A Look at Energy Efficient System Opportunities with Community Network Clouds

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***Abstract*—Community networking is an emerging model of a shared communication infrastructure in which communities of citizens build and own open networks. Community networks offer successfully IP-based networking to the user. In addition, some hosts are connected to the network nodes in order to provide network management and end user services. Recently, clouds have been proposed for community networks. Some research projects such as Clommunity have started deploying computational infrastructure to enable cloud computing within community networks. In this paper we propose different options for such community clouds to contribute to energy efficient systems, in particular regarding cloud-based services and in relation to Smart Grid. Further discussion and interaction with the research initiatives on energy efficient systems should identify the most promising approach and outline possible ways for implementation.**

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

I. INTRODUCTION

Community networks are user-driven communication networks which often originated from the lack of Internet connectivity in rural areas. There are several community-owned networks in the range of 500 to 20,000 nodes in Europe such as FunkFeuer, AWMN, Guifi.net, Freifunk and many more worldwide. Most of them are based on Wi-Fi technology (ad-hoc networks or IEEE 802.11a/b/g/n access points in the first hop, long-distance point-to-point Wi-Fi links for the trunk network), but also a growing number of optic fibre links have started to become deployed [1]. Guifi.net in Spain (Figure 1) is probably the largest community network worldwide and it is where the cloud deployment takes place which we are currently undertaking.

The community cloud we consider here are 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.

Such community cloud built in community networks have features which may contribute to energy efficient cloud system design and implementation.

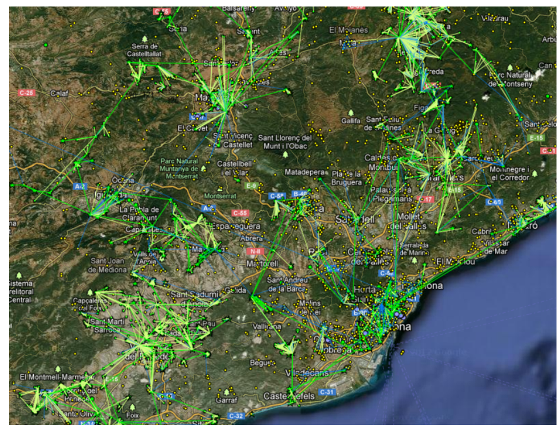

Fig. 1. Guifi.net nodes and links in the area around Barcelona

- Distributed and heterogeneous hardware: Cloud hardware in community clouds is contributed by the users, hardware can be heterogeneous and it is at the users' premises.
- Decentralized service management: The network and cloud services are managed by the users. Services may be shared among users to build collaborative applications.
- Community-driven services: The potential of the community cloud is to deploy services of local interest. Awareness of energy-efficiency may be brought to the users, which could drive a fast roll-out of services to support energy-efficiency.

We describe in the following section first the characteristics of the cloud deployment that we have started in the Guifi.net community network. Secondly, we sketch some proposals to benefit from community network cloud infrastructure to build energy efficient systems.

II. CLOUDS IN COMMUNITY NETWORKS

In this section we explain some components of the cloud we have deployed in Guifi.net community network, which presents a real case for our proposals for extending towards energy-efficiency in section III.

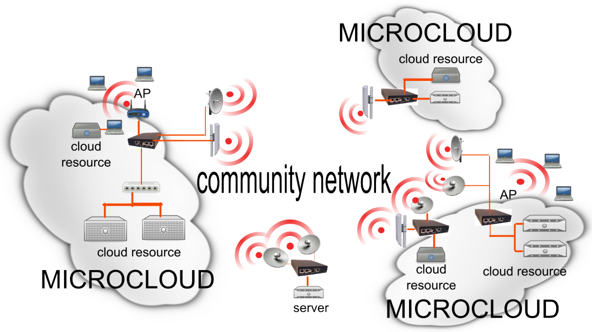

Fig. 2. Conceptual schema of microclouds in a community wireless network

A. *Topology*

Cloud in community networks needs to fit into the conditions of how these networks are built, governed and grown. Regarding their growth, one important aspect is the topology of community networks, which determines the scope of the options how the cloud infrastructure can be integrated. In Figure 2 some node types of a community wireless network are depicted. The picture shows some typical community nodes with a router and some server or clients attached to it. Some clients nodes are shown that are connected to the access point (AP) of a super node. In addition, however, these community nodes have cloud resources attached to them which are part of the community cloud. In addition, depending on the topology of the wireless network and the social structure of the community, several local community clouds may appear which manage locally the cloud resources belonging to a certain zone defined geographically or by its social networks. We call such local clouds microclouds. A set of microclouds are interconnected though the wireless links of the super node backbone network.

B. *Hardware*

In Figure 3 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 nodes represents the case of low-end cloud resources such as home gateways, that users provide to the cloud. These devices have been deployed through Community-Lab[1] [4] and can be integrated in the Guifi network management platform [5]. Other cloud nodes we have deployed are several Dell OptiPlex 7010 desktops. In addition, some Alix boards and Intel Galileo boards have been deployed for specific purposes. While the number of deployed cloud resources in Guifi is in constant evolution, the status of

Fig. 3. Cloud resource at a community network node

cloud deployment at time of this writing can be seen in the Clommunity project's Wiki[2].

C. *Cloud Management Platform*

Since the different local groups providing such microclouds are independently organized, the cloud management platforms (CMP) that are used are also heterogeneous. In the community clouds we have deployed we use mainly Proxmox and OpenStack as CMP. 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.

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 model. Cloudy is deployed on the cloud resources that form the microcloud and over the different microclouds in the community network, as illustrated in Figure 4.

III. Support of Community Clouds for Energy Efficient Systems

In this section we sketch a set of proposals on how to benefit from community clouds for building energy efficient systems.

A. *Energy-efficient resource allocation*

Community clouds are envisioned as a set of federated microclouds. Microclouds are composed of heterogeneous devices, which can range from resource-constrained home gateways up to server class desktops, even small crowd-funded data centres can be imagined. Depending on the service-level agreements of the requested cloud service, different cloud resources may be able to fulfil the requirements.

[1] http://community-lab.net/

[2] http://wiki.clommunity-project.eu/testbed:start

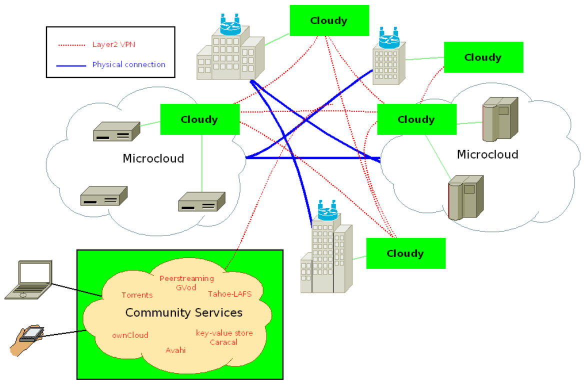

Fig. 4. Cloudy distribution deployed in microclouds

If an energy model of the different classes of cloud hardware available in the community clouds is available, the most energy efficient cloud infrastructure may be selected to which this job should be allocated. An initial proof of concept of such a system could be studied on a single heterogeneous microcloud. The level of federation support of the used CMP may allow extending such energy-efficient resource allocation over several microclouds.

In this scenario, the heterogeneity of community cloud hardware plays an essential role. Such energy-efficient resource allocation may be less applicable in commercial cloud systems where the hardware is more homogeneous.

B. Cloud computing with low-power devices

Different research initiatives, e.g. the Montblanc project[3], consider building energy-efficient cloud computing infrastructures with low-power devices.

Community cloud contributors are expected to target cloud hardware deployed on their premises which has a low energy consumption, for being able to run in a 24/7 mode without noticeable electricity consumption increase. Therefore, such a cloud scenario built upon many distributed low-power devices could be materialized by a user-provisioned cloud infrastructures in community clouds.

In order for such a scenario to be explored, CMPs need to be evaluated towards their capacity to support hypervisor solutions which may not require hardware supported virtualization. Several low-power devices have already been deployed in Community-Lab [4], making the hardware to explore this scenario mainly available.

C. Smart Grid support

Smart Grid scenarios build upon advanced metering and communication infrastructures, which enable to take more energy-efficient decisions on power consumption. For such scenarios, computational infrastructure is needed to process large amounts of data generated by electrical meters and combine it with additional contextual information. Such processing could leverage on community cloud hardware and services, and reduce the need of infrastructure that utility providers need to deploy in the last mile of the Smart Grid [6]. For further exploration of this scenario, the requirements of Smart Grid platforms need to be assessed. The community cloud which we consider does principally allow to deploy customized PaaS or integrate additional services into the Cloudy distribution, which may allow easier exploration than through closed commercial environments.

[3]http://www.montblanc-project.eu/

IV. Conclusion

The appearance of clouds in community networks can be witnessed nowadays. Such clouds consist of user contributed infrastructures which enable cloud-based services; the cloud hardware is often located at the user premises. Such community clouds offer unique features compared to commercial data centre type clouds, such as distributed and heterogeneous hardware, user-managed services and services of community interest. This paper sketches some opportunities which community clouds could offer to contribute to energy efficient systems. These opportunities are described towards energy-efficient resource allocation, clouds made out of low-power devices, and supporting the deployment of the Smart Grid.

Acknowledgment

This work was supported by the European Community Framework Programme 7 FIRE Initiative projects CLOMMUNITY, FP7-317879, and Community Networks Testbed for the Future Internet (CONFINE), FP7-288535.

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