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D3.1: FMI Vision, Use Cases and Scenarios

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This deliverable presents the developing vision of FLAME within the Future Media Internet (FMI). The FLAME FMI vision is described through use cases and scenarios for novel and high value media services to consumers and their combination with innovative infrastructure and network services. The vision addresses the changing nature of participation in content production workflows as well as demands for increasingly personalised, interactive, mobile and localised experiences. This deliverable describes scenarios and media service use cases, which leverage the content delivery optimizations provided by FLAME.

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EXECUTIVE SUMMARY

FLAME is challenged to demonstrate convincing evidence that its platform can realise compelling user experiences and meet project value propositions through the innovative delivery of new digital media services. To support this challenge, we introduce the FLAME Future Media Internet (FMI) vision through scenarios and use cases providing novel and high value media services to consumers. The FLAME project is motivated by the concept of optimising media content delivery through direct interaction with underlying network management functions. This deliverable identifies some initial FLAME scenarios and media service use cases, which leverage the content delivery optimisations provided by FLAME.

The FMI vision provides the scope, which is used to select target vertical markets (e.g. TV, radio and gaming) for FLAME. The FLAME consortium has selected four initial scenarios, which represent broadcast, gaming and transmedia vertical markets. Each scenario is part of the FMI Vision and is characterised by demands required to enable specific experiences. Key characteristics in the experiences of the experiment participants considered by FLAME are Personalisation, Interaction, Mobility and Localisation (or PIML). The four scenarios demonstrate the potential of FLAME and are representative of the opportunities and challenges offered by various vertical sectors dependent on effective production and distribution of media content, such as creative industries and beyond in education, healthcare and smart city management.

The scenarios take the form of user stories, describing how users interact with media services deployed on the FLAME platform. The use cases extracted from these scenarios and described in this deliverable are media service and application use cases. They document functionalities required by the scenarios, primarily with respect to the end users. Some of the media service use cases will impose requirements for the platform not possible to achieve using today's infrastructure. The analysis of the media service use cases, the determination of the platform use cases and capabilities required to support the experiments and trials will be documented in the upcoming deliverable D3.3 "FLAME Architecture and Infrastructure Specification". Experiments developed from the scenarios described here will be conducted on the first release of the FLAME platform. Based on the experience of these first experiments and trials, this document will be updated to feed into the second iteration of the architecture and subsequent software development and experimentation.

The scenarios are chosen and designed to capitalize on emerging trends in software defined infrastructure, mobile edge computing, flexible service provisioning and routing that will form an integral part of FLAME capabilities. The FLAME FMI vision is also described from this more technical perspective of city infrastructure and platform development. Technical differences are enumerated to identify specific capabilities of the FLAME platform compared to a conventional network and what benefits these differences bring. Given that the vision spans from infrastructure, through the platform to media services and end users, it also forms a key input to the project's stakeholder engagement strategy and further work examining how FLAME fits into the urban landscape will be undertaken.

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ABBREVIATIONS

AR	Augmented Reality
CCTV	Closed-circuit television
FLAME	Facility for Large-scale Adaptive Media Experimentation
FLIPS	Flexible IP-based Services
FMI	Future Media Internet
HQ	High Quality
ICN	Information Centric Networking
MWC	Mobile World Congress
OTT	Over-The-Top
PIML	Personalisation, Interactivity, Mobility, Localisation workflow characterization
QoS	Quality of Service
QoE	Quality of Experience
SDN	Software Defined Networking
VoD	Video on Demand
VSN	Virtualized Service Networks
WP	Work Package

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1 INTRODUCTION

This deliverable presents the developing vision of FLAME within the Future Media Internet (FMI). The FLAME FMI vision is described through use cases and scenarios bringing novel and high value media services to consumers and is examined here from both a top-down and bottom-up approach. The vision addresses the changing nature of participation in content production workflows as well as demands for increasingly personalised, interactive, mobile and localised experiences.

The FLAME project is motivated by the concept of optimising media content delivery through direct interaction with underlying network management functions. The current Over-The-Top content (OTT) distribution approach results in non-optimal resource allocations causing either overprovisioning costs for network operators or poor Quality of Experience for consumers. In a recent publication, Boniface et al. [1] motivate the FLAME approach to content delivery that addresses emerging media demand trends through cross-layer integration between Virtualized Service Networks (VSNs) and Information Centric Networking (ICN). The aim of this deliverable is to identify FLAME scenarios and media service use cases, which leverage the content delivery optimizations provided by FLAME.

1.1 FLAME INFORMATION MODEL

The information model represented in Figure 1 illustrates a scenario-centric relationship between the FMI vision, use cases and evaluation of scenarios through experiment trials. The following text elaborates on those relationships.

FMI Vision. The FMI vision provides the scope, which is used to select target vertical markets (e.g. TV, radio and gaming) for FLAME. As mentioned above, FLAME aims to optimise media content delivery by enabling deep interactions between media service providers and an underlying network which uses software defined networking and information centric networking techniques to provide features not seen in today's infrastructure.

Scenarios. The scenarios take the form of user stories, describing how users interact with media services deployed on the FLAME platform. The scenarios are characterized by demands required to enable specific experiences. Key characteristics in the experiences of the experiment participants considered by FLAME are Personalisation, Interaction, Mobility and Localisation (or 'PIML', see below). Other demands, such as scalability or security, additionally contribute to the characterization of the scenarios. The scenarios documented here are not commitments to realise the ideas; not everything here will be implemented and additional features will be added: they are indications of the types of applications that deliver value to the vertical markets and which FLAME seeks to support.

Use Cases. The use cases described here are media service and application use cases. They document functionalities required by the scenarios, primarily with respect to the end users. Some of the media service use cases (e.g. "Alice should be able to swipe right in the app to find her preferences") may have little to no bearing on the platform whereas others will impose requirements for the platform not possible to easily achieve using today's infrastructure (e.g. "When Alice requests a video it will be transcoded to be suitable for her device and will start play-back within 10ms"). The work of analysing these use cases will follow this document.

Experiments and Trials. The scenarios are tested through experiments and trials. The performance of the FLAME platform as well as the value to the vertical markets and end users will be investigated.

Experiment Methodology. Experiments and trials need to be designed and conducted in a methodical

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manner in order to make them as useful as possible and protect the interests of the end users.

Ethics Requirements. To provide personalisation, interactivity, mobility and localisation to the end users in an optimal fashion, there must be a trade-off between these desirable characteristics and the end users' privacy. The methodology must be regulated by ethics requirements on privacy, inclusion and risk.

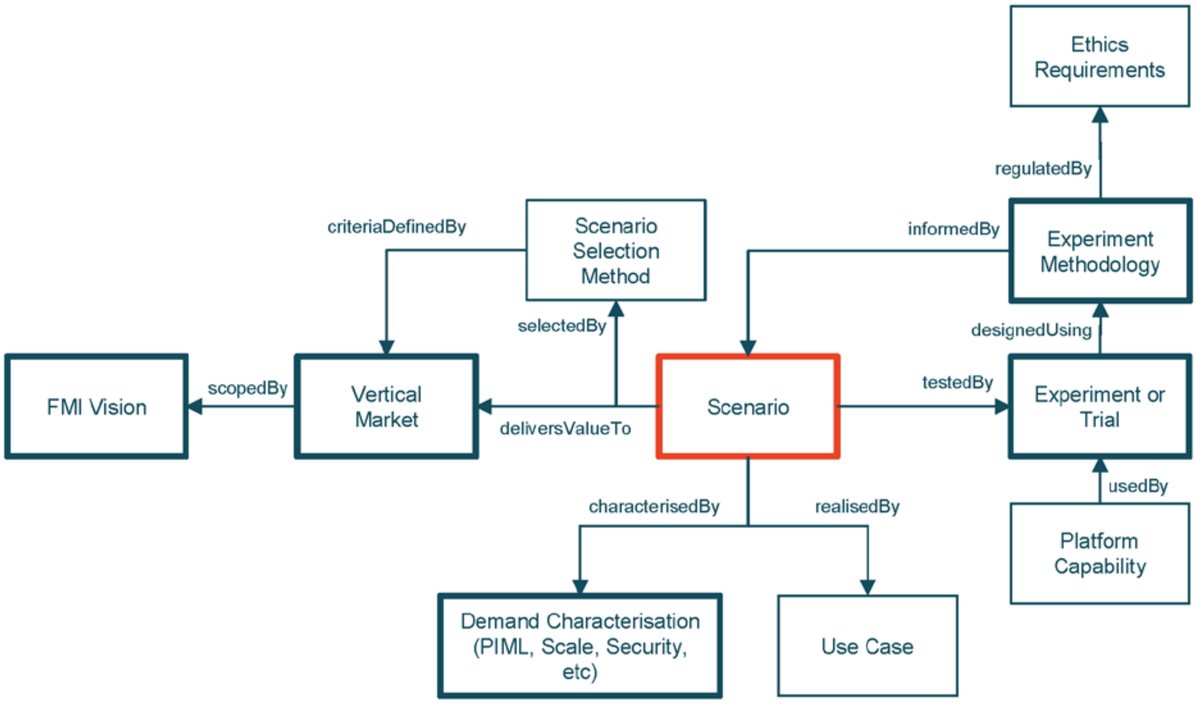

Figure 1: Information Model representing the relationship between FMI Vision, Scenarios and Use Cases.

PIML. *Personalisation*, *interactivity*, *mobility* and *localisation* (PIML) are characteristics that provide a quality of experience (QoE) orientated focus for the design and realisation of digital media services running on the FLAME platform. The quality of these services, enabled by FLAME platform capabilities and reflected in PIML, encapsulate a users' demand for digital content and services that are tailored to their specific preferences and usage context; their expectations that it will ready for them right where and when they need it; and that the context is highly relevant to their changing location as they move around the city. Meeting these demands is complex and has a number of associated costs to stakeholders invested in providing this service (these include content, platform and infrastructure providers). The concept of PIML and its role in understanding the value of the FLAME platform itself is discussed in detail in the D3.2 "Experimental Methodology for Urban-Scale Media Trials v1" deliverable.

1.2 RELATION TO OTHER FLAME ACTIVITIES

The experiment methodology, to be found in FLAME deliverable D3.2 "Experimental Methodology for Urban-Scale Media Trials v1", has been informed by and developed in parallel with this document. The scenarios described here represent a snapshot of partners' current thinking and will be further developed, refined and realised in FLAME through experiments and trials using media services and applications deployed on the FLAME platform and regulated by the ethics requirements considered and documented in an internal document. The demands on the system from the scenarios will be used

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to identify and define the requirements and use cases for the FLAME platform architecture. This deliverable focuses on describing media service use cases to guide the platform development. The next step is to develop the scenarios further to more closely align them with the platform capabilities. The subsequent analysis of the media service use cases, the determination of the platform use cases and capabilities required to support the experiments and trials will be documented later on in FLAME deliverable D3.3 "FLAME Platform Architecture and Infrastructure Specification v1".

Following the FLAME architecture specification, technologies will be chosen and developed, the platform deployed and experiments and trials conducted. Based on the experience of these first experiments and trials, the methodology and this document will both be updated and feed into an updated architecture and subsequent software development and experimentation. Another 20 experiments will be funded through open calls, each one bringing new scenarios and use cases. A high-level overview of this process can be seen in Figure 2.

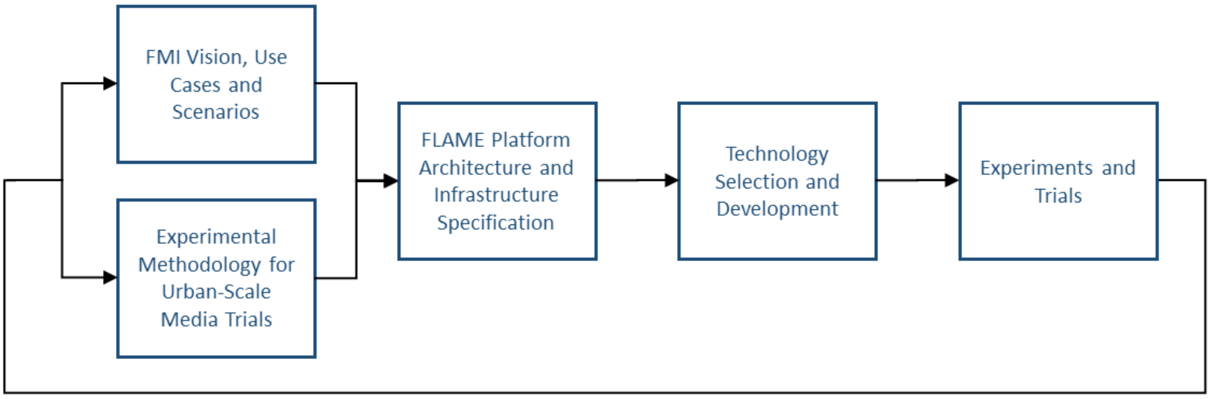

Figure 2: Overview of related FLAME activities.

1.3 OUTLINE

The FLAME consortium has selected four initial scenarios, which are represented by broadcast, gaming or transmedia vertical markets. The following four sections describe each of the scenarios:

- Section 2 – Scenario: Participatory Media for Interactive Radio Communities
- Section 3 – Scenario: Personalized Media Mobility in Urban Environments
- Section 4 – Scenario: Collaborative Interactive Transmedia Narratives
- Section 5 – Scenario: Augmented Reality Location-based Gaming

Each scenario is described in relation to the FMI Vision and includes a PIML-oriented characterization of stakeholders and relation to use case development defining the FLAME platform architecture. The four scenarios demonstrate the potential of FLAME and are representative of the opportunities and challenges offered by various vertical sectors dependent on effective production and distribution of media content, such as creative industries and beyond in education, healthcare and smart city management.

For each scenario, the stakeholders and value proposition is presented, plus a description of how FLAME addresses the demands for increasingly personalised, interactive, mobile and localised media

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services. Associated media service use cases are also listed in the respective scenario Subsection x.7 “Media Service Requirements”. The listed use cases are also cross-referenced in each scenario description using the format (**u.X**) to denote a reference to a use case. The aim is to produce a collection of media service use cases to provide requirements for FLAME platform use cases, which will be documented in a future deliverable describing the FLAME architecture and platform functionalities. As already described, the media service use cases of most relevance to the platform architecture will be those requiring functionalities that cannot be achieved with a purely OTT solution (i.e. where the media service has no interaction with the underlying network).

Section 6 “City Infrastructure” and Section 7 “Platform” describe how the FMI vision, scenario and use cases influence the FLAME architecture. The scenarios are designed to capitalize on emerging trends in software defined infrastructure, mobile edge computing, flexible service provisioning and routing that will form an integral part of FLAME capabilities.

Section 8 describes the next steps to evolve the FMI vision, including a review process composed of key industry leaders. The next steps aim to achieve the following expected outcome: a vision for the FMI including use cases and scenarios in key vertical areas exploiting the expected benefits of the FLAME platform and providing drivers for experimental methodology, platform architecture and experimentation activities. Section 9 concludes the deliverable.

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2 SCENARIO: PARTICIPATORY MEDIA FOR INTERACTIVE RADIO COMMUNITIES

Going to an event, such as a festival, entails so much more than attending a performance and watching a report on television afterwards. In any case, it could be so much more. From the perspective of both the organizer and the visitor, it requires some planning and effort. For instance, making sure that all practical information is clear, that there is a form of crowd control, that you know where to meet your friends and that you do not miss out on anything. In addition, the media should also be able to easily have access to the stream of knowledge and updates if they want to engage the audience in their news.

A smart city can accommodate these needs by connecting cloud-based applications to its platform that coordinates all efforts and allows for a more convenient way of organizing content. The infrastructure of a smart city guarantees a reliable network that fits the requirements of considerate bandwidth, real time streaming and detailed geo-location.

There are two different connected applications: one for the end user and one for the professional organization (event and/or media). As such, content can be freely sent in by attendees and filtered by the organization. The engagement between the two parties is key. The application to be built in this scenario is referred to as the **'Spotlight'** app.

The main goal of the scenario is to achieve the next step in interactivity: targeting specific communities based on user profiles, preferences, location, etc. via other ways than linear media. Media partners want ways to find, leverage and form communities using a variety of sensors (both from the users' devices and the environment) to initiate and steer this interaction.

2.1 KEY STAKEHOLDERS

The key stakeholders are described in Table 1.

Table 1: Key stakeholders for the scenario on Participatory Media for Interactive Radio Communities.

Stakeholders	Main Role
Event organiser	Organizing an event, testing Spotlight app. as professional user
Media partner	Covering an event as media partner, testing Spotlight app. as professional user
Event visitor	Visiting an event, testing Spotlight app. as end user
Infrastructure provider	Provide FLAME-enabled infrastructure for experimentation
Platform provider	Provide FLAME-enabled platform for experimentation
Media service provider	Provide FLAME-enabled media service for experimentation, develop the Spotlight app and its corresponding backend systems.

The media service may also be provided by the Media partner. This is often the case with big media companies like public broadcasters or brands from media groups.

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2.2 VALUE PROPOSITION

The scenario presented in this section includes value propositions for different stakeholders in the FLAME ecosystem. The stakeholders included in this scenario are an event organizer, a media partner covering the event, visitors of the event, the smart city infrastructure provider, a FLAME platform provider and finally media service providers (see Table 1). Whereas the Event organiser, Media partner and the Event visitor are users of the Spotlight app on top of the Flame network, the Infrastructure, Platform and Media service providers are the key stakeholders maintaining the Flame network operational.

The following paragraphs contain a list of values the envisioned scenario brings to each of the stakeholders in the ecosystem. There are three stakeholders which will use the platform and services (event organizer, media partner and end user), and three stakeholders that provide the necessary platform and services (infrastructure provider, platform provider and media service provider).

Event organiser (professional user):

- Efficiently collect and communicate all practical and urgent information, with the benefit of:
  - Coordinating information
  - Crowd control
  - Crisis management
- Engage with the community via chat, with the benefit of:
  - Informing, communicating and interacting with attendees for diverse purposes (warning, entertaining, evaluating)
  - Segmenting and targeting specific audiences
- Manage (crowdsourced) content via one tool, with the benefit of:
  - Getting real-time updates (about pressing matters)
- Making media with the communities

Media partner (professional user):

- Manage crowdsourced content, with the benefit of
  - Efficiently producing and combining live professional footage with crowdsourced materials
  - Capturing the atmosphere of the event and creating an immersive experience
- Community engagement via chat, with the benefit of:
  - Having access to the stream of knowledge and news updates
  - Interact with the audience by means of polls or other gaming features
- Save bandwidth, with the benefit of:
  - Efficiently organizing and storing content

Event visitor (end user):

- Co-create by uploading content (videos, pictures, news)
- Interact with community (find friends, join games, make arrangements for transport)
- Receive practical and urgent updates from the organization
- Have access to crowdsourced and professional content, with the benefit of:
  - Not missing out on other (simultaneous) performances
  - Making decisions for attending performances, based on the atmosphere of the different locations
    - Cheaper and more efficient way of contributing content via the WIFI-network

Infrastructure provider:

- Creating infrastructure for supporting real-time accurate media scenarios
- Maintenance of infrastructure in city context

Platform provider:

- Link infrastructure and media platforms built by media service provider for professional users applications
- Maintenance and performance

Media service provider:

- Providing all media services for the professional users: automation, analysis of content, smart caching, etc.

2.3 SCENARIO GOALS

Covering and creating stories of live city events, such as music festivals or sports events, has proven to be a challenging task for media companies. The events are usually scattered across a wide area making it difficult to place professional reporters and equipment everywhere as this would be too costly. However, the widespread use of mobile devices, the rise of social media communities and the increased availability of mobile bandwidth provide media companies with excellent opportunities to enable better storytelling around those live events: media companies (and especially radio stations) are increasingly active on social media and have been building those social communities for several years now.

The overall goal of the scenario is to exploit the opportunities listed above for collaborative media creation of a media company with its community of end users. The challenge is to engage and interact with audiences, stimulating them to contribute media related to a large scale live event (e.g. friends they attend the event with, fans of a certain band, people living in the same district, etc.). The goal is to learn how the available smart city infrastructure and FLAME platform capabilities can help to make this possible in a cost-effective and easily manageable way. The FLAME network with the proximity of network hubs providing a 'full mesh' platform can provide fast and accurate data exchange (content and metadata) for cutting edge real-time applications with more precise geolocation and streaming high end video (4K and up).

2.4 POTENTIAL EVENTS

As the experimentation initially will take place in Bristol and/or Barcelona, we have been looking for suitable events to which a FLAME experiment can be hooked. Numerous events are taking place in both cities throughout the year. In the subsections below, we have created a short list of potential events, which was created by considering how the following parameters have been taken into account to fit the user scenario:

- **Location** within the infrastructure of the smart city network and challenging the geo location features of the intended Spotlight application with venues spread out over the city.
- **Size of the audience** and **size of the event**. The event needs to be large enough to allow for a considerable amount of content and should be wide-spread enough to require geo-located

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tagging and interaction. Further, at least one thousand people should attend the event, making it large enough for the envisioned experiments.
- **Theme of the event**: the event should include concepts which are interesting enough for storytelling (such as stage performances, art, sport, etc.), allowing for engaging visual content.

In the following two subsections, we have listed several events in Bristol and Barcelona that have been validated against the criteria listed above.

2.4.1 Events in Bristol

Love saves the Day Festival. This two-day festival is held at the Eastville Park in Bristol in May. It started as an one-day event in 2012 and is an event for people of all ages. The aim of the festival is to combine the best of Bristol's thriving underground with pioneering artists from across the globe. The performances are held in tented structures. The festival is on the constant lookout for volunteers and the Spotlight app would definitely help coordinate and report the event.

Upfest brings Europe's largest live street art festival back to the streets of South Bristol with hundreds of artists entertaining the crowds. It is held for three days in July and takes place across Bedminster & Southville, which is situated in south Bristol (about a 15 minute walk from the city centre). Upfest takes place across more than thirty venues and locations centred around the 1.3km stretch of North Street.

Bristol Harbour Festival is one of the UK's largest public festivals and wants to showcase its rich musical and performance roots. It takes place in July for two days and offers plenty of opportunities for community engagement.

Brisfest is a community festival in July that focuses on the sound and talent of the South West region. It aims to support and promote local music, art and culture. The event is spread out over 15 different venues. Apart from the performances during the evening, there is also a daytime hub of activity around the Station and Island with outdoor stages, walkabouts and market stalls.

Let's Rock Bristol! is a retro event held for three day in June at the Ashton Court Estate. The family-friendly festival is held since 2009 and aims to bring the best of the 80's and 90's. Some of the event partners are Absolute Radio 80s and BBC Radio Bristol.

2.4.2 Events in Barcelona

Ús Barcelona festival is a festival to promote urban art. Two days of celebrating the city through street art, performances, markets and a conference. Local artists together with international guests explore the spatial environment of a city.

Parc del Centre del Poblenou, is a park in the neighbourhood **Poblenou**, once the epicentre of Barcelona's thriving textile industry. In the last few decades, though, it has left behind the austerity of large 19th-century brick mills to become a modern part of the city, bristling with youth and offering plenty of services and entertainment. During almost all year long different happenings are organised in this park.

2.5 NARRATIVE OF SCENARIO

In the following paragraphs, an example user scenario is described, based on the Bristol Street Art Festival, which is an event spread out in the city centre of smart-city Bristol. In this scenario, the following features are accounted for:

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End user. Co-create by uploading content (videos, pictures or text messages), interact with community (find friends, join games, make arrangements for transport), receive practical updates.

Professional user. Push messaging and community engagement via chat, crowdsourced content management, live production, crowd control, targeted communication.

2.5.1 End user protagonists

William Princeman (19 years old) lives at his parent's house in Bristol and studies "art, design and photography" at the Bristol university. He likes to take pictures of his everyday life. Instagram is his best friend.

George Crown (20 years old) lives in a student house with 3 friends, studies law, and is the typical student who regularly has a drink too many...

Harry Castley (19 years old) studies linguistics, lives in a dorm and enjoys Shakespearean literature. His girlfriend convinced him to take a dance course this year.

2.5.2 Professional users

The event organization:

Charles Knighty (38 years old) is the creator and chief editor of the Bristol Street Art Festival. He has a wife, 2 children and lives in the suburbs of Bristol.

The local media organization:

Diana Winters (27 years old) is a popular local radio host, has a boyfriend and plays tennis every weekend.

Camilla Royalting (29 years old) is a documentary maker and live reporter. She is single and has a cat. She also volunteers at a local charity organization.

Eduard Nobleman (34 years old) is an editor at the local radio station, has a boyfriend, cooks in his spare time, enjoys watching silent movies and has a travel blog.

2.5.3 Before the Event

Street Art Festival Editorial Office

Charles is chief editor of a small team at the Bristol Street Art Festival. He is in charge of the interactive application at the festival and the digital signage that is spread out over the different festival locations. The editorial office has different tasks:

- To share both the professional and crowdsourced content via the on-site digital signage and the Spotlight app.
- To manage user interaction (chat, chatbots etc.), interact with the attendees and answer the questions that the chatbot cannot resolve.
- To execute the predefined script that lines up the different interaction stories of that day (e.g. interactive poll, festival flash mob, surprise acts, giveaways, etc.)

As soon as visitors start to pour in, Charles and his team of editors log in to the professional Spotlight app, which provides an overview of the incoming data, real-time stream of video, pictures and

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messages **(p1.1[1])**. The visitors of the Music Festival willingly respond to the call of the media partner to share their festival experiences with the Spotlight app.

Media partner Radio Bristol

Diana is the radio host of a popular local radio show on Radio Bristol. With the Street Art festival in town, it is the busiest period of the year for her and her team. They plan on doing a live coverage of the festival from a studio on-site and video-stream everything live on their online platform. For this, they make use of the city's excellent infrastructure in order to manage the video production and distribution.

Diana has two editors, Eduard and Camilla, who will be live reporting from the different festival venues. The team also has access to the Spotlight professional app. They can use the user-generated content in their show and use the chat to interact with the visitors. This conversation will happen in name of the radio station or show, so that the visitors know who's talking to them, like in a standard messenger application.

William, a visitor

William is a young student at the Bristol School of Art. Before the event, he signs into the Spotlight end user app to schedule his evening by selecting the different performing acts he is interested in and by buying the necessary tickets. A list of all his chosen activities according to time and location is visible in the app and push messages will alert him on time via the chat **(u1.1)**.

Moreover, William's parents are away for the weekend and he does not have his own car. Neither do his friends. Via the app, he's able to see that he is able to carpool with a group of people that live in his street **(u1.2)**.

2.5.4 During the event

Friend finder

William arrives at the opening night of the Bristol Street Art Festival and wants to find his friends. There are a lot of activities going on in different venues. The street art trail takes up the whole city centre and William has no idea where his friends are. He takes his phone, opens the Spotlight app and starts the 'friend finder' feature **(u1.3)**. A map of Bristol pops up and in the centre of the map is a red dot locating William. Different blue dots are spread out over the map, each having a name written next to a dot corresponding to Williams' friends. They are also logged on to the Spotlight app. William can now see that George and some other friends are not that far away from where he is standing and decides to meet them. By clicking on George's dot two possible routes are highlighted, of which one is highlighted in green, indicating that it is the way with the least crowded streets.

George gets a push notification that William is within 50 metres of him and directly warns a friend who is ordering some drinks at the bar. As William approaches within 20 meters of George, the map interface changes to one big compass, by pointing the compass in different directions, the arrow of

[1] The numbers p1.x, and u1.x refer to envisioned use cases in the scenarios. They are elaborated in Section 2.7. The letters "p" and "u" stand for professional user and end user respectively.

the compass shows William where George is standing. When William closes in, he is welcomed by George and his friends with a fresh pint of beer.

Content contributions, audio-visual and text messages

Suddenly, William and his friends are alerted that their favourite artist is beginning his set on stage **(u1.1)**. They decide to move more closely to the stage. During the performance, William also tries to capture the atmosphere with his camera. All of his short videos are sent via the Spotlight app **(u.4)**. As the organizer and editor, Charles is able to monitor all incoming videos from the audience. By means of metadata and tags, Charles can easily find content that is interesting to share with a larger audience **(p1.2)**. One of the videos of William draws his attention and he decides to share it with the public. The video is now sent to the on-site digital signage **(p1.3)**. Since the application knows where the video is shot and where William, the owner of the video, is located on the site, it triggers the surrounding digital signage to immediately play this video **(p1.3.b)**. William is glad to see his video featured on one of the public displays.

Besides the on-site displays, all validated content is also collected and displayed in the application **(p1.4)**. That way George, who had to leave the event because he was feeling sick, can still follow what is going on without missing out on anything **(u1.5)**. Even more, George is able to filter the content based on location, artist or data from his friends **(u1.6)**, or look at the livestream of the different locations **(u1.7)**. He can consequently zoom in on the different stages to gather the atmosphere at the corresponding locations.

Automatic tagging

While dancing to his favourite music, William sees a man showing off his best moves. William decides to take his camera and make a video and some pictures of him. He opens the Spotlight app and uploads his audio-visual content **(u1.4)**. By means of specific location, time detection and potential facial recognition, the app is able to identify which person is most likely captured.

Via his own Spotlight app, visitor Harry can collect all audio-visual content in which he (or his friends) might be present and note that he and his dancing talent have been shot in some images **(u1.8)**.

Content contributions used by the organization: gathering safety, emergencies and crowd control

All of a sudden, a fire starts next to the tent in front of William and his friends. William is able to easily alert the organization via a post in the chat **(u1.9)**. A chatbot automatically identifies the topic as urgent and redirects it to the organization and fire department, who are able to respond quickly and efficiently **(p1.5)**. In addition, the organization uses the Spotlight app to warn all festival-goers with the necessary safety measurements and additionally send the alert to the digital signage **(p1.6)**. People localized near the fire get a push notification from the app that directs them away from the fire. People heading towards the hazardous centre are similarly warned to move in a different direction. All people blocking the way for emergency services are being notified to make sure there is free access to all motorized vehicles.

Content contributions used by the media: intercepting news stories

Thanks to the quick response from the organization, the friends are able to reach a safe location. However, they are confused by how it suddenly started. Harry tells his friends that he did see a person, appearing drunk, spill beer over a power grid. He decides to notify the organization and media of this fact **(u1.9)**. His story also complements the police images from the cameras that are already installed in the city. With all input from the visitors via the app, the media is able to gather all the statements

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and engage the community in a truthful account on the cause of the fire. For a news broadcast, radio host Diana is able to reach out to Harry and use his story as a testimonial **(p1.7)**.

Interact with festival-goers: Gaming feature: location-based interactive poll

The concert comes to an end and the artist leaves the stage, causing a huge applause from the audience. An encore is requested, and the artist gives the audience the chance to choose between songs A or B **(u1.10)**. Therefore, Charles and his editorial team made a poll in the professional app which can be pushed to the audience near the stage **(p1.8)**. Because William is standing in front of the stage, he gets to see the poll on his smartphone and opts for song B. Backstage, the results are visualized as they come in. To motivate the audience to vote for their favourite song, Charles selects the visualization of the incoming results and features them on the screens in front of the stage **(p1.9)**. The audience can now see the changing results in real-time. Unfortunately for William, song A wins and the artist appears once more on stage.

Interact with festival-goers: Gaming feature: AR / game

For the youngsters in age or mind, the Street Art festival introduces a new feature this year: the Street Art Secret Portal **(u1.11)**. It is an AR layer that can be activated in the Spotlight app. The street art paintings can literally come to life by pointing the camera to the art pieces. By object recognition, the live animations stay in place to match the physical street art in the real world.

The true detectives and die hard gamers are able to unlock hidden images (Easter eggs) in the street art tour. If you find all hidden images, you win a street art temporary tattoo. An example of such an AR feature is given by https://www.youtube.com/watch?v=swWPojYxVEM.

Interact with festival-goers: Livestream of reporter on site

After the show, Diana asks Camilla, her reporter on-site, to interview some people of the audience to give their opinion on the performance. She has selected these people by contacting them by the chat after they posted some interested tweets online **(p1.10)**. The interview is live on air and online available via a video stream **(p1.11)**.

2.5.5 After the Event

Overview of collected content

The event comes to an end and most people go home. When Harry arrives at his apartment, he opens the Spotlight app to get an overview of all collected videos **(u1.12).** He is specifically interested in the events that happened in the streets around the different stages. Via the app, he is able to find the videos linked to their specific locations as they are visualized on a map of the festival site or a timeline. Also radio host Diana added a small summary of the events for people to see in the app **(p1.12)**.

Crowdsourced after-movie

In the late hours, William gets home from the festival. He is still overjoyed and thinking about the fun time he had with his friends. With the pictures and videos taken and uploaded via the Spotlight app, William is able to receive a personalised after-movie of the festival and is happy with this review of the most interesting performances and side events, shot by both a professional camera as well as user generated pictures or videos **(p1.13, u1.13)**. The video he made of the dancing man is also incorporated in the after-movie as well as a visualisation of the AR game he played. To relive the event once more, he shares the movie with his friends via social media.

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Evaluation

After the event a summary can be made up to capture the feedback of the user **(p1.14)**. This can be done by tracking keywords people posted during and after the event. Smart word clouds are able to visualize this evaluation.

Crowd movements can be visualised with heat maps, to give accurate information for emergency services and city planning for following events **(p1.15)**.

For this user scenario, we have outlined the concept of an application for events. However, in a later phase, the application could also be valuable in a wider context. In that sense, the end users would be the visitors and citizens of the city, while the other version of the app could be managed by the city council.

2.6 PIML CHARACTERIZATION

Personalisation is used to store user profiles (e.g. age, gender, interests etc.) allows for targeting, defining and classification of communities during an event.

Interactivity between audiences and broadcasters is through content the audience provides, which can be analysed to create metadata (lighting, A/V quality, blurriness, objects). This allows broadcasters to discover useful content quickly, to reward the audience by publishing their content and also use gamification techniques to stimulate event participation and content contribution.

Mobility relates to how audiences contribute before, during and after the event as they use transport networks to converge on a location and diverge again whist reflecting with friends and the broadcaster about their experience.

Localisation is related to connecting with people in a certain 'zone' of the event terrain, where something interesting might be happening (e.g. a famous band plays an exclusive set) providing an opportunity to capture some exclusive content. A cameraman from the radio station will presumably not be present at that time, at that location. If the radio station has a smartphone app available, however, the presenter can send a push notification to people in a certain perimeter around the gig. He can ask the present community for audio-visual contributions (photos, videos, audio recordings and so on). Moreover, he can communicate with certain people in that community (e.g. someone who is standing on a great spot for shooting great content, an amateur reporter who has a professional microphone at hand, etc.).

2.7 MEDIA SERVICE USE CASES

The media service use cases are grouped according to the PIML characterization. “u” denotes a user-oriented use case and “p” denotes a professional user use case. The number refers to the numbers mentioned in the scenario above.

Personalisation:

- **u1.1** - Users can select their favourite artist/workshops/... based on a line-up. The list of all chosen activities is made visible in the app according to time and location. Push messages will alert them on time via the chat.

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- **u1.6** - Users can filter the content based on location, artist or data from their friends
- **u1.8** - By means of specific location, time detection and potential facial recognition, the user can be informed about content they are likely tagged in.
- **u1.9** - Users can chat with the organization/media company as a way of communication.
- **u1.13** - Users can get a personalised after movie of the event, including their own generated content
- **p1.3.b** - Particular videos can be favoured on digital signage, e.g. based on the identified location of the video or the proximity of the owner of the video to a specific signage.
- **p1.6** - The organization can use the Spotlight app to inform all attendees concerning safety measurements or crowd control and to send additional alerts to the digital signage. Information can potentially be addressed to a segment of the attendees, e.g. based on the location.
- **p1.13** - The application can automatically make a personalised after movie for every active visitor of the event.

Interaction:

- **u1.2** - Users can communicate within the community of the event, e.g. to carpool.
- **u1.3** - Users can localize their friends via the friend finder feature.
- **u1.4** - Users can send audio-visual content to the Spotlight app, which can be featured in the app itself, on digital on-site signage or used by a media company
- **u1.9** - Users can chat with the organization/media company as a way of communication
- **u1.10** - Users can interact and communicate via polls.
- **u1.11** - Users can play AR games by activating animations through object recognition.
- **u1.12** - Users can get an overview of collected audio-visual content and apply filters based on location, activity, friends, etc.
- **p1.5** - A chatbot can automatically identify the topic and redirect it to the relevant instances (e.g. the organization, the media company, etc.).
- **p1.7** - With input from the visitors via the app, the media is able to gather stories, testimonials, and engage with the community to enhance storytelling.
- **p1.10** - Editors can interact with visitors and contact them with the chat function

Mobility:

- **u1.2** - Users can communicate within the community of the event, e.g. to carpool.
- **u1.3** - Users can localize their friends via the friend finder feature.

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- **u1.5** - Users can view the shared and validated content in the Spotlight app, from both professional as well as end users.
- **u1.7** - Users can view a livestream, potentially containing both professional and user-generated content, of the different locations of the event.
- **p1.1** - The organization (of the event) and media company get an overview of the incoming data, real-time stream of video, pictures and messages.
- **p1.8** - Editors can create interactive polls in the professional app which can be pushed to a segment of the audience.
- **p1.11** - Reporters of a media company can live stream video using the city platform.

Localisation:

- **u1.6** - Users can filter the content based on location, artist or data from his friends
- **u1.8** - By means of specific location, time detection and potential facial recognition, the user can be informed about content they are likely tagged in.
- **u1.12** - Users can get an overview of collected audio-visual content and apply filters based on location, activity, friends, etc.
- **p1.3** - Selected audio-visual content can be highlighted on the on-site digital signage.
- **p1.6** - The organization can use the Spotlight app to inform all attendees concerning safety measurements or crowd control and to send additional alerts to the digital signage. Information can potentially be addressed to a segment of the attendees, e.g. based on the location.
- **p1.8** - Editors can create interactive polls in the professional app which can be pushed to a segment of the audience.
- **p1.12** - Editors can make an overview or summary of the collected content, e.g. location based
- **p1.15** - The organization can get a visualization of the crowd movements by means of heat maps. These give accurate information to emergency services and city planning for following events

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3 SCENARIO: PERSONALIZED MEDIA MOBILITY IN URBAN ENVIRONMENTS

Entertainment systems are getting increasingly popular in homes and public spaces with applications for media distribution over various fixed and personal/portable devices pervading our daily lives. Many broadcasters have developed multichannel television offers, based on fixed interactive digital platforms with high definition at fixed places (e.g. home) and complementary streaming applications available on PC and Mac, Xbox, Android and iOS mobile devices for the fruition of movies, entertainment and sports events. For example, many broadcasters (e.g. Sky, DISH) have multichannel television offers (e.g. Sky Go, DISH Anywhere) which couple the traditionally interactive digital platforms with set-top box and HD TVs with complementary streaming applications to access contents everywhere. Additionally, and more, on the personal media side, most of the digital home systems today are generally stand-alone platforms, which are typically deployed in a rack of servers running the media application software and hosting the user's digital contents (Video on Demand – VoD – and video-surveillance systems – CCTV), and include a constellation of terminals (video clients, touchpads, handheld devices, phones, cameras, domotic devices, etc.) all in the coverage area of the personal home network.

The personalised streaming from the closed home networks to the broadcasting is now an increasing business sector basically dominated by the Over the Top (OTT, i.e. service providers providing their services generally across the Internet). These cloud-based media service providers are progressively merging with broadcasters (or taking over their traditional market role) and capturing the emerging interest of users. Examples include Netflix, Amazon Prime Instant Video, HBO Go.

The overall goal of this scenario is to explore the changing way consumers participate and access personal media on the move (personal VoD and CCTV recording/streaming), focusing more on the "Personalised Media Mobility" (PMM) aspects than the standard fruition of media contents on the move. In particular, we are interested in experimenting how a media service provider can serve users on the go within the Smart City (see Figure 3), granting them access anywhere to e.g. personal contents they produce and interact with (e.g. from CCTV monitoring systems). We aim to evaluate the feasibility (in technical and business terms) of a personalised media service in the Smart City infrastructure empowered by the FLAME platform. We expect to have media distribution service chains automatically deployed and adjusted while users move in the smart city and reach areas covered by FLAME network access points (in walking areas or on public transportation systems or in main public spaces with digital signage posts. We are also interest in identifying the value (business opportunities) produced through this scenario for the various stakeholders involved.

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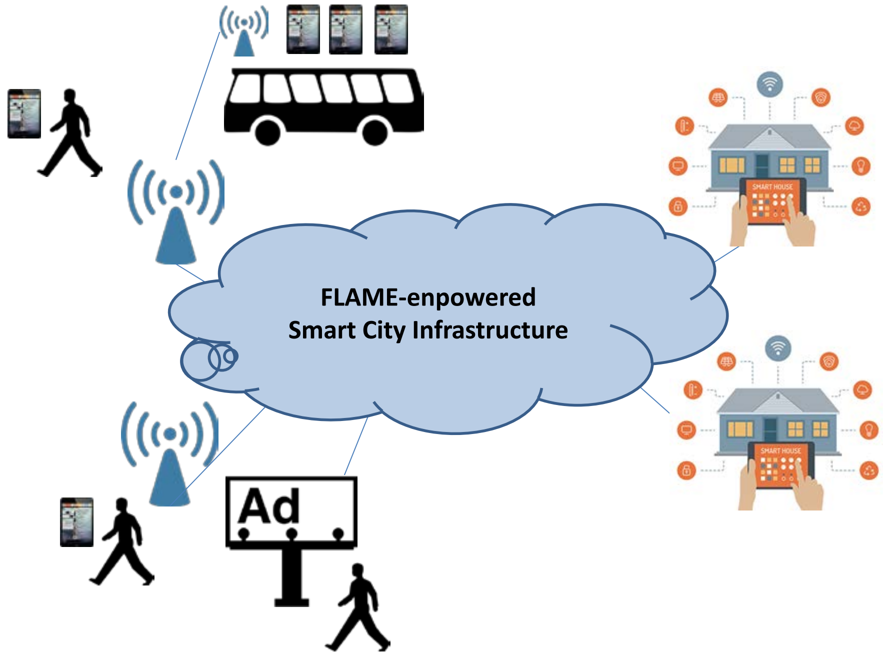

Figure 3: Visualization of the Personalized Media Mobility in Urban Environments

3.1 KEY STAKEHOLDERS

The key stakeholders involved in the PMM scenario are listed in Table 2.

Table 2: Key stakeholders for the scenario on Personalized Media Mobility in Urban Environments.

Stakeholder	**Main Role**
Media/VoD service provider	Offer a service of VoD on the move (my screen follows me). This offer complements the traditional "streaming anywhere" offer by various broadcasters, adding interesting personalisation and interactivity elements to the service that make it highly customized for the customer.
Media/VoD technology provider	Offer the technology for VoD services integrated in FLAME ecosystem. A virtualized architecture of media streaming service components is deployed to implement the access to contents cache, the media transcoding and the media streaming chain, beyond the state of the art.
Smart City infrastructure operator	Provide access to the FLAME-enabled network infrastructure for the Smart City, capable of programming virtual network slices for various tenants across
End users	Consume the personalised media streaming across various personal devices (fixed TV, smartphones, pads, etc.)

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3.2 VALUE PROPOSITION

For each of the stakeholders identified in Table 2, the specific value of participating to this experiment scenario is discussed in the following.

Media/VoD service provider. This stakeholder is primarily interested in evaluating the feasibility of a personalised media streaming service across the Smart City leveraging the FLAME platform and the Smart City software defined infrastructure. The focus is both technical and business oriented. In fact, the scenario can provide different values including:

- Technical evaluation of mechanisms to optimize bandwidth and resources to be deployed in the infrastructure to serve its user community.
- User acceptance and interest in such a service to drive the definition of a business proposition for Personalised Media streaming in the market.
- Preliminary identification of the technical and business relationships with the other stakeholders that might be needed to develop and roll-out such a service in the Smart City.

Media/VoD technology provider. This stakeholder is more interested in the technical aspects of the experiment and particularly in tuning and enhancing his application and software middleware for media streaming (VoD and CCTV) to be ready to work in a Smart City with software defined infrastructure. As side effect, this stakeholder gets value in assessing the interest of the other stakeholders (in particular the VoD service provider and the Smart City infrastructure operator) in the developed platform and subsequently its market/business opportunities.

Smart City infrastructure operator. The main values for this stakeholder consist in

- assessment of the feasibility of personalised media streaming services in the software defined infrastructure
- evaluation of the infrastructure demand and resource requirements that drive the provisioning of a service offering of that kind
- evaluate the applicability of a similar service model to City-driven media streaming services, e.g. for augmented touristic services promoted by the municipality, or enhanced user information streamed via various devices and access points (e.g. digital signage totems)

End users. This stakeholder concentrates his value in having a seamless experience of personalised media streaming services across the Smart City, thus accessing a seamless media fruition experience, continuous access to personal media contents and mobility of personal preferences across various environments.

3.3 EXPERIMENT GOALS

In this scenario we explore how consumers participate and access broadcast media on the move through various personal devices, from fixed and mobile type. In particular, we will not focus on how personal videos at home (in local VoD/NAS) will follow users, but rather how Media Service Providers can serve users on the go (within the Smart City) and how they can build a media distribution service chain while users move in the smart city.

We aim to experiment with the FLAME platform an adaptive follow-me streaming services across multiple devices and locations.

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3.4 POTENTIAL EVENTS

The scenario can primarily be trialled in a normal day/week in Barcelona city, with users moving from their smart homes across the Smart City areas and/or via public transportation (e.g. bus) served by the FLAME platform.

Once demonstrated in normal daily conditions, the experiment can be extended to an urban scale and executed during a large community event in the Smart City (e.g. at the Mobile World Congress events in Barcelona).

3.5 NARRATIVE OF SCENARIO

3.5.1 "My Screen follows me"

Johns are a family of 3 located in Barcelona. Bernat (43) is a businessman, Mariana (40) is a musician at Barcelona Opera House and their child Jordi (15) is a student. In Barcelona they own a smart home, equipped with CCTV and media services delivered by the local provider Watch4Me. Thanks to their partnership with the local Smart City operator, Watch4Me is capable to offer to their users a Watch4Me-Any service, which allows to consume media in the personal VoD/Music library and to stream the contents of the CCTV camera in user's house from anywhere through the smartphones/pads and fixed TV installations equipped with the Watch4Me set-top box.

The Johns have all a personal account on Watch4Me service (**u2.1, u2.2**) in which personal preferences for media (genres, playlists, authors, hobbies, interests, etc.) are stored. They also all subscribed to the Watch4Me-Any service (**u2.3**, **u2.4**) in order to continue the fruition of the preferred media while commuting from home to work (Bernat and Mariana) or to school (Jordi).

The scenario is activated by any of the Johns, e.g. Mariana the musician, who is streaming the opera she is working on at the moment at home on the fixed smart audio devices and "swipes" it from the fixed player to the smartphone when she decides to move to Opera House across the Smart City (**u2.4**).

Mariana starts moving in the Smart City and gets network connection from the FLAME platform, which in turn retrieves her location (**p2.3**). Based on Mariana's location and the measured QoS/QoE parameters (**p2.2**) for her streaming logged from the media server, from the app client on Mariana's smartphone, and from the FLAME platform, the Watch4Me-Any media control server invokes the FLAME platform to dynamically adapt the media streaming service chain from Mariana across the controlled infrastructure and optimize the streaming for specific QoS levels (**p2.1**).

While walking towards the Opera House, Mariana passes close to a music store that subscribed to a Watch4Me advertising service and thus can push ad-hoc Ads to potential customers via the Watch4Me platform (**p.5**). Based on the location information in Watch4Me systems, Mariana gets a notification on her smartphone for an incredible promotion on a classic guitar they were looking for from a long time for their son Jordi who's studying classic guitar at the city conservatory. All these personal preferences and interests are profiled in the Watch4Me user registration form (**u2.1**) and allow for discounted fees on monthly service subscription (**u2.2**). Mariana considers buying the guitar.

Once at work, Mariana pauses the streaming (**u2.5**). After work, Mariana jumps on a FLAME-empowered public bus and connects to the Watch4Me-Any app. She is now capable to resume the playing from where she paused (**u2.5**) and the FLAME platform instantiates local server and caches on the bus (**p2.2**) to optimize QoS/QoE during a fast move across network access points in the Smart city.

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Bernat and Jordi played similar swiping scenarios as Mariana in their movements during the day within the smart city.

In addition, during the day when at work Bernat received a notification on his smartphone of an intrusion alarm at home from the Watch4Me app. Bernat connects to Watch4Me-Any, logs into the CCTV cameras and starts inspecting the house environment with pan/tilt/zoom actions (**u2.3**). It's a false alarm, the external camera captured a cat traversing the terrace. Nevertheless, Bernat starts a recording from that camera to be able to watch it in more details later on. After work, while on the bus to home, Bernat browse his personal library of CCTV recordings on Watch4Me-Any and watches the full recording configured in the morning. The FLAME platform instantiates local server and caches on the bus (**p2.2**) to optimize QoS/QoE during a fast move across FLAME access points in the city.

3.5.2 Urban scale personal media for public events

Watch4Me and the Smart City operator are technical partners of the XYZ Congress (e.g. MWC) celebrated in the city for a full week. The event collects delegates from worldwide. Watch4Me offers a special free version of the app Watch4Me-Any for the people in the Smart City to select and consume video streaming from various sources (cameras) in the congress centre. Users can log Watch4Me-Any (**u2.1**) and browse the available media sources, some of which live others recorded (**u2.3**). The same library is available at digital signage posts installed in public places of the Smart City, used as smart information points for citizens and delegates. The user with Watch4Me-Any and close to a digital signage is localized (**p2.3**) and can swipe the content he is interested in from the digital post to his smartphone/pad to watch it while moving towards the conference, (**u2.4, u2.5**). Based on user's location and the measured QoS/QoE parameters, the FLAME platform dynamically adapts the media streaming service chain across the controlled infrastructure to optimize the streaming for specific QoS levels (**p2.1**, **p2.2**).

3.6 PIML CHARACTERIZATION

The PIML aspects related to this scenario are summarized here below.

Personalisation. The user in this scenario can select the personal devices through which he can consume the media while moving within the urban area. This is a primary aspect of personalisation activated by the swipe action on the remote control to let the streaming join the selected device. Also, in case of CCTV streaming, the user can select the camera from which to stream and remotely control zoom, pan/tilt etc. to implement a personal view of specific zones under control and record.

Interactivity. The interactivity of this scenario occurs at different levels, at first with the user interaction with his personal media library to configure and manage personal contents and access to personal library of recordings; then, it can occur with the possibility to select the streaming format (if HQ or standard) and with remote control commands issued to preview/fast-forward/rewind a content. In case of CCTV (i.e. live contents from video-surveillance cameras) interaction occurs in case of tilt, pan, zoom-in/out.

Mobility. Users' moving the Smart City areas covered by FLAME represent the main mobility aspect of this scenario. While the user moves from one cell/network access point to another one, the media delivery service chains need to be dynamically re-adapted to continue streaming the selected media with the committed QoS/QoE levels.

Localisation. The FLAME platform can expose location information about the user (e.g. user attached to a specific network access point, in a specific city zone, etc.). This information can be used to infer a

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derivative information of user close to a shop window, or in a mall, which can trigger location-based advertisement/notification also matching user preferences. This could further extend the stakeholder group to shopkeepers possibly interested in covering parts of the service costs in exchange for promotions/Ads in overlay onto the user's streaming.

3.7 MEDIA SERVICE USE CASES

In this section we summarize the main use cases raised by the PMM scenario. Use cases marked with "u2.x" refer to end-user-oriented use cases, primarily satisfied by a media/VoD service provider. On the contrary, those marked with "p2.x" denote provider oriented use cases which are instrumental to the PMM media/VoD service in the Smart City and are primarily satisfied by the Smart City service operator and the FLAME platform.

All the following media service use cases are grouped according to the PIML characterization:

Personalisation

- **u2.1** – The user must be authenticated to participate in the FLAME PMM scenario and access personal only contents. The user's smartphone is intended to be the primary device for user interaction with the system.

- **u2.2** – The user's personal information and media preferences (playlists, scenarios, settings) must be stored in the media streaming application servers and must be accessible only to the user and the application provider.

Interactivity

- **u2.3** – The user must be enabled to browse his personal library of contents and start streaming stored media or from live devices (e.g. CCTV cameras) while on the move

- **u2.4** – The user must be enabled to "swipe" the screen to pass the streaming from one device to the other

- **u2.5** – The user must be enabled to pause and resume his personal playlist (music or video) from where he paused while move in the Smart City or on a public bus

Mobility

- **p2.1** – The Media/VoD service provider must be capable to invoke the FLAME platform by the media service application to serve the user moving in the Smart City. The user will not recognize a network change but simply continues consuming his/her media while on the move with the same quality as before.

- **p2.2** – The Media/VoD service provider must be capable of measuring QoS and QoE parameters related to the streaming and trigger reactions in the FLAME platform and infrastructure to maintain the QoS/QoE levels. Metrics to measure and monitor include:
    - QoS parameters to measure on media server side:
        - Average Bit Rate – the average bandwidth being consumed by the video stream from origin server to the client viewing the content

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    - Round-Trip delay) - the average/min /max propagation time between the media client and the server

- QoE based metrics

    - Display quality (fidelity): is the image quality sufficient for the device's screen size?

    - Start Time – the elapsed time from when "play" is pushed to when video starts on the screen

    - Re-buffer Rate – the number of times a re-buffering event occurs during viewing

    - Mean Opinion Score - does the video play smoothly? User's perceptive evaluation in the range 1 (bad) – 5 (excellent) of the media streaming perceived quality.

Localisation

➔ **p2.3** – The Media/VoD technology provider should be capable to consume location information about the user (e.g. user attached to a specific network access point, in a specific city zone, etc.) as collected by the FLAME platform and implement added-value services in overlay to the media streaming.

4 SCENARIO: COLLABORATIVE INTERACTIVE TRANSMEDIA NARRATIVES

Storytelling lies at the heart of the human experience that connects us both to each other as well as to the locations where we spend our lives. The popularity of television and film content attests to the strong way in which stories resonate with people. However, actively engaging in story progression can provide an even deeper and more rewarding experience. We aim to provide an immersive story experience in which human users become active participants in the unfolding narrative. We investigate collaborative interactive transmedia storytelling embedded in real-world locations. The demonstration scenario described below is a story-based city-wide quest.

4.1 KEY STAKEHOLDERS

The key stakeholders of our scenario and their roles are described in Table 3.

Table 3: Key stakeholders for the scenario on Collaborative Interactive Transmedia Narratives.

Stakeholder	**Role**
Transmedia Experience Provider	Produce transmedia application, content and experience
Local Organization	Any organization (or business) with interest to motive user engagement with physical locations or services
Smart City Infrastructure / Platform Operator	Provide FLAME-enabled infrastructure for experimentation
End User	Experience interactive narrative-based city quest

4.2 VALUE PROPOSITION

The value proposition associated with this scenario is described for each of the stakeholders identified in Table 3.

Transmedia Experience Provider. This stakeholder is primarily interested in enabling new forms of interactive transmedia experiences. The stakeholder is the primary application designer, developer, and content producer. The application will utilise the FLAME platform to enable novel forms of user interaction during a city-wide quest.

Local Organization. This stakeholder is interested in benefiting from novel ways to motivate people to engage with physical locations associated with the organization. This stakeholder may include a local business or tourism provider. The organization may partner with the transmedia service provider to integrate the organization within a city-wide interactive, collaborative, transmedia narrative-based experience.

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Smart City Infrastructure / Platform Operator. This stakeholder is the operator of a FLAME-enabled infrastructure and platform. This stakeholder derives value from enabling novel end user experiences as well as enabling economic opportunities for local organizations. This stakeholder is interested in evaluating the feasibility of story-based city-wide experiences and adapting city infrastructure to the needs of the application.

End User. This stakeholder derives value from the novel experiences offered by the FLAME-enabled application. The stakeholder is guided to engage with locations, which provide a novel way to experience the city.

4.3 SCENARIO GOALS

The high level context of use is to enable a story-based city-wide quest. The experience takes the form of a collaborative interactive transmedia narrative embedded in real life environments. The narrative is designed around the story-based quest that helps end users experience urban environments in a new way. Collaboration is achieved through the end user's participation to influence narrative progression, which generates a personalised story. The narrative experience is responsive to the interactions of the user. Different media types may be integrated within the experience, which opens up opportunities for interactive media services and storytelling.

4.4 POTENTIAL EVENTS

This scenario does not target a specific event for experiment purposes, but rather aims to provide an experience that can be coordinated with a user's availability.

4.5 NARRATIVE OF SCENARIO

We begin by describing the activities of a transmedia experience provider, Daniel (30 years old), who has developed an interactive storytelling system that leverages the FLAME infrastructure to enable information sharing between users and the storytelling system while experienced within an urban environment. The system integrates different media types to convey story information to the end user and empowers the user to interactively explore the story.

Daniel is collaborating with Bob (45 years old), who manages a local organization. Bob is searching for novel ways to attract people to the services he provides within the city. Daniel has agreed to integrate information about Bob's location within the story-based quest. As requested by Daniel, Bob produces descriptions of appropriate physical locations. Bob suggests different ways to present this information as well as ways users may interact with it. Daniel produces one or more modular stories, which integrate information from Bob within the city-wide quest.

Charlie (40 years old) is the managing operator of the local smart city infrastructure, which utilizes the FLAME platform. Daniel works with Charlie to ensure that local infrastructure is compatible with the needs of his story-based city-wide quest. Daniel is provided with a collection of existing FLAME media service platform functionalities (**u3.3**), which he may utilize. Daniel may also work with Charlie to integrate new media service platform functionalities (**u3.3**) as required by his transmedia storytelling application.

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Our representative end user, Alice (25 years old), participates with the expectation that she will be guided on a city-wide quest, which will provide a novel way to experience the city. Alice has pre-installed the story-based quest application on her smartphone or tablet device. Alice starts the application and authenticates her user account (**u3.1**). The application displays a virtual character that greets Alice and offers to guide her exploration of the city. The virtual character may provide the following services: It may guide Alice to experience locations (**u3.2**) within the city using pre-authored experience patterns as well as Alice's evolving user profile as a guide. Her profile may include a history of her experience including locations visited and knowledge gained (**u3.4**). The virtual character may also provide details about locations and services involved in the quest, and may also request feedback from Alice to assess her interest and engagement, which will help to optimize narrative progression. With the help of the virtual character, Alice is guided to locations within the city and consumes transmedia content provided by FLAME infrastructure (**u3.3**) associated with the context of those locations (**u3.4**). During the narrative experience, Alice is confronted with choices. Her decisions will lead her to different locations, which influence narrative progression. The application may predict future movements of Alice and cache transmedia content in those locations (**u3.5**). Alice's narrative path is recorded, resulting in a personalised story, which she may choose to share with her friends (**u3.6**).

A successful outcome at the end of the scenario may include the following: Alice experiences a collaborative interactive transmedia story embedded in a physical urban environment. She is able to explore a city in a way that is responsive to her interest and interactions, which enriches the experience. The FLAME infrastructure and platform enables the information sharing (e.g. transmedia content and other narrative state information) between the user and our storytelling system while distributed throughout an urban environment.

4.6 PIML CHARACTERISTICS

A PIML characterization is utilized to describe the following aspects of experience for the experiment participant:

Personalisation. A user model is constructed containing information about locations visited by the user as well as knowledge gained during each part of the city-wide quest experience. This information is used to determine the optimal path for the user. The virtual character can fill-in the users about experiences they may have missed.

Interaction. The user may choose to follow or ignore advice provided by the virtual character. The user interacts with the quest by choosing which physical location to visit next, which triggers different paths through a branching narrative.

Mobility. The user ultimately decides where to go and what to do during the city-wide quest experience. The user's smart phone provides the primary interface enabling the user to freely navigate the city environment while connected to the storytelling system. In our scenario, interaction utilises user mobility.

Localisation. The storytelling system uses location-based services and proximity to FLAME infrastructure to infer where the user is located and what they are experiencing.

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4.7 MEDIA SERVICE USE CASES

The following list contains media service use cases associated with this scenario:

- **u3.1** – User is authenticated to be participating in a FLAME compatible smartphone (or tablet) application. The user's smartphone is intended to be the primary device for user interaction with the system.
- **u3.2** – User geo-position is determined also with respect to the location of FLAME media services integrated within the scenario.
- **u3.3** – User can retrieve transmedia content provided at designated locations within the FLAME infrastructure. The aim is to enable a novel transmedia experience combining the smartphone interface as well as physical objects within the city.
- **u3.4** – The user's personal information, location, and participation behaviour should be privately stored and accessible only to the user and the application provider.
- **u3.5** – Future movement of the user is used to predict locations where transmedia content may be consumed. Transmedia content may be stored in physical locations based on this prediction.
- **u3.6** – Experienced transmedia content may be retrieved and combined into a personalised story reflecting the user's adventure.

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5 SCENARIO: AUGMENTED REALITY LOCATION-BASED GAMING

Through their unique combination of visual, narrative, auditory, and interactive elements, video games provide an engaging medium of expression within our society. The proliferation of mobile devices that combine computation and graphics processing with video and GPS sensors holds great potential to enhance gaming. Furthermore, augmented reality (AR) provides the ability to blend virtual and real-world experiences so that location-aware games extend past our televisions, weaving the magic of gameplay into cultural locations such as the cities in which we live. In this way, games become an augmented version of real settings, bridging between imaginative worlds and the reality around us.

5.1 KEY STAKEHOLDERS

The key stakeholders of our scenario are described in Table 4. Stakeholder goals and expectations are described below in the Value Proposition Section. Stakeholder participation is described in Section 5.5.

Table 4: Key stakeholders for the scenario on Augmented Reality Location-based Gaming.

Stakeholder	Role
User/player	Play the game
Game developer	Create, evaluate, and analyse the game

5.2 VALUE PROPOSITION

The value proposition of the scenario is demonstrated in context of the goals and expectation of the key stakeholders.

Players/Users. In a multiplayer location-based trading game, players are engaging in a shared virtual game world, integrated into the real world. Players are interacting with the game world, with its virtual economy, as well as with each other, which creates a social environment suited to study socio-economic player behaviour. During experiments and playtesting sessions, players' expectations are that the game is generally working and playable but they expect that there might be some bugs or problems as the game is still under development.

Game developers. A game developer's goal is to understand all aspects of the game. During experiments and playtesting sessions, the developer expects the game to be functional in general, however, as the game is still under development, small bugs might still occur.

5.3 SCENARIO GOALS

This scenario explores a location-based game concept that encourages real-world interactions and gamifies daily commuting activities in a city. Enhanced with augmented reality technology, we create an immersive, pervasive trading game called *Gnome Trader*, where the player engages with the game by physically traveling to predefined locations in the city and trading resources with virtual gnomes.

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As the virtual market is a crucial component of the game, we take special care to analyse various economic game mechanics.

5.4 POTENTIAL EVENTS

This scenario does not target a specific event for experiment purposes, but rather aims to provide a continuous experience.

5.5 NARRATIVE OF SCENARIO

Felix (18 years old) and Steffi (24 years old) are friends who like to play online multiplayer games together. In Gnome Trader, Felix and Steffi embody virtual traders, equipped with a bag to carry resources. The goal of the player may be to travel within the city and trade resources at specific locations to make a profit. Figure 4 depicts an area of approx. 6 km x 6 km of central Zurich. A trading location is placed at every bus, tram, and train stop.

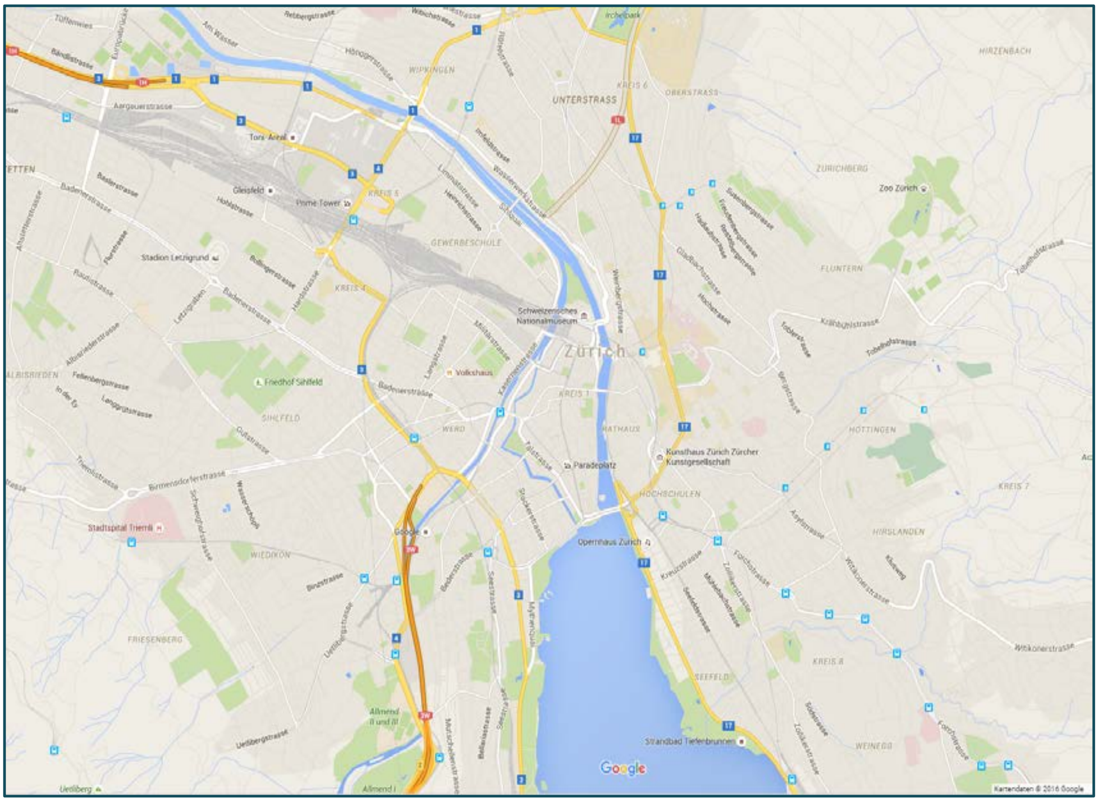

Figure 4: Map depicting approx. 6 km x 6 km region of central Zurich[2]

Felix visits a location near his house. He is presented with the option to buy 7 peas for 2 gold pieces per pea, he agrees. Steffi is at work in the city centre. During lunch, she visits a trading location nearby. She buys 4 peas for 5 gold pieces each. Here, the peas are more expensive because there is a bigger demand around the city centre. The pea prices are dynamically calculated based on the local demand

[2] Image © Google.

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and supply model. Because Steffi is trading in a crowded area in the city centre, her screen is life-streamed to several nearby public screens (**u4.1**), while she is interacting with the trading location. This attracted the attention of several pedestrians that walked by the screens. She may be picked for live-streaming by the system because she made a particularly good deal with the trading location (for that area) or because she made use of a unique game mechanic. Later that day, both locate a trading location that offers to buy peas for 8 gold pieces per pea. Both sell all their peas. That day, Felix made a profit of 42 gold pieces and Steffi made a profit of 12 gold pieces. They will invest the profit later into buying upgrades or purchasing new resources.

Over time, Felix and Steffi engage in the game on a daily basis, finding trading locations in the city, and trading resources with them. They slowly progress in the game and make full use of all game mechanics.

Hans (31 years old) is lead designer and a core developer on the Gnome Trader development team. He is observing the virtual game economy as players contribute. He inspects plots on how resource prices evolve around the city, where players move, how players interact, and analyses other statistics about the game. At the end of the experiment, questionnaires filled out by the participants provide valuable feedback to Hans.

A possible successful outcome could be that Felix and Steffi enjoyed the game and identified a few issues that should be solved. Based on his observations of the game server backend during the experiment as well as from Felix' and Steffi's questionnaires, Hans has a better understanding about what is working well in the game and which issues have to be solved. Felix found a loophole in the game, where a small bug could be exploited to make a disproportionate amount of gold at a specific location. Hans would later fix that bug and hence improve the game. Finally, during the trial, Hans could define a metric that defines how many trading locations are needed for a given number of players to ensure and optimal and balanced gameplay. Hans also gained insight into the required network bandwidths that was used by the players to synchronize game state with the server.

5.6 PIML CHARACTERISTICS

Personalisation. Players log in to their personal account that tracks their progress in the game. A shared leader board allow players to share their personal scores with others and compare their progress with the progress of other players.

Interactivity. An online multiplayer location-based trading game allows its players to interact with a virtual game world that includes a virtual economy as well as to interact with each other. The game's graphical user interface running as part of the game client on a smartphone is the primary form of interaction, and directly and permanently connects the player to the game world. This means the players game state is constantly synced with the server backend. All game changes such as price of resources are available all the time. AR components allow the users to interact with the game through 3D objects virtually and seamlessly integrated into the real world. Potentially, social game features such as chat, sharing, or resource trading could allow players to interact with each other through the game world.

Mobility. Player movement is essential to the game. At all times, the game server needs to know each active player's GPS location. Depending on (unspecified) game mechanics, this information could be continuously (anonymously) broadcasted to the all players. In order to create an immersive experience for the players, communication to the game backend needs to be low latency.

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Additionally, a real-time video stream of a players screen as the player interacts with the game could be broadcasted to public infrastructure displays in the player's vicinity to allow other players and even pedestrians to follow the player's actions.

Localisation. The virtual game world and its elements are seemingly integrated in the real world. As such, players experience the virtual world localized as if linked to the real world. Specifically, in the trading game, different types of resources may appear in the game as if influenced by the real world. For example, water resources may be found near lakes and rivers, snow and ice may be found in high altitudes, and wood and soil may be found in nature scenery.

5.7 MEDIA SERVICE USE CASES

This subsection lists and describes media service use cases, which inform the integration of FLAME platform functionalities.

- ➔ **u4.1** – A real-time video stream of a players screen as the player interacts with the game could be broadcasted or multi-casted to public infrastructure displays in the player's vicinity to allow other players and even pedestrians to follow the player's actions. Critical factors are bandwidth and latency. High bandwidth is required to allow multiple players to stream their screen in high quality to numerous public screens. Low latency is required to enable spectators to quickly react to other player's actions, whose gameplay they are watching.

- ➔ **u4.2** – Players require a permanent, low latency connection to the game backend infrastructure to enable a seamless integration and synchronization of the players with the virtual game world.

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6 CITY INFRASTRUCTURE

To deliver an effective platform with real impact, FLAME leverages on the deployment and integration with actual city infrastructures. For this reason, the FLAME project engaged very early on with key partners supporting those activities in Barcelona (Spain) and Bristol (United Kingdom).

Both cities have a unique mix of openness to experiment, willingness to innovate and appetite for pushing the limits of the network infrastructure technologies through programmability and challenging use cases. To that end, the partners contributing and operating infrastructure technologies in FLAME have identified several capabilities maximising value and impact of the FLAME platform. In no particular order, those capabilities are as follows:

➔ **Combined in-premise and in-field asset hosting, both physical and virtual.** The use cases for the FLAME platform benefit from having an advanced hosting capability for both physical assets (small form factor computing devices, network devices, etc.) and virtual assets (virtual machines, virtual network devices or appliances, software back-ends, etc.). The hosting capability must fulfil mechanical requirements for physical installations and logical requirements for setting up the infrastructure per experiment. This is achieved by considering the following design principles in FLAME:

- The operational environment for the experiment must offer physical (space) hosting in the network points of presence (in-premise) and virtual (cloud) hosting at the same time, on a converged approach.
- The virtual hosting capability (cloud deployment) is designed to operate interconnected to the city network infrastructure; hence reaching devices hosted in street cabinets.
- The operational environment for the network is designed to achieve the adequate level of configurability and programmability to adapt to demands triggered by the platform.
- The network and computing infrastructures are operated using converged tools, not as independent isolated deployments.

➔ **Distributed and heterogeneous computing.** Having a combination of cloud and (network) edge computing capabilities is key to support the FLAME platform. The infrastructure in the project will offer a private cloud solution along with an edge computing solution in street cabinets. The design and implementation of the solution will be delivered as part of future documents in the project.

➔ **Programmability and dynamic (re-)configurability of the network infrastructure.** Seamless network infrastructure configuration and re-configuration, including automation tools, will provide an agile provisioning environment for infrastructure services. However, FLAME also aims at leveraging on network management techniques based on programmability (e.g. using Software Defined Networking). This is a key differential factor compared to how city network services and the internet are used nowadays. Moreover, the infrastructures will feature different network technologies, ranging from dark fibre network, hybrid L2/L3 networks, Wi-Fi, WiGig and others.

➔ **Integrability with novel network and computing technologies.** In FLAME, future uses of the platform may require advanced network and computing technologies to be deployed. For example, some media applications would benefit from 5G technologies for access to content in

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a reduced latency, increased bandwidth context. Similarly, micro services and flexible software container platforms can boost adoption of user-location aware media services and edge processing of content, which can only be achieved by leveraging on cutting edge computing techniques. FLAME will consider easy adoption of such novel techniques at the infrastructure level by introducing their operational principles right in the infrastructure development roadmap.

The above-mentioned key capabilities will characterise the infrastructure offered in FLAME to support the media service use case requirements described here and the platform requirements to be described later, specially targeting the following list of actions:

- The platform will be allowed to deploy services at the edge of the network (e.g. in a street cabinet) by the infrastructure.
- The infrastructure will offer a private, distributed cloud offering that will be integrated with an edge computing platform for experimentation.
- The platform will be allowed to deploy content and processing close to the user's location, by provisioning on the adequate locations in the infrastructure directly.
- The network infrastructure will be programmable (using SDN) to accommodate advanced applications and management (e.g. the FLIPS system provided by IDE).
- The infrastructure will allow the installation of physical devices in city premises and street cabinets, along with local partners' premises.
- The infrastructure will ease the adoption of novel network technologies (e.g. 5G), if available.

6.1 FLAME INFRASTRUCTURE IN BRISTOL

Bristol is Open has a fibre network connecting four switching sites with wireless access points around Bristol city centre (see Figure 5). The main switching sites are at the University of Bristol Merchant Ventures building, Engine Shed, At Bristol and Watershed.

Each of the active nodes has a fibre switch and an OpenStack computer that can run several projects simultaneously on different network slices. There is some hosting ability at the active nodes for third party equipment if needed. The main active node is the one at the university and this is where the centralised management and access is located.

The wireless sites use Meru AP832e Wi-Fi routers controlled through a computer at the university. An SSID can be broadcast simultaneously across several sites so that devices can roam between them. Individual sites can also broadcast multiple SSIDs at the same time so that different users are segregated to their own network slice.

Locations are linked to the active nodes by a combination of fibre, microwave and millimetre wave systems depending on the physical network. Most sites utilise street side lampposts, three however are located on roof tops. There is some hosting capability at radio cabinets for additional switches and customer equipment if required.

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Figure 5: Current Wireless sites[3]

The infrastructure may evolve in the future to provide the following additional capabilities:

- Some locations will have 4G LTE cellular base stations installed and some additional Wi-Fi units are being planned.
- Computing capabilities will be enhanced with a new high performance computer and additional switching nodes and wireless sites.
- It is planned for the infrastructure to fully support Software Defined Networking (SDN) with new switching and control functionality that will provide better visualisation and more flexibility to our customers.

6.2 FLAME INFRASTRUCTURE IN BARCELONA

The city of Barcelona is planning to deploy an infrastructure in the city of Barcelona that can be used to provide wireless access to citizens/users and will serve also as a 'last mile' wireless backhaul for the transferred data. Additionally, the infrastructure will allow for the exploration of in-site fog/edge computing capabilities.

As illustrated in Figure 6 (a), the initial hardware infrastructure will consist of three main parts: i) indoor cloud-enabled wired testbed, ii) optical fibre link and iii) outdoor street testbed.

The indoor cloud-enabled wired testbed, at i2CAT premises, consists of OpenFlow-enabled switches with Gbps capacity on the network links, whilst the cloud cluster is composed by IT assets, i.e. CPU cores, RAM and HDD storage. Thus, this part could provide hosting and computing capabilities for third party equipment if needed. The centralised management of the BCN infrastructure will be located here.

The optical fibre link will connect the infrastructure at i2CAT site with the switching equipment installed in a cabinet on-street city infrastructure. This switching equipment will provide connectivity

[3] Image © Google.

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with both i2CAT premises and with each of the wireless nodes installed in the street. The capacity of the infrastructure should support high speed transmissions and high bandwidth-demanding services, coping with Future Media Internet (FMI) requirements.

The outdoor street testbed is planned to be deployed along Pere IV Street, in the "22@" district. This area will span approximately 0.5 km. The outdoor street testbed will consist of several high speed Wi-Fi-enabled lamp post nodes and one street cabinet, as illustrated in Figure 6 (b). The lamp posts will provide high-speed wireless backhaul and access connectivity to the moving end users (e.g. vehicles, group of people, etc.) allowing mobility experiments. In the cabinet, a high performance server will provide computing and storage capabilities; this will allow experimenters/ providers/third parties to implement edge computing techniques or move hosting capabilities to the street site in order to improve the overall performance, the Quality of Service (QoS) or the Quality of Experience (QoE) of the offered services.

Along with SDN to dynamically configure the network, Network Function Virtualisation (NFV) techniques will be used for mainly deploying and managing the lifecycle of the computing nodes at different Points of Presence (PoPs).

Therefore, the overall physical and virtual infrastructure of the deployment will be managed by an NFV MANO compliant with the ETSI NFV MANO reference [2], an SDN controller, a Cloud Manager and a Service Orchestrator.

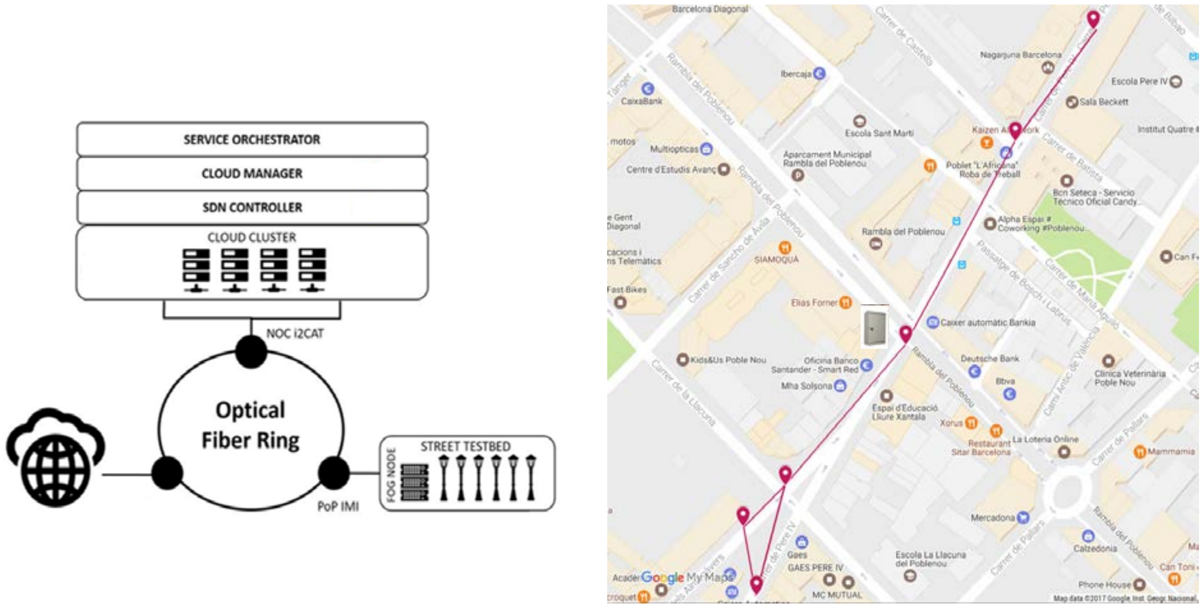

Figure 6: a) Schematic diagram of the FLAME testbed in Barcelona, b) Planned street infrastructure[4]

[4] Map image © Google.

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7 PLATFORM

The scenarios described above rely on media services and the platform to deliver the necessary capabilities. An analysis of the media service requirements and the consequent platform use cases will form part of the architecture deliverable (D3.3). Here, we focus on the FMI Vision aspects of the platform and enumerate the technical differences and specific capabilities of the FLAME platform compared to a conventional network and what benefits these differences bring.

Low latency distributed compute

The platform can deploy services at the edge of the network (e.g. in a street cabinet). As a consequence, compute capabilities may be located just one hop away (at best) from the users. Deployment planning tools and reactive systems can deploy compute services at the edge, providing low latency access to compute services as well as having the compute workload distributed across the network. Together with emerging new radio access technology, such as 5G radio or GBit Wi-Fi, we expect to ultimately experience service level latencies of 5ms or less.

Compute services inevitably deal with content, ingesting and or serving it. An example where this local compute capability would be of benefit to the media service user would be a video transcoding service personalising a video stream to comply with a user's device specifications. By having such a service located at the edge of the network, the user would receive an instant adapted video stream.

Such a local service could also provide benefits when processing video content uploaded by users. Local processing could make use of computer vision techniques to quickly identify interesting content and make it available to other users on the network rather than relying of centralized capabilities for such processing, possibly increasing the needed bandwidth for the transfer of content to such central locations before deciding on the 'value' of the content.

End user: Low latency access to personalised services that process content (e.g. videos).

Media service provider: Process media close to the users, providing them with faster access to processed content.

Low latency distributed content

By combining the aforementioned base capability to deploy services at the very edge of the network with a content distribution network (CDN) and both deployment planning tools and reactive systems for deployment and content updates, the content required by a media service user can be placed close to the users' location. By means of distributed cache nodes deployed across the infrastructure, the CDN is able to provide lower connection latencies for media service users reducing at the same time the traffic volume going through the underlying network. Such capabilities allow users to possibly experience e.g. instant video playback independent of their location.

Additionally, it is also possible to leverage the virtualization capabilities of the platform to deploy, migrate and or terminate CDN node instances to cover traffic peaks based on specific demand of media service users or FLAME experimenters e.g. video streaming of a one-time street music show.

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End user: Low latency access to high bandwidth content (e.g. videos) regardless of location.

Media service provider: Cheaper provisioning of media services providing access to content at latencies well below conventional networks.

Fast and dynamic service request routing

In a conventional network, an instance of a (media) service is found using the DNS: the user's client queries a DNS server to map from a domain name to an IP address. The subsequent service request is then routed through the network between the client and the service. If the user is doing a DNS lookup to access content served by a CDN then the DNS service will maintain a list of IP addresses that can be returned for a given domain name and will try to return an IP address of a node geographically close to the client.

Should the (media) service provider want to replace an instance of their service with another one at a different IP address (and potentially a different physical location) then the DNS tables must be updated. This is done by updating the local authoritative DNS server which then propagates the new mapping to DNS services across the world.

DNS propagation can take up to 48 hours so fast dynamic switching from one service instance to another is not possible in conventional networks. Even more so, there are no general practises to propagate these changes to the client. This is important for cases in which clients will cache previously received DNS responses to domain names – a practise that is widespread among browsers and even at operating system level. If an assignment of DNS name and IP address now changes (and is ultimately finally diffused in the DNS system), the client might not know about it until it flushes its local DNS cache, which in turn will further delay any reaction to the change.

In contrast, the FLAME platform provides fast (between 10 and 20ms) switching time from one service instance to another by not relying on the DNS for service location. Furthermore, the FLAME platform does not rely on typical mobility management approaches found in IP networks, usually leading to inefficient 'triangular' routing of requests through a common 'anchor' point. Instead, the fast and dynamic service routing of the FLAME platform leads to so-called direct path mobility, where the path between the requester and the responding service can be determined as being optimal (e.g., shortest path or direct path to a selected instance), avoiding the use of anchor points.

From a media service user's perspective, having fast switching between services means that services can be dynamically deployed *and found and used quickly* enabling mobility, one of the key PIML characteristics of the platform: services following users around. From the perspective of the media service provider it can be seen as a fine-grained load balancing solution that allows for proactive pre-placement as well as reactive activation, therefore providing for a trade-off between costs and performance benefits.

End user: Fast availability of services deployed in their location.

Media service provider: Fine-grained control of load across the network, reducing costs for the level of performance achieved.

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Multicast delivery of HTTP responses

The underlying properties of the FLAME network enable the possible multicast-based delivery of HTTP responses to service request. This is done transparently to the (otherwise unicast) semantic of HTTP transactions. The platform provides this capability at the level of each individual service request for constantly changing user groups. With that, scenarios in which individual users exit the multicast delivery, e.g., when a user watching a video together with many other uses pauses the transmission, are supported without any particular penalty to the operation of the platform beyond the obvious additional transmission of the unicast responses.

With this, media services that create a semi-synchronous request pattern across a number of users (e.g., for HTTP-level streaming scenarios over a popular catalogue of videos or the synchronization of HTTP-level resources across a number of clients) will likely see a significant reduction of costs due to the multicast delivery realized by the platform, while not needing to adapt the media services to the specifics of the multicast delivery. The potential for such cost reduction have been showcased at recent events such as the Mobile World Congress 2016 as well as 2017 for scenarios of HTTP-level media streaming. Such cost reduction and improvement on network utilization will also have significant QoE impact on media service users.

End user: Access to media services which would otherwise have been too costly.

Media service provider: The capability to cheaply broadcast content to multiple users without any need to adapt clients and services to multicast protocols.

Net-level indirection

When relying on many surrogate service endpoints to exist in the network, including content delivery nodes, there is a clear issue of certain resources not being available in one surrogate instance while existing in another. With that, state synchronization across all surrogate instances becomes a vital issue. As an alternative to such state synchronization solutions at the media service or application level, the platform also provides the capability to indirect service requests at the network level. With this, when a service request is being sent to one surrogate instance but results in a 404 or 5xx error response, the platform can be configured to redirect the original request to another alternative surrogate. Nesting these operations effectively leads to a net-level ‘search’ among all available surrogate instances until the search is exhausted (with a negative result) or the resource is found.

We expect this capability to play a significant role in distributed media services that create local content or state, where access to such state is not limited to the local service only, i.e., it could be requested from other places in the network. User generated content is one such example. Such net-level indirection capability could lead to significant reduction of traffic needed otherwise for (possibly unnecessary) state synchronization. This in turn leads to cost reductions which are of direct benefit for both media service providers and users alike.

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End user: Access to new media services that provide instant access to local content whilst retaining access to all information held in other locations.

Media service provider: The ability to create simpler media services which can rely on the underlying network to find content resources, reducing or even removing the need for content synchronisation.

Less chance of insecure direct object references

The use of CDNs in many use cases, such as the distribution of social media resources (e.g., photos, videos), usually leads to the leakage of insecure object references. This is due to the original service request, possibly issued within the secure transaction context of the service, is indirected (via the DNS canonical name entry) to, typically, the closest CDN cache node to the user. With that, the direct link of the media being retrieved changes from the secure media context to the likely insecure CDN retrieval context. The latter is likely insecure since it is usually unaware of the original security context. For instance, if someone shared a photo on a social networking site with just her friends then the photo might end up to be distributed via a CDN. Her friends, authenticated by the social network, would be given the CDN address of the image in their newsfeeds and could then access the image. However, her friends could also copy the address of the image in the CDN and share it with people not authenticated by the social network (and not friends of the poster). The problem here arises that the CDN is usually not aware of the particular authentication to view or use the particular media. Sending the (CDN) link to somebody without proper authentication will enable that person to simply access the media that was originally protected through the authentication defined by the original social media service.

The underlying network technology in FLAME enables the use of surrogates instead. With this, CDNs morph into surrogate service endpoints with the potential to also hold the necessary security context when serving the desired content. This ability simplifies the security model and benefits the media service developer. The benefit to the media service user is that there is less possibility to mistakenly or wilfully share content not intended for sharing.

End user: Private data in a service is more secure with less chance of it being accessed by unauthorised users.

Media service provider: Allows for secure data provisioning in combination with content replication, therefore increasing trust in solutions.

Secure end-to-end access to content

In conventional content delivery networks there are various difficulties when serving HTTPS content. When a user accesses a website over HTTPS they expect that their connection is to the website and that it is encrypted end to end. If a conventional CDN is used as the primary host for the site then in a sense the CDN acts as a “man-in-the-middle”, signing a certificate claiming to be the site in question but potentially retrieving data from the origin site (as well as serving cached static content). In some configurations the connection from the CDN to the origin site is unencrypted, breaking the contract with the end user once again.

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By lifting content delivery onto the level of surrogates, the FLAME platform exposes CDNs as properly secured endpoints. The necessary certificate sharing between content and CDN provider will then allow for securing the content delivery (again) according to the originally intended end user facing contract.

End user: Access to content can be encrypted end-to-end whilst still having the advantages provided by conventional CDNs (e.g. low latency).

Media service provider: Deployment of secure media services is made simpler. Trust in the service by the end users is increased.

Adaptive media delivery

Network conditions across the infrastructure may vary due to different causes such as the number of active media service users in a spot, a moving object blocking line-of-sight or weather conditions affecting the coverage of wireless nodes. To deal with these problems and to guarantee the best Quality of Experience to the users consuming media content, the FLAME platform offers adaptive media transcoding and trans-rating capabilities that adapt the streaming to the variations of the network capacity. Different video qualities can be served to each end user dynamically with the aim of maintaining a retransmission without interruptions. Furthermore, by providing a customized video player FLAME will support the media content consumption from any device e.g. mobile phones, tablets, laptops, which when combined with the aforementioned FLAME capabilities can potentially lead to a seamless transition of the media playback between devices.

End user: Access to video adapted for their personal device.

Media service provider: Off-the-shelf capability to adapt video for end users.

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8 NEXT STEPS

Later in the project, there will be a follow-up deliverable to describe the evolution of the FLAME FMI Vision, Scenarios and Use Cases. In the near term, this document will inform the evolution of the FLAME experimental methodology and also inform the FLAME platform architecture development. It will also influence experimentation activities, which include the implementation of each scenario to enable investigation of the FLAME scenarios, validation of the FLAME platform and demonstration of success stories that will motivate 3rd party project participation through open calls.

This document spans the vision of FLAME from infrastructure operators, through the platform to media service providers, their scenarios, applications and end users. As such it is an important input to the work already proceeding in the project in understanding and documenting the FMI Ecosystem Engagement Strategy and Plan. Further discussions with stakeholders about the vision for FLAME will undoubtedly be held. In particular, how FMI fits into the urban landscape will be further explored through meetings in Bristol and Barcelona.

Finally, as a future step, the FLAME Experimentation Impact Board (EIB) will consider this document as part of the external review process. The EIB includes representatives of key industries such as telco vendors, telco operators, equipment manufacturers, creative SME hubs and links to key initiatives such as the 5G PPP and NEM. The EIB is responsible for identifying FMI vision, strategy and reviewing experimentation progress, ensuring FLAME's priorities reflect areas with potential for significant socio-economic impact.

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9 CONCLUSIONS

This deliverable describes the developing vision of FLAME within the Future Media Internet (FMI). The FLAME FMI vision is described through scenarios and use cases for novel and high value media service to consumers. The vision addresses the changing nature of participation in content production workflows as well as demands for increasingly personalised, interactive, mobile and localised experiences.

We have described the relation of this deliverable to other FLAME activities, including how those activities feed into the engagement strategy, and architecture as well as subsequent software development and experimentation. We have described how the media service use cases presented here will influence the FLAME platform architecture, and have included a relational model of how use cases, scenarios and the FMI vision relate. In Figure 7 we summarise the developing relationship described in this document between the FLAME vision and its scenarios with the development of the project's platform and its realisation on FLAME city infrastructures.

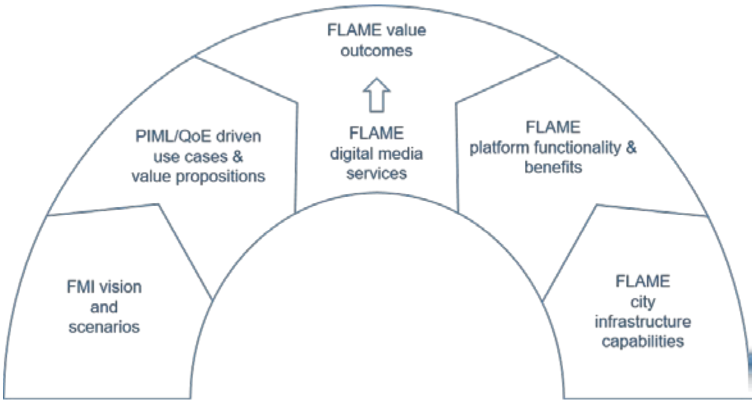

Figure 7: FMI vision, scenarios, use cases, platform and infrastructure

The four FLAME scenarios provided by consortium partners are an initial snapshot of the ongoing work to understand what the FLAME platform can achieve. They come from the broadcast, gaming and transmedia vertical markets and later in the project will be joined by 20 further scenarios coming from experiments funded through open calls and representing a broader range of vertical markets. Our scenarios seek to demonstrate the potential value of FLAME and indicate some of the opportunities and challenges arising in these vertical sectors which are dependent on effective production and distribution of media content. Each scenario contributes to the FMI vision and includes a PIML-oriented characterisation of proposed digital media applications and services that are anticipated to benefit end-users and other stakeholders of a FLAME eco-system.

FLAME's FMI Vision has also been presented from the viewpoint of consortium partners responsible for infrastructure and platform development. Our vision and scenarios described here are designed to capitalize on emerging trends in software defined infrastructure, mobile edge computing, flexible service provisioning and routing that will form an integral part of FLAME capabilities. These unique capabilities will be used to enhance the FLAME digital media services that run on the FLAME platform and their value will be evaluated in terms of the value propositions set out in our FMI vision for the FLAME project.

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