Cloud-based extension for Community-Lab

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***Abstract*—Community-Lab is an open, distributed infrastructure for researchers to carry out experiments within wireless community networks. Community networks are an emergent model of infrastructures built with off-the-shelf communication equipment that aims to satisfy a community's demand for Internet access and ICT services. Community-Lab consists of more than 100 nodes that are integrated in existing community networks, thus giving researchers access to community networks and allowing them to conduct experimental evaluation of routing protocols, services and applications deployed there.**

Community networks have now the opportunity to extend the collaborative network building to the next level, that is, building collaborative services implemented as community clouds, built, operated and maintained by the community, that run on community-owned heterogeneous resources, and offer cloud-based services that are of the community's interest.

This demo paper focuses on demonstrating the cloud extension of Community-Lab, enabling now community cloud experiments. By means of selected applications, we show how Community-Lab has been extended with distributed clouds, where different devices such as server, desktop PCs, low-resource embedded PCs and IoT boards are brought together forming a heterogeneous distributed cloud environment for researchers to experiment in community networks.

***Index Terms*—community networks; cloud computing; cloud storage; fault tolerance**

I. Introduction

Since the first community networks started more than ten years ago, they have become rather successful nowadays. There are several large community networks in Europe having from 500 to 20000 nodes, such as FunkFeuer[1], AWMN[2], Guifi.net[3], Freifunk[4] and many more worldwide. Most of them are based on Wi-Fi technology (ad-hoc networks, IEEE 802.11a/b/g/n access points in the first hop, long-distance point-to-point Wi-Fi links for the trunk network). Figure 1 shows as example the wireless links and nodes of the Guifi.net community network in the area of Barcelona.

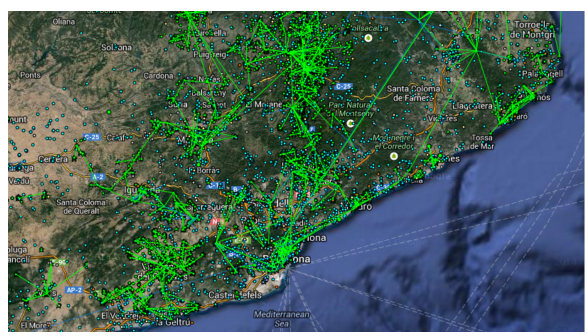

Fig. 1. Guifi.net nodes and links in the area around Barcelona

Applications have a challenging environment to cope with when deployed in community networks. Community networks are characterized by:

- Hardware and software diversity: The network nodes and computers are often inexpensive off-the-shelf equipment with large heterogeneity in the hardware, software and capacity.
- Decentralized Management: The network infrastructure and the computers are contributed and managed by the users. They belong to the users and are shared to build the network. There is usually no (or a rather weak) central authority that is responsible for resource provisioning.
- Dynamics: The number of network and computing nodes may rapidly change when members join or leave the

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

network, or when nodes overload or fail.

This demo paper presents a cloud-based extension of Community-Lab [1] [2] [3], which allows community network members and researchers to deploy their experiments and run their applications on heterogeneous cloud-based infrastructures within community networks. Community-Lab is a testbed with testbed nodes deployed within real community networks. Different to simulations or small controlled laboratory experiments, Community-Lab offers to researchers a realistic environment for experimentation with the characteristics of real community networks.

Community-Lab is inspired by PlanetLab, but differs. First, the domain is community networking: a large number of small-resource devices, limited network links, more fragile and less managed than commercial or academic networks; second, Community-Lab is designed to allow experiments ranging from the physical layer, routing, transport, applications to services, and even social experiments. Community-Lab nodes are integrated into and form a small part of large real production networks. Community-Lab applies container virtualization, allowing for concurrent and long term experiments on non-dedicated nodes.

II. Community-Lab testbed

Community-Lab consists of an operational testbed with currently more than 100 nodes deployed among three community networks in Europe. Testbed nodes are deployed in Guifi.net in Spain, Funkfeuer in Austria, and Athens Wireless Metropolitan Network (AWMN) in Greece.

A. Testbed node system

The nodes in Community-Lab are deployed as additional nodes within the community networks. Like a typical community network node, the testbed nodes extend the community network by offering an experiment or services and applications to be deployed on them. While from the perspective of the community network, the testbed nodes are just additional nodes, the testbed nodes offer at the same time remote access to researchers allowing them to conduct experimental studies. In order to achieve this double functionality of the testbed nodes, a node system was developed for the testbed. The Community-Lab testbed node consists of two devices: a community device and a research device [4]. As detailed in [1], community devices are off-the-shelf wireless routers, while research devices are low-power embedded PCs with a customized OpenWRT distribution that allows container virtualization. Figure 2 shows some outdoor nodes of Community-Lab. The wireless routers (integrated in the antennas) connect to other nodes of the community network, achieving thus a real integration of the testbed nodes into the community network.

In Figure 3 a research device of Community-Lab is shown. Depending on the hardware used for the research device, these research devices are deployed either outdoors attached to the community devices, or indoors with Ethernet connection to the community devices.

Fig. 2. Outdoor nodes deployed in Commmunity-Lab

Fig. 3. Indoor device deployed in Commmunity-Lab

B. User access application

Researchers use the testbed portal[5] to browse and select resources and create slices, a set of virtual machines on a subset of the nodes. The researchers can identify their slice and the nodes with the configuration they need for remote access and to perform experiments.

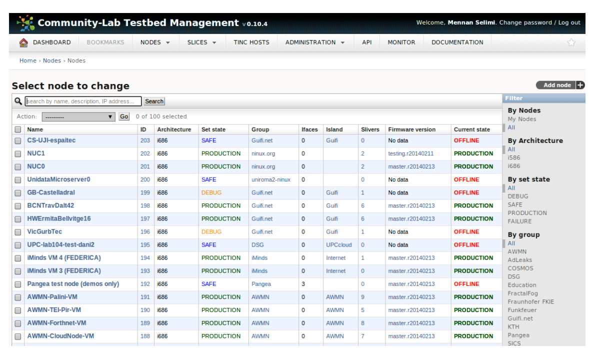

Fig. 4. Node selection view of user access application in Community-Lab

[5]http://controller.confine-project.eu

C. *Usage and management services*

Community-Lab nodes are spread among the community network. In order to enable research with them, services for the usage and management of the testbed have been developed. These testbed management services allow registering testbed nodes, carrying out sliver and slice management on testbed nodes, and allowing researchers to access the nodes. The components of the testbed management consist mainly of a centralized controller and extensions in the node system software of the research device that communicate with the controller. The management services interact with the portal database in order to associate users to slices and nodes.

III. Community clouds

Resource sharing in community networks from the equipment perspective refers in practice to the sharing of the nodes bandwidth. This sharing enables the traffic from other nodes to be routed over the nodes of different node owners. This is done in a reciprocal manner which allows community networks to successfully operate as IP networks. The sharing of other computing resources which is now common practice in today's Internet through cloud computing, hardly exists in community networks, but it can be made possible through clouds in community networks.

The concept of community clouds has been introduced in its generic form before, e.g. [5], [6], 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. We refer here to a specific kind of a community cloud in which sharing of computing resources is from within community networks, using the application models of cloud computing in general [7], [8]. Realising community cloud involves a lot of challenges both in technological and socio-economic context, but also promises interesting value proposition for communities in terms of local services and applications.

For the cloud extension of Community-Lab, apart from using the Community-Lab research devices located in Guifi.net (Spain), AWMN (Greece) and Funkfeuer (Austria), we deploy local clouds in Guifi.net locations in Catalunya (TAR, HAN, UPC), in Sweden (KTH) and Italy (ICTP), where the KTH and ICTP nodes are part of the Guifi community network infrastructure, being integrated in Guifi.net through EoIP tunnel and having a Guifi.net IP address range. This cloud extension enables researchers to include also such local community clouds to their experiments. In addition, we also include Internet-of-Things (IoT) boards (Intel Galileo), with which users can write and read sensor data. Figure 5 shows the complete scenario of the distributed heterogeneous scenario for experimentation. Cloud infrastructure of these nodes is provided by KVM-based VMs from Proxmox and OpenStack cloud management platforms, by Linux containers (LXC) from a community resource management platform, and even from IoT embedded boards.

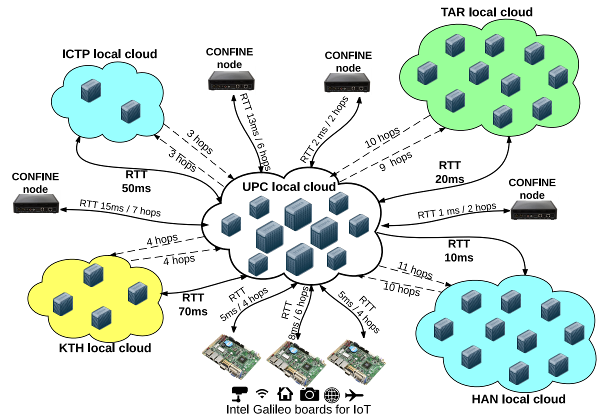

Fig. 5. Distributed community cloud deployment scenario

IV. Cloud-based Applications in Community-Lab

Applications are needed to make community networks attractive to a larger part of society. We consider in this section three representative applications to exemplify how the Community-Lab testbed allows researchers to deploy, evaluate and enable community cloud experiments. The performance analysis of experiments provide clues to researchers on what needs to be improved in these applications for achieving an improved user experience when run in community networks.

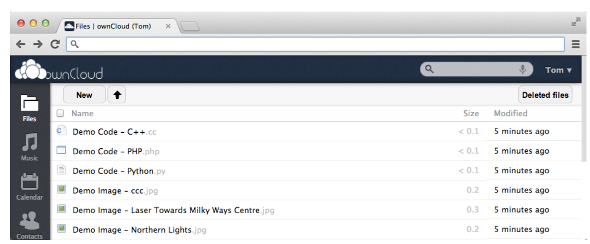

Fig. 6. Owncloud user interface

Service Name	Nickname PeerID	Connected?	Since	First Announced	Version
storage	TARADELL10 bk6u4fht5jvyhmnor4gje5sosodmg6pl	Yes: to 10.140.224.44:45648	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	KTH3 bxegpl535aermyld6bxpr2bkmzdtpsmk	No	19:03:16 02-Apr-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	TARADELL5 b7iy54e7avxdud2xgpleowge3bvg6a63	Yes: to 10.140.224.39:44122	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	HANGAR4 cfqq3n4ax7u6iuu4p7hc72bdzq72mqx4	Yes: to 10.139.94.115:34476	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	UPC8 e2izvwr7ief33h6gm7mgyapwuzp24wof	Yes: to 10.139.40.118:53834	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	TARADELL3 f2oq2zgksvxa5twisdyyzetbooll4e6m	Yes: to 10.140.224.37:48695	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	UPC2 gc4ik5hch56syvhcm37d32d6t2g65imd	Yes: to 10.139.40.120:50619	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	ICTP-2 gkhois64ozzpobnyp6tu5uweekc2pewz	No	12:13:08 01-Apr-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	TARADELL2 hjhameaf63pbry6ttqeodxak5drwgtdp	Yes: to 10.140.224.36:58057	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	HANGAR1 hstdoids642kkurpy6a4em7osgjtv4fq	Yes: to 10.139.94.112:46086	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	HANGAR6 jenmi3rxhtqheowyw3xma6ajkzjevgea	Yes: to 10.139.94.118:40564	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2
storage	UPC7 jtotbujwz5rszkeymmrwddc65p6vsdvf	Yes: to 10.139.40.74:48547	23:10:29 29-Mar-2014	23:10:29 29-Mar-2014	allmydata-tahoe/1.9.2

Fig. 7. Tahoe-LAFS introducer page

We select for our demonstration of cloud-based community services three application types. These applications are also used in our own research. They were selected because they have several attractive features for end users. Successful operation of these applications should encourage community network users to join and participate in community clouds. As applications to deploy on Community-Lab we select ownCloud[6], a popular open source software which in some features resembles the commercial Dropbox, a distributed file system, and BitTorrent.

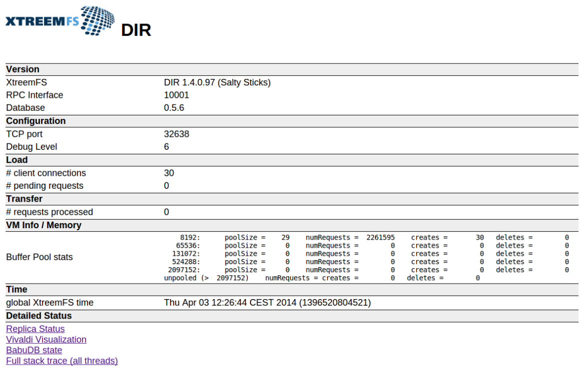

Fig. 8. XtreemFS DIR web interface

OwnCloud allows to select among different distributed file systems as storage backends. We select to deploy Tahoe-LAFS [7] and XtreemFS[8] as distributed file systems. Tahoe-LAFS is a secure and fault-tolerant distributed file system, potentially suitable for the conditions of community networks, to be used as storage backend of ownCloud. XtreemFS is an open-source file system for fault-tolerant distributed storage. Different replica selection policies make both an interesting option as distributed file systems for community networks. We host the Tahoe-LAFS and XtreemFS distributed applications on nodes of a community clouds spread inside of the community networks. We deploy BitTorrent for demonstrating a file-sharing application that runs on the heterogeneous infrastructure of Community-Lab.

V. Demonstration

The demonstration at the MASCOTS 2014 conference is a live demo of the cloud extension of Community-Lab in two parts: 1) A live demo of the access and usage of the Community-Lab testbed by researchers. For this purpose we will connect to the Web interface of the Community-Lab portal, connect to testbed nodes integrated in Community-Lab, and show how the testbed can be used by researchers. 2) A live demo of a local Community-Lab testbed with some operational devices deployed at the conference. A set of Community-Lab testbed nodes (2 nodes) will be installed at the demo location. A set of distributed applications (e.g. decentralized storage, file-sharing) will be installed on the research devices to exemplify the usage of Community-Lab for experimenting with applications deployed in community clouds.

VI. Conclusion

The demo of Community-Lab shows how a set of application and services are deployed and run in cloud-based Community-Lab, an experimental facility that allows researchers to conduct experiments in real community networks. The demo is organized in two parts: First we show for researchers the remote access to the Community-Lab portal and testbed and secondly, we show how experimentation with cloud-based applications is done in Community-Lab. In the remote access to Community-Lab, the demo shows the access through the portal to the experimental facility and gives the audience a clear idea on how researchers can experiment with applications in Community-Lab. A local deployment at the demo location of a few Community-Lab nodes will show the infrastructure on a small scale. Cloud-based applications experiments will be shown for a Tahoe-LAFS deployment in Community-Lab on a large number of nodes, to which we will add new nodes and interact with permanent Tahoe-LAFS storage servers. We will also show how through the community distribution, new services and applications are deployed in Community-Lab. Therefore, the demo shows to researchers Community-Lab as tool which helps to conduct research by real deployments at different levels of the community network system. Community-Lab has been extended to support distributed services and applications evaluation on a distributed heterogeneous system. This extension opens ultimately the possibility to experiment on systems with cross-layer interactions between social and technical aspects.

[6]https://owncloud.org
[7]ttps://tahoe-lafs.org/trac/tahoe-lafs
[8]https://xtreemfs.com

VII. Acnowledgements

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