available viewpoints?
- Was there any other content, apart from the alternative camera angles, which you would have liked to have at your disposal? If so, what would you have liked, and how would you have used/interacted with this feature?

Social

- What is your opinion on the video chat feature?
- What is your normal method of interaction with other people, do you normally text, video message, to phone call?
- Would you have preferred to be able to choose how you interacted with the other house? Would you have preferred "alternative communication method" to be available to be social?
- Would you like different text functionality available at different points in the performance?

Social Rules

- Do you think the video chat made it feel more social?
- Did the experience feel more or less social that watching television?