Journal of Computer and System Sciences 81 (2015) 1479–1495

Contents lists available at ScienceDirect

Journal of Computer and System Sciences

www.elsevier.com/locate/jcss

Incentive-based resource assignment and regulation for collaborative cloud services in community networks

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ARTICLE INFO

Article history:
Received 1 July 2014
Received in revised form 14 December 2014
Accepted 14 December 2014
Available online 24 December 2014

Keywords:
Cloud computing
Community networks
Incentive mechanisms
Resource regulation

ABSTRACT

Community networks are a successful example of a collective where communities operate ICT infrastructure based on the principle of reciprocal sharing of network bandwidth. Cloud computing, common in today's Internet, has however not materialised within community networks. We analyse in this paper socio-technical characteristics of community networks in order to derive scenarios for community clouds. Based on an architecture for such a community cloud, we implement a prototype for the incentive-driven resource assignment component and evaluate its behaviour experimentally. In simulations of large-scale community cloud scenarios we study the behaviour of the incentive mechanism in different configurations. Our evaluation gives insight into how the developed mechanisms regulate the consumption of cloud resources. Our results suggest a further integration of this regulation component into current cloud management platforms in order to open them up for the operation of an ecosystem of collaborative cloud services in community networks.

1. Introduction

Community networking is a shared communication infrastructure in which citizens build and own open communication networks. Most of these community networks are based on Wi-Fi technology such as ad hoc networks or IEEE 802.11a/b/g/n access points in the first hop and long-distance point-to-point Wi-Fi links for the trunk network. Recently, a growing number of optical fibre links are also being deployed [1]. Despite the lack of reliable statistics, community networks seem to be rather successful. There are several large community networks in Europe, having from 500 to 20,000 nodes, such as Athens Wireless Metropolitan Network (AWMN), Freifunk.net, FunkFeuer.at, Guifi.net, Ninux.org, and many others worldwide. Fig. 1 shows the wireless links and nodes of Guifi.net in the area around Barcelona.

The community cloud we present in this paper is the vision of a cloud deployment in community networks: A cloud hosted on community-owned computing and communication resources providing services of local interest. The concept of community clouds has been introduced in its generic form before, e.g. [2,3], as a cloud deployment model in which a cloud infrastructure is built and provisioned for an exclusive use by a specific community of consumers with shared concerns and interests, owned and managed by the community or by a third party or a combination of both.

Community networks successfully operate as IP networks, since the nodes' bandwidth is shared among all the members in a reciprocal manner. While there are also services offered from within the community networks, most members of community networks use the infrastructure solely to access the Internet, and they consume services in the Internet and not

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http://dx.doi.org/10.1016/j.jcss.2014.12.023
0022-0000/

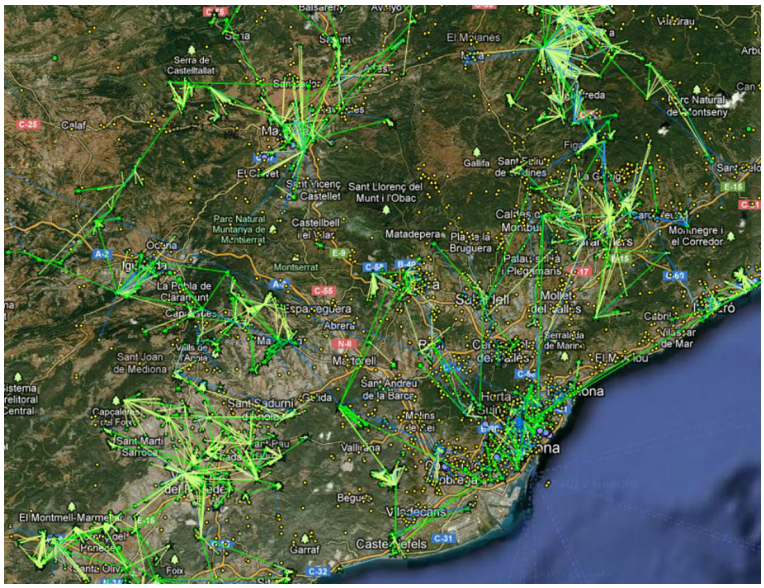

Fig. 1. Guifi.net nodes and links in Barcelona.

within the community network. If there are services inside the network, they usually run on machines exclusively used by a single member (normally the owner of the machine). We emphasize that the sharing of storage and computational resources, which is now common practice in today's Internet through cloud computing, hardly exists in community networks.

Community networks are an ecosystem which is able to regulate and maintain itself, some of the community networks are there for even more than a decade. Participants of the community network not only contribute infrastructure to the network, but also their knowledge, time and effort for successful operation of the network. We anticipate that cloud infrastructures for community networks will need additional incentive mechanisms in order to achieve sustainability. In this paper we study an incentive mechanism for clouds in community networks, keeping in view the key characteristics of community networks and the scenarios we foresee for community clouds. This incentive mechanism is inspired by Parecon economic model [4,5], and based on the idea of effort of each participant, which we define as its contribution relative to its capacity. Our approach is to do the evaluation with a prototype and simulation experiments, which will allow us to derive additional conclusions regarding its feasibility for implementation and deployment on a wider scale. The main contributions of this paper are the following:

1. We identify a community cloud scenario, envisioned as a federation of local clouds, which is derived from a socio-technical analysis of community networks.
2. We implement a proposed incentive mechanism in a regulation component and deploy it in real nodes of a community network.
3. We evaluate experimentally with the deployed prototype the behaviour of the incentive-driven resource assignment in the community cloud scenario.
4. We evaluate the behaviour of incentive mechanism in simulations of large-scale community cloud scenarios with different configurations.

We elaborate our contributions in the following way. In Section 2, we analyse community networks and bring about the community cloud scenario. In Section 3, we discuss a cloud architecture applicable to the topology of community network deployments, taking into account socio-economic context of the community networks necessary for encouraging collaborative resource sharing. In Section 4, we introduce the prototype implementation for the resource assignment component of the community cloud architecture, and we evaluate in experiments the resource assignment behaviour of the prototype by deploying it in a testbed of real community network nodes. In Section 5, we evaluate our incentive mechanism with simulation experiments in a community cloud scenario. In Section 6, we present related work, and in Section 7, we conclude and indicate future work.

2. Clouds in community networks

Since our community cloud is targeted to be used in real community networks, it is a must that our architecture, design, implementation and deployment fits into these conditions and scenarios. We focus our analysis on the Guifi.net community network, which is considered the largest community network worldwide, and it is where we have also deployed our prototype.