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An experimental service composition tool for media-centric networked applications

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ABSTRACT

In order to explore diverse types of media-centric service composition in real environments, we have built a service-oriented testbed named as FIRST@PC (Future Internet Research on Sustainable Testbed based on PC). FIRST@PC targets a flexible and cost-effective testing environment where media-centric service compositions are flexibly realized on top of computing/networking resources. In this paper we design and implement an OMX (Open Media eXperiment for service composition) experiment control tool to support media-centric service composition. By following the SOC (service-oriented computing) paradigm, the OMX tool assists experimenters to flexibly integrate computing and networking services. To explore the possibility of media-centric service composition, we also prototype the FIRST@PC testbed consisting of multimedia computing and networking devices. The implemented OMX tool is verified by an HD media service composition scenario run on this prototyped testbed.

1. Introduction

Increasing demand for immersive media contents requires advanced multimedia systems that process widely dispersed media contents and dynamically compose media-centric services on heterogeneous computing and networking devices [1]. These systems supports new insertion of live and stored data streams into real environments, mashup of captured media streams to create mixed visualization data, and real-time media processing to customize original media data for end users. To satisfy these demands, many researchers adopt the basic concept of service-oriented computing in designing reusable media-centric services that can be dynamically composed into more complex multimedia applications [2]. Unlike web service composition, media-centric service composition has to consider technical issues for continuous QoS provisioning. To maintain the quality of end-user experience, it should periodically monitor the performance metrics of service composition and execute the required control methods to recover from the affected resource availability of underlying infrastructure.

To validate the feasibility of newly designed services, we need to prepare an experimental testbed that accommodates the diverse needs for media-centric service experiments. To handle data-intensive and media-specific processing jobs, we carefully select suitable hardware components such as GPU-based workstations, high-volume storage, large-format displays, and video cameras. We also consider a flexible architecture to experiment with media-centric service composition by using a variety of tools. With this experimental testbed, we hope to incubate creative ideas for advanced media-centric services. Thus, to explore the possibility of innovative media-centric services, we have built a FIRST@PC (Future Internet Research on Sustainable Testbed based on PC) testbed. For the

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FIRST@PC testbed, by preparing new control and management tools, we aim to support the flexible development and stabilized operation for media-centric service composition experiments. As a part of this effort, our previous work in [3] constructed an early prototype of FIRST@PC MediaX testbed, which includes a partial version of experiment control tools and PC-based devices for media capturing, processing, delivering, and display. In [4], we also discussed various service compositions ranging from static to dynamic levels and demonstrated the static-level composition experiments using the computing resources leaving the networking aspect behind.

Recently, tied with Future Internet testbeds, a number of network-focused testbeds have been deployed by utilizing both programmable networking capability and virtualized computing substrates [5]. The effort of GENI (Global Environment for Network Innovations) [6,7] has achieved the goal to construct mezo-scale testbeds that combine OpenFlow programmable networking [8,9] and four candidates of GENI control framework such as PlanetLab [10], ProtoGENI [11], ORCA (Open Resource Control Architecture) [12], and OMF (cOntrol and Management Framework) [13]. GENI testbeds promote the preparation and federation of practical resource aggregates to harmoniously utilize networking and computing services. Going with this technical trend, our effort on the FIRST@PC testbed also explores the usefulness of media-centric service composition by arranging GENI-compatible resource aggregates and associated tools.

Thus, in this paper, we focus on developing a software tool named as OMX (Open Media eXperiment for service composition) that enables experimenters to describe, execute, and monitor their experiments for media-centric service composition. By using this OMX tool, experimenters are assisted in realizing the designed service composition that can adapt heterogeneous deployment environments. It extends a prior work, published in [4], which realized a basic idea to experiment with static service composition according to the inter-relationship of services. To cope with time-varying situations, it now supports rule-based adaptations with monitoring feedbacks in performing the service composition experiments. We also extend the prototype of FIRST@PC to actually support both programmable computing and networking resources for such experiments.[1] The specific contributions of this paper are summarized below.

- We design and implement the OMX tool for media-centric experiment control that interprets an experiment description and combines distributed services into a media-centric networked application. To assist media-centric service composition, the OMX tool helps experimenters to control a service composition process that includes service discovery, matchmaking, placement, stitching, monitoring, and tuning. It also supports balanced service composition by connecting computing services with networking services within the FIRST@PC testbed. Note however that we can easily extend the OMX tool to be utilized in any other distributed computing environments.
- We build the FIRST@PC testbed having resources that are highly programmable and virtualized in the sense of both computing and networking and then demonstrate the feasibility of the OMX tool over the FIRST@PC testbed. The realized prototype of FIRST@PC supports diverse experiments for media-centric service composition by providing balanced networking and computing resource capabilities. By using the OMX tool over the FIRST@PC prototype, we demonstrate an interesting experiment that adaptively combines several HD (high-definition) video streams from multiple remote sites.

The rest of this paper is organized as follows. Section 2 introduces the concept of media-centric service composition and reviews related work on it. We then discuss the design consideration about experimental testbeds in Section 3. Section 4 discusses our approach for media-centric service composition and details the design of the OMX tool to support such experiments. In Section 5, we explain the constructed testbed prototype and the HD media service composition experiments for verification. Finally, we conclude this paper in Section 6.

2. Background and related work

In this section, we explain the experiments for media-centric service composition based on the SOC (Service-Oriented Computing) paradigm. The SOC paradigm promotes systematic assembly for service realization by integrating independent and composable services in a variety of ways. We also introduce a short review of research literature focusing on futuristic service composition.

2.1. An overview on media-centric service composition

The multimedia community has accommodated the fundamental basis of SOC in building media-centric networked applications [14]. Basically, media-centric service composition can be achieved by a process where multiple media-centric services are connected regarding control and data dependencies in order to create a new composition over heterogeneous and distributed computing/networking infrastructures. By combining the SOC concept and sophisticated processing of media contents, we can create a convenient and flexible way to build media-centric systems. Generally, media-centric service composition can be characterized by three properties such as flexibility, controllability, and efficiency [15]. Flexibility is about how we can change the entire configuration of service composition in order to quickly adapt to different conditions and circumstances. Next, controllability enables us to intentionally adjust control variables like the amount and types of utilized resources, which affects the overall performance of service composition. Lastly, efficiency prompts an

[1] Note that the FIRST@PC testbed and the OMX tool are supported by the testbed control framework of GENI and specialized hardware and tools for massive media processing and delivery [3]. With this experimental testbed, we would like to incubate creative ideas for futuristic media-centric services.