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Leveraging deployment models on low-resource devices for cloud services in community networks

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ABSTRACT

Community networks are crowd-sourced IP networks that evolved into regional-scale computing platforms. This has led to adapting the cloud computing model for services that can operate and use computing resources inside a community network. The network and computing infrastructure is contributed by individuals, companies, organizations and maintained by its members. Community cloud devices are often low-capacity computing devices, such as home gateways or cabinet servers, with limited capabilities. These devices are used to install and operate specific personal or community services, but can be turned into multi-purpose execution environments applying machine or operating system (container) virtualization. However that requires addressing the problems of resource sharing in low-capacity devices, related to predictable performance and isolation. Our comparative analysis with the current infrastructure in community networks gives evidence about how devices can concurrently run multiple services, the trade offs between the number and resource requirements of services and the degradation of quality that services may suffer.

1. Introduction

Community networks are large-scale, self-organized and decentralized networking infrastructures built and operated by the community itself. They are open, free and neutral IP networks. Hundreds of community networks are operating, which are geographically distributed in different parts of the world without relying on any specific social or economic reasons. The larger networks have from 500 to more than 30,000 nodes, such as guifi.net[1], FunkFeuer[2], AWMN[3], Freifunk[4]. The infrastructure is contributed by individuals, companies and organizations in a joint effort.

Resource sharing within the community networks refer in practice to the sharing of network bandwidth from each device. This enables traffic from devices to be routed through others to its destination. The sharing of services, such as video streaming, storage, VoIP, which through cloud computing that has become common practice in the Internet, hardly exists in community networks. Therefore, a community cloud model could suit to accommodate services and/or resource sharing among community members.

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[1] http://guifi.net.
[2] http://www.funkfeuer.at.
[3] http://www.awmn.gr.
[4] http://freifunk.net/.

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The CONFINE project[5] (2011–2015) was initiated to advance the understanding of the community network model, to explore the ways of improving the users quality of experience in a shared platform and to measure the sustainability of the network. For this purpose, the CONFINE project has developed an infrastructure called Community-Lab [1], which provides an environment to perform community network related experiments. The physical computing devices in Community-Lab are low-power mini-PCs placed in non-specialized locations such as homes, garages, farms, schools. These resources can be shared among community members and used for the energy-efficient and distributed service hosting.

The Clommunity project[6] (2013–2015) aimed at developing the community cloud model and developed Cloud[7] to allow community networks to sharing their resources for user-oriented services. For that purpose, a number of low-power computing devices (called Minix) were deployed within guifi.net, in order to experiment with users on sharing resources and using services within the Community network.

These two environments have restrictions in using computing resources for private purposes (in Community-Lab) or for the deployment of generic services (in Clommunity). We address this limitation by designing an environment in each device that can benefit both the community and the device owner. Consequently, this produces a multi-purpose environment in a single device, such as one environment for the device owner and another environments shared with the community network. With the support of machine or operating system virtualization, these environments can achieve the requited security or performance objectives.

The main contribution of this work include:

- The design of container-based resource virtualization on top of low-power devices, enabling a multi-purpose environment isolated from each other. Users can share a portion of the device resources, isolating the portion allocated to the owner from the portion for third-party services.
- Evaluation of the performance of devices when running services on the virtual environments, and comparison with the current Community-Lab devices.
- Evaluation of the quality degradation on services in our proposed approach with an heterogeneous environment, when increasing the number of services running concurrently.

For validation we create a small-scale physical Community-Lab infrastructure using several low-power devices together as computing and storage devices and its own Community-Lab testbed controller. In the experimental system we deploy services such as file storage (Tahoe-LAFS) [2,3], video streaming (PeerStreamer) [4,5] and IoT (ThingSpeak)[8], as community cloud services. These services serve as an entry point to measure their performance when running in an environment according to our design. This way, we can gather knowledge on the quality of service when running services from both owner and community networks simultaneously and in an heterogeneous infrastructure. These services represent typical network, processing or storage demanding services of community networks.

The rest of the paper is organized as follows. Section 2 explains the Community cloud and relates to the Community-Lab experimentation testbed, its functionality and the technologies that are deployed, along with the sustainability models for these models. Section 3 describes the system architecture and the deployment approaches. Section 4 refers to the experimental setup used. The evaluation and results are presented in Section 5. The related work is described in Section 6. Conclusion and future work is explained in Section 7.

2. Community clouds

Community clouds are formed by a collaborative effort to create a computing platform where the infrastructure is shared between a number of organizations in order to provide a platform for common computing concerns. One particular objective is to provide a scalable computing platform to conduct community network related research and experimentation. In this section, we explain the system overview of the CONFINE Community-Lab infrastructure.

2.1. Community-Lab: a community networking testbed

The CONFINE research project aimed at expanding community networks and facilitate the deployment of experimental or production services [6], as if they were deployed in any commodity cloud platform. Each Community-Lab device, and there are in the range of 200, has a range of IP addresses (IPv4 and IPv6) to allow running multiple services.

Community-Lab, shown in Fig. 1, is an infrastructure that provides a set of tools allowing researchers to easily deploy, run, monitor and experiment community cloud services, protocols and applications in a real community IP network (guifi.net, FunkFeuer, AWMN and Freifunk) instead of simulated environments.

The platform is monitored by a single entity, the controller, which allows users to lease resources from any of the devices, and deploy their experiments on the selected nodes. Particularly, users can choose geographically distributed computing

[5] http://confine-project.eu.
[6] http://clommunity-project.eu.
[7] http://cloudy.community.
[8] http://thingspeak.com.