2016 International Conference on Computing, Networking and Communications (ICNC), Workshop on Computing, Networking and Communications (CNC)

Cloud-based Community Services in Community Networks

Roger Baig*, Felix Freitag†, Agusti Moll‡, Leandro Navarro†, Roger Pueyo‡, Vladimir Vlassov§
*Fundació Privada per la Xarxa Lliure, Oberta i Neural Guifi.net. Mas l'Esperanca, 08503 Gurb, Catalonia
{roger.baig}@guifi.net
†Department of Computer Architecture. Universitat Politècnica de Catalunya. Barcelona, Spain
{felix, leandro}@ac.upc.edu
‡Routek S.L., Barcelona, Catalonia
{agustimoll, rogerpueyo}@routek.net
§KTH Royal Institute of Technology. Stockholm, Sweden
{vladv}@kth.se

***Abstract*—Wireless networks have shown to be a cost effective solution for an IP-based communication infrastructure in underserved areas. Services and application, if deployed within these wireless networks, add value for the users. This paper shows how cloud infrastructures have been made operational in a community wireless network, as a particular case of a community cloud, developed according to the specific requirements and conditions of the community. We describe the conditions and requirements of such a community cloud and explain our technical choices and experience in its deployment in the community network. The user take-up has started, and our case supports the tendency of cloud computing moving towards the network edge.**

***Index Terms*—community networks; cloud computing;**

I. INTRODUCTION

Community networks are a communication infrastructure model in which local communities of citizens build, operate and own open IP-based networks. Community networks often originated for providing Internet access to the population of areas which were unattended by commercial telecom operators. These networks are often set up through a collective effort, using off-the-shelf equipment for wireless communication between nodes, and maintain with the contributions of time and knowledge the communication network [1].

A community cloud is a cloud deployment model in which a cloud infrastructure is built and provisioned for use by a specific community of consumers with shared concerns, goals and interests. It is owned and managed by the community or by a third party or a combination of both [2]. A community cloud offers features that are tailored to the needs of the specific community it addresses. The difference between one community cloud and another is that the provision of certain features, e.g. performance, security, ease of usage of the cloud, are emphasized. Community clouds exist today for different industry sectors and are commercially operated.

The community cloud we show in this paper is the vision of a cloud hosted on community-owned computing and communication resources providing services of local interest. It is a particular case of a community cloud, a cloud for community wireless networks, tailored to the specific requirements and conditions of such a community and adapted to the technical challenges of these decentralised and WiFi based networks. While the foundational elements of such a community cloud solution have been discussed before [3], deployed implementations have just started. We leverage in our proposal on the concept of community clouds, but propose a community cloud that is collectively built and maintained by citizens.

We contribute in this paper with technical choices and practical experience from having deployed and observed a real community network cloud during several months. We assess different aspects of this cloud such as user engagement, cost, security and innovation potential. Our results suggest the potential of this type of cloud to cover several applications of edge computing in the future cloud computing landscape.

II. CONDITIONS AND REQUIREMENTS

In order to position this cloud for wireless community networks, we first review the characteristics of these networks regarding their technical and social aspects, and elicit some of the resulting requirements.

Hardware aspects: Community networks are built with off-the-shelf and cheap hardware. Currently community networks mainly consist of the networking infrastructure (router and antennas) and are configured as IP network. In order to materialize the vision of community network clouds, users will need to add computing and storage devices to this network infrastructure. These devices will be heterogeneous and will depend on the investment each user is willing to make.

Therefore, the community network cloud software must be able to run on different hardware and architectures, in particular x86, but also ARM, to enable the integration of energy saving, low-capacity devices such as the Raspberry Pi in the cloud.

Social aspects of community networks: In large community networks, the community consists of a diversity of people. Some have technical backgrounds and are able to configure and set up routers and computers, but others do not. Furthermore, participants of community networks are consumers and producers. As producers, they contribute infrastructure and time to the network. As consumers, they use the available services and resources. Personal and social relationships play an important role in the maintenance and growth of the network. Newcomers typically receive support from the community to join it.

Given the diversity of people in the community, an important requirement of the community network cloud is that its software is user-friendly and that it can be used by the average user. In addition, self-management capability of the software is essential to save the users' time, since users can often only contribute time on volunteer basis.

Ownership: Typically, the participants keep the ownership of the contributed resources. However, the usage of these resources is made available to the whole community forming an infrastructure hold in commons. A critical mass of contributed resources should to achieved in order to facilitate the creation of useful services for the benefit of the whole community.

This condition generates the technical requirement to be able to share resources. On the infrastructure level of cloud computing, virtual machines allow to do this. However, on the platform and software service level, sharing of services must also talk place, in order to be able to provide a basic set of support services which enable the inter-operation of the contributed resources.

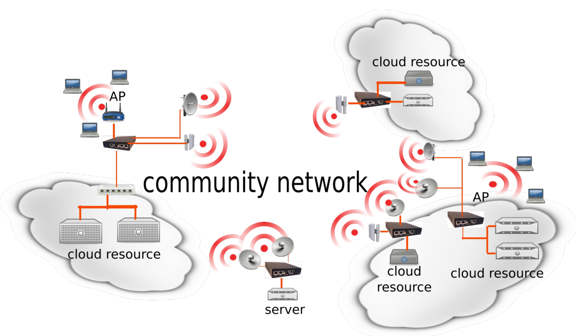

Fig. 1. Cloud in a community wireless network.

III. Deployed Community Cloud

We describe in this section the cloud infrastructure that we have deployed in a community network. Figure 1 illustrates the system. The picture shows some typical community nodes with a router and some servers and clients attached to it. In addition, these community nodes have cloud resources attached to them. They are part of the community cloud.

In the following we describe our case, which is a real deployment of cloud computing infrastructure and services in the Guifi.net[1] community network, located around Barcelona in Spain. Guifi.net with more than 30000 nodes can be considered the largest community network worldwide.

A. Hardware

In Figure 2 an example of the indoor hardware of a cloud node is shown. In this case a small Jetway device is used as cloud resource. A UPS keeps the node running in case of power failures. It is connected over Ethernet to the outdoor community network node. This cloud node represents the case of a low-end cloud resource, such as a home gateway, which users can provide to the cloud. Other cloud nodes which we have deployed are several Dell OptiPlex 7010 desktops.

Fig. 2. Cloud resource at a community network node.

B. Cloud Management Platform

In the high-end community clouds which we have deployed, e.g. desktop PCs, we use mainly Proxmox as Cloud Management Platform (CMP), and experimented with OpenStack. The reason for using Proxmox is that within the community network, there is already some positive usage experience, and the installation and operation of Proxmox is relatively easy compared to other CMPs. OpenStack on the other hand, is popular as a powerful customizable cloud platform, supported by a large user community, though not within community networks.

C. Containers and Virtual Machines

Cloud management platforms provide Infrastructure-as-a-Service (IaaS) in terms of virtual machines (VMs) and virtual networks. The VMs we provide in the community cloud are either virtual machines based on the KVM hypervisor (managed by OpenStack and Proxmox) or containers (OpenVZ provided by Proxmox or Linux Containers (LXC)).

D. Software Distribution

We provide a community cloud GNU/Linux distribution, codenamed *Cloudy*, aimed and designed for building clouds in community networks. This distribution contains the platform and application services of the community cloud system.

Cloudy[2] is the core software of our cloud, because it unifies the different tools and services of the cloud system in a Debian-based Linux distribution. Each community cloud user who contributes infrastructure to the cloud is encouraged to install the Cloudy distribution on his/her on-premise device at home.

[1] https://guifi.net/

[2] http://repo.clommunity-project.eu/

Cloudy is open-source and can be downloaded from public repositories[3]. Cloudy is meant to be useful and usable for the end-user, to be installed on any kind of on-premise devices, which then can become part of community network cloud. Therefore, Cloudy has been installed on desktop PCs, but also on low-resource single-board-computers, such as RaspberryPI and BeagleBoard Black[4].

Cloudy installs like a standard Debian distribution and is given in three flavors: As a standalone version to install on real hardware, a container-based one to install on a virtualized operating system, and an operating system image to install on virtual machines.

Figure 3 shows Cloudy's Web-GUI after login. It can be seen that Cloudy contains three main types of services: 1) search, 2) community services, and 3) Guifi.net services.

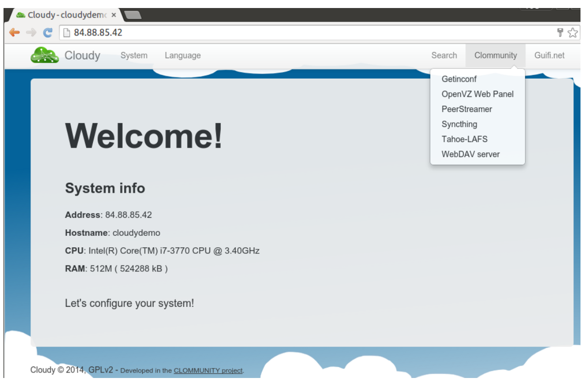

Fig. 3. Services in the Cloudy distribution.

E. Services

We provide in the Cloudy distribution a set of ready-to-install services, which community cloud users are expected to find useful and attractive, grouped as Search, Community and Guifi.net. The Search service allows the user to find Cloudy instances in the community cloud, and to discover services deployed in these Cloudy instances.

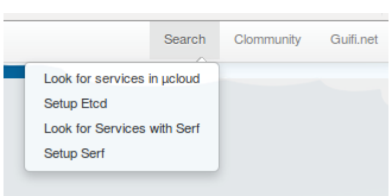

Fig. 4. Discover instances and services in the community cloud.

The Community service menu in the Cloudy GUI shows the applications which come already integrated in the cloud distribution (although the user is free to decide if he/she wants to activate them), see Figure 3. In the current version of Cloudy, Tahoe-LAFS as a service for building a secure distributed storage system is already integrated. The Peerstreamer application is available for live video streaming from web cams or TV channels.

The Guifi.net services of Cloudy allow users to install a set of community network management services (Figure 5). These services include a proxy service based on Squid to enable Internet access from within the community network, a SNMP service for network monitoring, and a DNS service for name resolution within the community network.

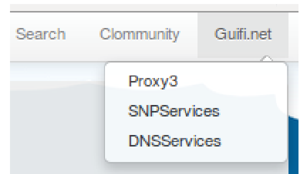

Fig. 5. Community network management services offered by Cloudy.

IV. Evaluation

We aim to assess this community network cloud from the perspective of its deployment and usage by the community. This cloud became operational in spring 2015. Among the goal of this cloud system is its usability, operation, and sustainability. Suitable values of technical metrics contribute to assess these goals, but other parameters such as cost, security and innovation opportunity should be considered as well. The sum of the features makes the system attractive to be accepted and taken up by the community of users.

A. Usage and engagement

Usage and engagement is a key indicator to assess take-up. We measure the engagement of users in the community network cloud in terms of instances deployed and services provided. The values of the metrics are obtained from logs taken at a Cloudy instance during one month of observation. Instantaneous values can be seen at any time through a publicly available Cloudy instance[5]. Since the Guifi community cloud is in production, values may vary from one moment to another. Figure 6 shows the number of on-line Cloudy instances, Figure 7 the number of Syncthing services, and Figure 8 the number of DNS services during one month. The oscillations of the service availability during the days and even within the days can be explained by the dynamics within the community network. One reason can be that Cloudy instances are hosted on nodes in different network segments and often with several hops of wireless links between each other. Changes in the network connectivity can cause that on-line Cloudy instances are not always seen by other Cloudy instances all the time. Another reason is that Cloudy instances (or their services) may be temporarily deactivated by the owner of the node where Cloudy is hosted.

[3] http://repo.clommunity-project.eu/images/

[4] see boards and guides in http://wiki.clommunity-project/howto

[5] http://demo.cloudy.community User: *guest*, Password: *guest*

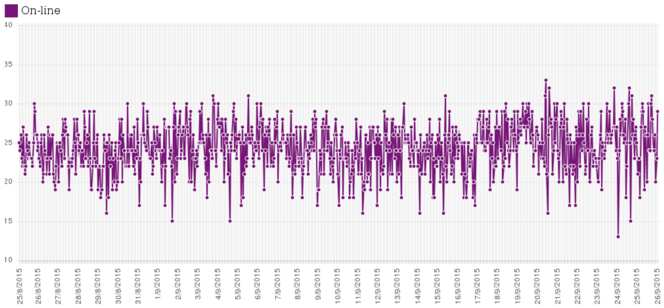

Fig. 6. Number of one-line Cloudy during one month.

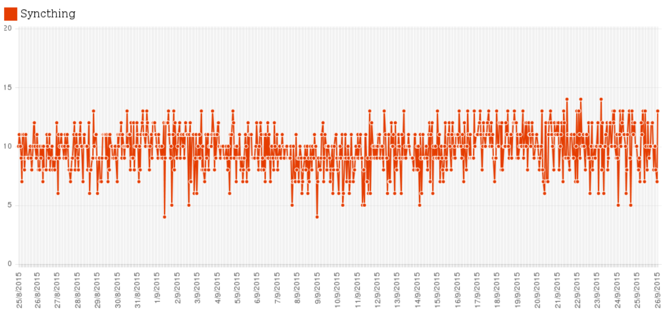

Fig. 7. Number of Syncthing services during one month.

B. Performance

The performance of the community network cloud can be seen as the aggregation of the performance of the services it offers. We conducted several experiments on the performance of the applications (Tahoe-LAFS, PeerStreamer, Search service) provided by the community network cloud [4][5][6]. To to this, we deployed these applications in the community network on several nodes, and assessed their performance. Once the performance was found to be suitable, the application was integrated in the Cloudy distribution.

The successful operation of the search service is shown in Figure 9. It can be seen here that the service presents the successfully discovered Cloudy instances as a list.

The specific results of the performance evaluation of Tahoe-LAFS is detailed in [4]. We report the performance of the Peerstreamer application for live video streaming within

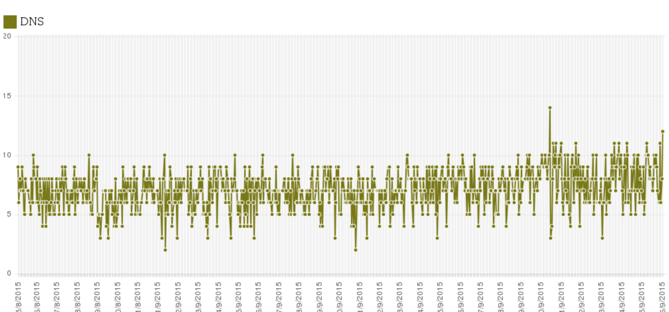

Fig. 8. Number of DNS services during one month.

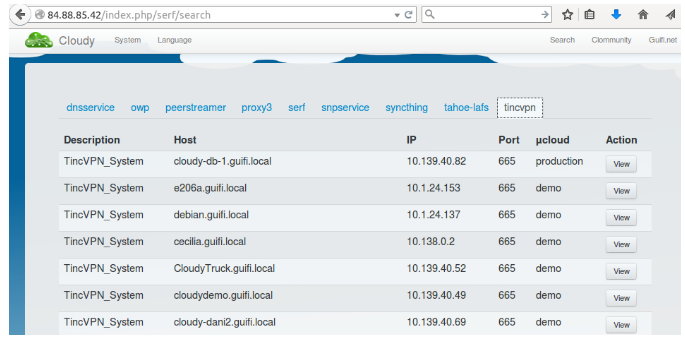

Fig. 9. Cloudy instances discovered by the search service.

community networks in [5]. Before we took the decision to chose Serf for the search, we evaluated an Avahi-based search service. We observed however scalability problems when we experimented with larger scenarios [6].

C. Cost

The cost of the community cloud can be divided into CAPEX and OPEX costs, and can be seen from the perspective of the users, but also from the perspective of SMEs.

From the perspective of individual users, the current operation model of this cloud is one which is sustained by user contributions, both in terms of hardware (CAPEX) and in terms of maintenance (OPEX) contributions. Since the Cloudy software runs on heterogeneous devices, including mini-PCs and low-capacity devices like Raspberry Pi[6], the cost which a user has to afford to contribute hardware to the cloud is not too excessive. The user that contributed a node is typically also the node administrator. There is thus some cost of time, which a user needs to spend to maintain its node. Cloudy itself has been designed to have self-management features, such as the capability to make make updates and to minimise the administration time. Time for the installation of Cloudy is therefore only needed at the first installation of the node.

From a commercial perspective, e.g. seen by an SME, this cloud offers resources and basic services without need to pay a fee. Compared to commercial alternatives, it represents a free access to resources, which significantly reduces the SME's CAPEX cost. Since the community among itself maintains the cloud, the OPEX cost is also minimal for an SME. It can therefore be argued that from the point of view of an SME, this cloud is a very suitable infrastructure to explore business opportunities with very little initial investments.[7]

D. Security and availability

Typical security concerns are also applicable to these community network clouds. Compared to commercial clouds, community network clouds are prone to node failures. Replication techniques are therefore essential mechanisms which

[6]http://wiki.clommunity-project.eu/howto:configurecloudyonrasppi

[7]Note that currently there are no restrictions for the usage of the cloud resources. With the consolidation of the system, however, resource usage will need to be accounted. In addition, commercial usage, while encouraged, will need to be regulated.

applications need to apply such that users will not loose their data. Confidentiality is another feature which needs to be addressed at the application level.

To increase the security in some important applications, the Tahoe-LAFS service was integrated. Tahoe-LAFS encrypts the user's data already at the client side, assuring thus confidentiality and integrity. Tahoe-LAFS in addition applies erasure coding in order to be tolerant to node failures. In the default configuration of Tahoe-LAFS, objects of the user's data are stored on 10 nodes of the storage server pool. To retrieve the data successfully, only 3 of these these nodes need to be operational.

Overall, the strength of the security solution is application specific. The use cases that are run in this cloud must take into account the available security features.

V. Related work

In comparison with other approaches which suggest cloud systems for communities, there are only few research prototypes, but none for community networks such as targeted by us. Skadsem et al. [7] provides applications for communities by using local cloud services, leveraging on social mechanisms like trust. The Cloud@Home[8][8] project has similar goals to harvest in resources from the community for meeting peaks in resource demands. The system is well described in terms of design and motivation, but a deployed systems seems not to be available. The Clouds@home[9][9] project focuses on providing guaranteed performance and ensuring quality of service even when using volatile volunteered resources connected by Internet. The authors focus on voluntary computing systems, but do not consider the particular context of community networks.

From the perspective of cloud-based service provision which involve edge computing devices, works like [10] suggest to bring the user in the loop to participate in the edge cloud computing services. Edge cloud computing devices by telecom providers located near to the end user are proposed in [11], where computational intensive tasks within applications are off-loaded to these cloudlets in order to improve the user's quality of experience.

VI. Conclusions and Outlook

This paper describes a deployed cloud in a community network. This community cloud is designed to fit to the socio-technical requirements imposed by the environment in which community wireless networks are built. It extends the collective effort put by its members into building the network to collectively enabling applications and services.

The analysis of the take-up, performance, costs and security suggests the suitability of this type of community cloud for edge cloud computing applications. While not replacing available commercial services in established areas, the observed features of the community cloud may enable new types of innovative services at the edge, which focus on the local context and local processing.

Having the cloud infrastructure deployed in the community network, our next steps aim at getting feedback from end user participation to further shape the development of the community cloud components. A measure of success will be that community network members will start using the community cloud services. Another important step is achieving the engagement of SMEs. To this end, a joint exploration with pilot deployments will help to understand better suitable business models.

Acknowledgment

This work was supported by the Spanish Government through the project TIN2013-47245-C2-1-R and the Universitat Politcnica de Catalunya BarcelonaTECH. Support was also provided by the Horizon 2020 framework programme project RIFE (H2020-644663), the E2E Clouds project funded by the Swedish Foundations for Strategic Research under the contract RIT10-0043, and the European Framework Programme 7 FIRE Initiative projects CONFINE (FP7-288535) and CLOMMUNITY (FP7-317879).

References

[1] B. Braem and et al., "A case for research with and on community networks," *ACM SIGCOMM Computer Communication Review*, vol. 43, no. 3, pp. 68–73, Jul. 2013.

[2] "The NIST Definition of Cloud Computing". National Institute of Science and Technology, U.S. department of commerce." [Online]. Available: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

[3] A. Marinos and G. Briscoe, "Community Cloud Computing," *Computing*, vol. 5931, no. December, p. 11, Jul. 2009.

[4] M. Selimi, F. Freitag, R. Pueyo, and A. Moll, "Distributed storage and service discovery for heterogeneous community network clouds," in *7th IEEE/ACM International Conference on Utility and Cloud Computing (UCC 2014).*

[5] M. Selimi, N. Apolonia, F. Olid, F. Freitag, L. Navarro, A. Moll, R. Pueyo, and L. Veiga, "Integration of assisted p2p live streaming service in community network clouds," in *to be published in 7th IEEE International Conference on Cloud Computing Technology and Science CloudCom 2015)).*

[6] M. Selimi, F. Freitag, R. Pueyo Centelles, A. Moll, and L. Veiga, "Trobador: Service discovery for distributed community network micro-clouds," in *Advanced Information Networking and Applications (AINA), 2015 IEEE 29th International Conference on*, March 2015, pp. 642–649.

[7] M. K. Skadsem, R. Karlsen, G. Blair, and K. Mitchell, "Community Cloud - Cloud Computing for the Community," in *Proceedings of the 1st International Conference on Cloud Computing and Services Science*. Setubal, Portugal: SciTePress, 2011, pp. 418–423.

[8] S. Distefano and A. Puliafito, "Cloud@Home: Toward a Volunteer Cloud," *IT Professional*, vol. 14, no. 1, pp. 27–31, Jan. 2012.

[9] S. Yi, E. Jeannot, D. Kondo, and D. P. Anderson, "Towards Real-Time, Volunteer Distributed Computing," in *2011 11th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing*. IEEE, May 2011, pp. 154–163.

[10] P. Garcia and et al., "Edge-centric Computing: Vision and Challenges," *ACM SIGCOMM Computer Communication Review*, vol. 45, no. 5, pp. 37–42, Oct. 2015.

[11] N. Powers and T. Soyata, "Axaas (acceleration as a service): Can the telecom service provider rent a cloudlet ?" in *IEEE 4th International Conference on Cloud Networking (CloudNet 2015).*

[8] http://cloudathome.unime.it

[9] http://clouds.gforge.inria.fr