Experimentation-as-a-Service Methodology for Building Urban-Scale Media Ecosystems

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Abstract— **The H2020 FLAME project is developing an Experimentation-as-a-Service (EaaS) methodology for building urban scale media ecosystems. Using a flexible media service platform deployed within real-life smart city infrastructures, the approach allows exploration of key benefits of adaptive software-defined and cloudified network infrastructures including mobile edge computing. FLAME's initial experiments include multiple stakeholder roles (platform provider, media service provider, and consumers), each exploring acceptance and viability from different perspectives of envisaged value networks. FLAME experiments will provide the core knowledge on optimal redistribution of information and control, thus inspiring how commitments and obligations can be codified in Service Level Agreements for potential future B2B and B2C relationships.**

Keywords— Next Generation Internet Testbeds, Experimentation-as-a-service, Media, Smart Cities, software-defined infrastructures

I. Introduction

The digitisation of production processes and ubiquitous Internet connectivity is transforming the creative industries from supply chains based on the linear distribution to adaptive processes that incorporate participatory media from consumers. Massive structural changes in media ecosystems are occurring driven by four main cross-cutting trends of Personalisation. Interactivity, Mobility and Localisation (PIML) [1]. To meet this demand fundamental advances in adaptive infrastructures and services are needed. In this paper we briefly introduce an EaaS methodology for exploring the structural transformation of media ecosystems caused by increasing software-defined infrastructures and its impact on operators and sectors of the creative industries. The methodology aims to provide an open and trusted approach that allows different stakeholders to gain insight into the performance, acceptance and viability of solutions including potential governance arrangements between stakeholders.

II. EaaS Platform and Infrastructure

Our approach builds on a media service platform that exploits the software-driven nature of compute, storage and communication infrastructures (see Figure 1). Layered modular architecture principles are adopted at media and web resource level and extended through suitable layering to service routing and switching level, utilizing advances that exposes communication and routing resources through software, allowing for runtime operational and experimental manipulation. This includes the switching hardware deployed deep in the network and towards the edge of it, near end users and even on end user devices. At the compute and storage management level, Service Function Chains (SFCs) define networks of media services, utilising the infrastructure through Network Function Virtualization. The platform is deployed within real-life smart city environments offering open and programmable infrastructure capabilities that integrate software defined networking (SDN) enabled by optical, wireless, sensor mesh and computing resources [2]. The approach moves away from traditional data centre cloud resources to computing infrastructure distributed across service providers and network operators, located at the edge of the network in small gateways or in common-off-the-shelf hardware collocated with network equipment close to users. This paradigm shift is consistent with industry efforts in the Mobile Edge Computing [3].

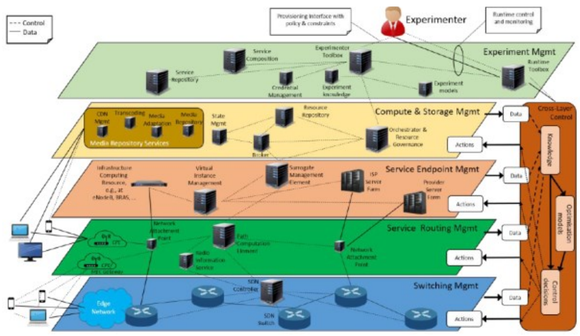

Fig. 1. FLAME functions layering for EaaS control and management

III. Experimentation-as-a-Service Methodology

Our methodology targets acceptance and viability of Future Media Internet (FMI) systems in real-life settings considering the expected demand patterns of PIML workflows. We aim to create knowledge about the platform and its use through multiple experiments and trials. We will understand the ecosystems (see Figure 2) in terms of value to vertical markets, determine demand characteristics (Quality of Experience - QoE), determine platform responses to demand (Quality of Service - QoS), maximize the outcomes of experiments and trials by maintaining quality and consistency of evaluation, and ensure conformance to regulatory and legislative guidelines (e.g. ethics).

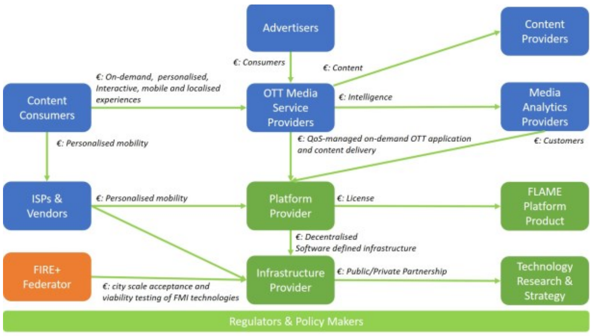

Fig. 2. FLAME stakeholders for a media ecosystem in Smart Cities

The methodology is designed to establish multi-stakeholder knowledge for optimal distribution of information and control whilst providing indications on how to dimension SLAs governing B2B and B2C relationships. The platform itself captures interactions between users but may not be in a position to understand the complex relationships between demand, context and content within applications and services necessary to optimise the use of infrastructure. Through experimentation, knowledge will be acquired on how platform value is divided between stakeholders, how disagreements and resource contention is resolved, what the appropriate governance structures are and what the appropriate standards, APIs and protocols are to support sustainability. The knowledge model is designed to allow experimenters to understand the detail of demand and experience of the system and the contributing QoS factors. The knowledge model builds on a hybrid data approach which combines formal, often numeric, metric reporting with semantic provenance information [4]. This hybrid approach allows the collection of large quantities of measurement data (e.g. service response times, network latency, user satisfaction, etc.) whilst allowing the exploration of causation between observations within such data. The ability to efficiently explore and analyse monitoring data between QoS and QoE is an essential capability for evaluation of ecosystems, and the development of SLAs and resource management policies based on derived knowledge.

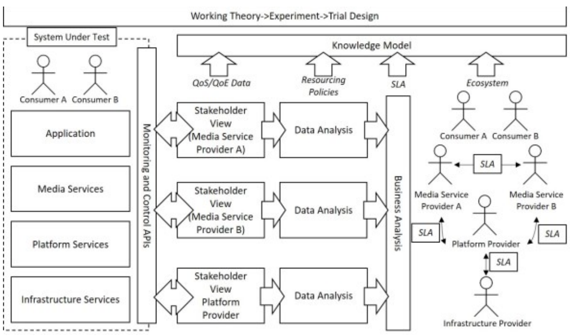

Fig. 3. Multi-stakeholder knowledge creation development process

The development process for multi-stakeholder knowledge combines working theory co-creation, experimentation and trials (See Figure 3). Working theory defines a hypothesis using rules and assumptions from the knowledge model. Experiments test theory under controlled conditions (with emulated human behaviours) to examine the validity of a hypothesis, whilst trials then provide the opportunity to test in real-life conditions. Each stakeholder within the experimental ecosystem has an information and control view of the system under test according to their role. Data and business analysis allows exploration of aspects such as the cost/benefit of temporal sharing of information or opening up of closed API functions.

IV. Validation Experiments

The methodology will be validated through 20+ experiments from the creative industries exploring different aspects of PIML. For example, an initial experiment explores audio-visual content mobility across heterogeneous devices, transport and city locations. The goal is to understand the viability of using contextually-aware mobile edge computing to increase accessibility and reduce response times for highly mobile consumers. The experiment will use platform functionality to dynamically provision SFCs responsible for managing surrogate services and content caches in response to demand. Experiment-driven manipulations of the platform include adapting links (e.g., test service routing policies for critical FMI services), constraining of communication resources, such as bandwidth on a critical access link (e.g., inducing the rate adaptation of a new coding scheme) and adaptation of computational resources dedicated to services (e.g., inducing transcoding artefacts in a video scenario).

V. Conclusions

In this paper we have outlined an EaaS methodology for establishing urban scale media ecosystems exploiting advances in software defined infrastructures. Future work will use the approach to build evidence for effectiveness through experiments and trials that engage creative industries (broadcast, gaming, etc.) and ICT industries (network operators, ISPs, service providers) responsible for online broadcast, communication, and distribution of digital content.

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