Demonstration of a Social Aware Wireless Content Delivery Paradigm

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***Abstract*—Cloud based Content Delivery Networks have emerged over the last years as a viable cost-effective alternative to traditional CDNs. In this work we demonstrate a novel surrogate server placement strategy for fostering content delivery within the evolving wireless Cloud environment by combining Social Network Analysis inspired metrics and virtual network embedding strategies. The proposed paradigm, in terms of its feasibility and operational efficiency, is validated over the OpenLab infrastructure that offers a realistic large-scale experimentation environment.**

I. Introduction

Traditional CDNs have proven to be successful at supporting delivery of content. Most commercial CDN providers (e.g. Akamai) follow an overlay approach for CDN deployment, where content is replicated over application-specific servers (i.e., surrogate servers), while client requests are redirected to the most appropriate surrogate [1]. Traditional CDN deployments require significant investment, and are to a large extent application-specific. On the other hand, cloud based CDNs that leverage cloud resources to reduce the cost associated with implementing content delivery services, constitute a viable and cost-effective alternative ([2], [3]). At the same time, exploiting features and metrics of Social Network Analysis (SNA) [4], has be proven to be a viable option for improving performance within various contexts leading to socio-aware networked computing systems e.g., [5].

Motivated by the above two trends, we propose Social-Aware Virtual Network Embedding (SAViNE) for wireless content delivery - within the OpenLab [6] initiative - that aims at establishing, assessing and prototyping a novel framework for realizing a wireless CDN.

II. Demonstration Description and Operation

The study demonstrates and evaluates how a virtual network embedding algorithm adapted to solve the surrogate placement problem in CDN [3], is refined with the integration of SNA inspired metrics. To evaluate the proposed solution feasibility and efficiency, the envisaged scenario and CDN deployment is conducted and demonstrated over the experimental testbeds within the OpenLab infrastructure, and compared with current surrogate placement techniques [2]. The execution of the experiment consists of the i) offline and ii) online phases. During the offline phase, the experimenter selects the service area to design the wireless CDN (Fig. 1) by acquiring real-time information from the OpenLab infrastructure. The experimenter can select one or more of the proposed algorithms to

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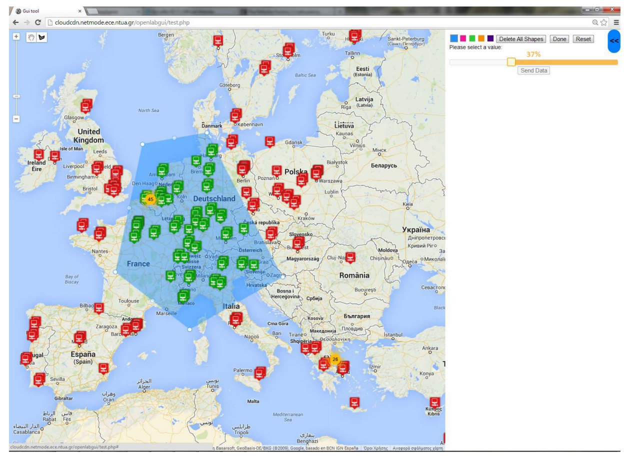

Fig. 1. SAViNE Experimental Environment

execute the surrogate placement, following the geographical dispersion of the recipients of content. The online phase involves the actual CDN deployment and operation over the topology extracted during the offline phase, where clients gain access to the requested content.

A. Architecture and Operation

The SAViNE framework, is implemented as loosely coupled set of components (Fig. 2). Four entities interact with each other during the experiment execution namely the CDN Design Engine, the SAViNE module, the OpenCDN software [7] and the Online Measurement Tool. The CDN Engine is activated during the offline phase. The core of this component is a discrete event Java-based simulator called Simulator for Controlling Virtual Infrastructures (CVI-SIM) [3] that enables the execution of the proposed algorithms and virtual surrogate placement scenarios. SAViNE module is the control entity that has been developed to initiate the overall experimental process and orchestrate the CDN Deployment and Operation phase. It receives all necessary information to deploy the CDN overlay over the testbed(s) and set up its operation. OpenCDN software is used, an open source tool which enables the deployment of an application-level multicast overlay network for content delivery. The Online Measurement Tool is deployed at the selected set of nodes and retrieves periodically appropriate evaluation metrics. A web based Graphical User Interface (GUI) has been implemented to facilitate (i) the selection of the service area (ii) the execution of the surrogate placement algorithms (iii) the selection and triggering of the CDN solution to

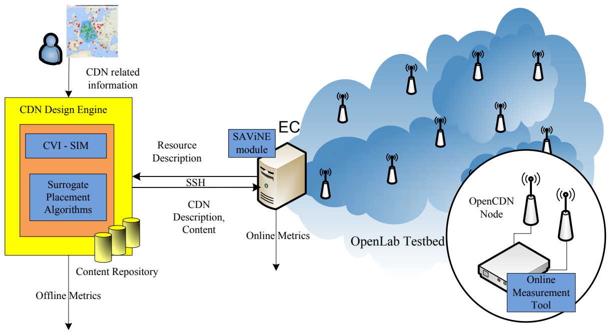

Fig. 2. SAViNE Framework

be deployed on the testbed (iv) the retrieval and presentation of statistics based on the actual operation of the CDN.

B. OpenLab Infrastructure

The experimental environment includes three testbeds of the OpenLab infrastructure [6]. The wireless w-iLab.t testbed provides an isolated, pseudo-shielded environment consisting of 60 interconnected nodes creating a multi-hop environment. Similarly, the NITOS testbed is an outdoor, real world wireless testbed consisting of 30 nodes. Finally, for the purpose of setting up cross testbed, large-scale experimentation, 200 nodes from PlanetLab Europe are employed utilizing appropriate emulation techniques. Since nodes in PlanetLab can provide a full mesh topology, the experimenter can select the percentage of connectivity between the nodes in the service area to create a multi-hop environment (Fig. 1).

C. Surrogate Placement Algorithms

In this study surrogate placement is optimized with regards to QoS and CDN deployment cost, over the wireless cloud. Within the cloud, the replica placement is a joint problem of building content distribution paths and replicating content [2]. Towards this direction, two socio-aware heuristics are introduced that is the SNA Inspired Virtual Surrogate Placement (SNA-VSP) and a greedy replica placement algorithm referred to as SNA Inspired Greedy Virtual Surrogate Placement (SNA-GVSP) [3]. The SNA-VSP is a sub optimal algorithm with the objective to minimize the overall CDN deployment cost, while maximizing the average Shortest Path Betweenness Centrality (SPBC) [4] of the selected set of surrogates (SPBC is a social metric indicating the popularity of a node, in terms of the extent to which a node has control over the traffic-carrying capabilities of the infrastructure). SNA-GVSP has the goal to greedily assign end-users to virtual surrogate servers, maximizing the average SPBC of the selected set of surrogates, as means to minimize the path length of the content distribution path. A third algorithm called Greedy Site (GS) presented in [2] is also considered and is based on finding a candidate surrogate with a maximum utility function.

D. Offline Evaluation Metrics

Regarding the offline phase, the efficiency of the surrogate placement solution is evaluated through a number of offline metrics. Fig. 3 illustrates the solution of the SNA-VSP algorithm in the w-iLab.t testbed. Nodes depicted with yellow color

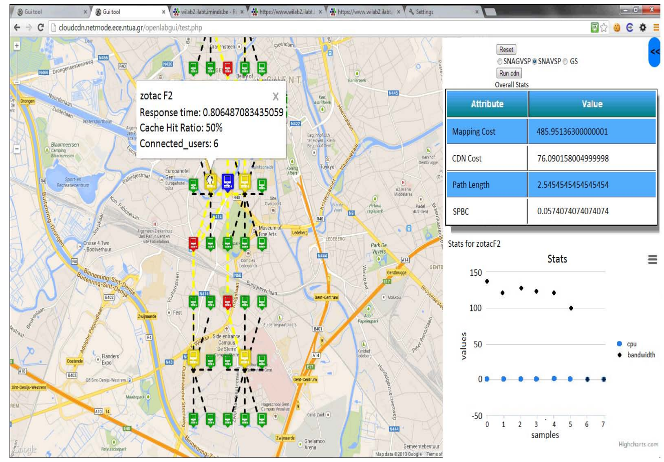

Fig. 3. SAViNE Offline Online evaluation

represent surrogate servers. Transit nodes (red color), relay the content from origin (blue color) to surrogates. Clients are illustrated as green nodes. The table on the right side of Fig. 3 presents the offline metrics including i) CDN deployment cost, based on the adopted cost model (retrieval, update, storage) [2] ii) the mapping cost of using the testbed's physical resources [3], iii) the average number of hops between clients and the origin server and iv) the average SPBC of the CDN solution.

E. Online Evaluation Metrics

On the other hand, to measure the CDN's ability to serve customers with the desired content, some commonly adopted online metrics are evaluated. Specifically the experimenter can select a node (Fig. 3) to obtain the user perceived response time (in case of clients) and number of connected users / cache hit ratio (in case of surrogates). Complementary, the correlation between the medium quality and CDN performance leads to the inspection of throughput, illustrated at the bottom right of Fig. 3. Finally, the surrogate server aggregate load is sampled over a specified time window.

Acknowledgment

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