

# Personal Cloud Management Cockpit with Social or Market-Driven Asset Exchange

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**Abstract**—Digital and physical assets such as software, data and hardware resources have historically been exchanged in a product-style wholesome transfer. Now, the rise of Cloud Computing and the increasing delivery of Everything-as-a-Service in an Internet of Services require new techniques for users to perform asset discovery, exchange and management. This applies to both personal assets (such as already received or self-produced ones) and public assets (from commercial markets or open sites). We identify three popular asset types in cloud environments and for each of them define a service representation and propose a set of techniques for their management and exchange. Furthermore, we define methods for selecting and exchanging the assets in order to build a federated community of personal cloud environments along social network structures. With CloudRemix, an interactive cockpit to manage personal clouds, we achieve a reduced reliance on central infrastructures and a raised balance of service provisioning and consumption. Attached to a novel local device discovery tool (FlexiSource), to a service registry and to a social network, the CloudRemix prototype demonstrates its utility to manage personal clouds.

## I. MOTIVATION

Everything-as-a-service (XaaS) is a paradigm to deliver digital assets or access to these assets such as software applications and datasets as well as access to physical assets such as compute and storage resources to whoever needs them, on demand, according to conditions specified in non-binding service descriptions and binding service level agreements. With the increasing use of online resources and services due to the industry push towards cloud computing, the client-side issue of keeping an overview about which assets belong to whom becomes very real. Furthermore, finding new assets across providers while at the same time reducing the dependency on particular providers becomes challenging. While providers and hosters of services benefit from recent research results on tradeable services and can use powerful service platforms and associated management tools [1], a complementary software stack for client devices, accessible to service consumers and casual asset providers, is notably missing.

Personal clouds, a context-dependent variant of home clouds, summarise a recent conceptual flavour of cloud computing environments. They let users manage their assets and control which assets are entrusted to which provider in which locations and social contexts [2]. This concept appear to be an important solution block to solve the issue mentioned before. The techniques to build and manage personal clouds

and the assets contained in these clouds have not yet been systematically presented. Our work contributes solutions to this problem domain with a set of techniques for both the management and the social and market-oriented sharing of cloud assets, for instance, just-in-time resource provisioning [3].

Hence, we present CloudRemix, a user interface to overcome the limitations by allowing users to build and manage their personal clouds and all assets therein. Whereas related projects only consider either physical or digital assets, or have other restrictions including provider lock-in and restrictive licences [4], the goal of CloudRemix is to be open, user-centric regarding the manageable assets, and flexible regarding their free or commercial exchange, with or without explicit contract negotiation.

## II. KEY DEMONSTRATOR FACTS

CloudRemix was first sketched by a group of students participating in curricular labwork. Johannes Schad and Stephan Zepezauer, two students of Computer Science at TU Dresden, refactored and enhanced the CloudRemix prototype and designed and implemented FlexiSource, respectively. Josef Spillner of the FlexCloud young researcher group assisted with the integration into a service-oriented landscape which includes a service marketplace and a social service network and continues to maintain the combined prototype.

The implementation requires a runtime for PHP with an SQLite database for CloudRemix, and a Python runtime atop a Linux system for FlexiSource. All software is publicly available from a Git repository and is licensed under GNU GPLv3+. Furthermore, it is integrated as a central component into FlexCloud's upcoming  $\pi$ -Box Live virtual machine which, if run as a VM or as appliance, acts as gateway between personal and public clouds and hence relies on both a cockpit and local device discovery and integration [2].

The proposed demonstration runs the appliance on a nettop-style computer. Users can access it through usual keyboard, mouse and screen interaction, but also dynamically attach their mobile devices and notebooks over heterogeneous connections to build up their own personal cloud environments. Group interaction is supported through the social service network.

### III. DETAILED DEMONSTRATOR DESCRIPTION

#### A. Personal and Public Cloud Assets: Resources, Data and Software

Resource-as-a-Service (RaaS) is the predominant service type among the infrastructure services in cloud environments. Typically, resources for storage, computation and communication are distinguished and billed separately. Offering RaaS from personal resources requires a device discovery over heterogeneous channels like Bluetooth, Ethernet and operating system internal messages, followed by resource identification and integration. FlexiSource handles these steps. Data-as-a-Service (DaaS) ranges from downloadable or queryable datasets to hosted databases and data warehouses. Description languages such as the RDF have made the web of Linked Data possible [5], and further efforts like OCS and W3C DCAT exist. The provisioning of DaaS requires an appropriate data repository for which we provide a tool which lets users define custom datasets with access permissions. Software-as-a-Service (SaaS) is a well-established concept on the Internet. The Unified Service Description Language (USDL) and the Web Service Modelling Language (WSML) are representative approaches for achieving fully self-described and tradeable SaaS. The provisioning of SaaS requires a service execution container or a service platform which can itself be offered as a service (PaaS). The SPACE platform handles these steps in our demonstrator.

#### B. Unified Approach and Federation

The analysis of asset description formats reveals a larger than necessary heterogeneity which prevents the efficient management and sharing of them as services. In our demonstration, this is solved through a unified XaaS description ontology with shared base concepts such as price or producer and unique domain-specific concepts such as capacity for storage resources and versioning for data repositories. To find sellers or buyers of cloud assets, both trustworthy or otherwise known social network contacts and public marketplaces can be used.

In recent years, the architecture of social and collaborative software has been increasingly adopting federated topologies, often in combination with P2P infrastructures to strengthen the users' autarky. While federated social networking for the exchange of messages is increasingly used [6], the exchange of assets still happens primarily over central distribution sites. For our demonstrator, we refactored these markets as aggregation of federated providers in order to let providers keep the control over their offers and decrease the dependency on the availability and functionality of markets. Fig. 1 contrasts these two models as extension of the message exchange over centralised and federated social networks.

#### C. The CloudRemix Prototype in Use

CloudRemix presents a web-based cockpit as primary user interface for controlling a personal cloud. It gives control over the discovery, management and exchange of cloud assets. To

achieve our desired asset unification, we contributed to the

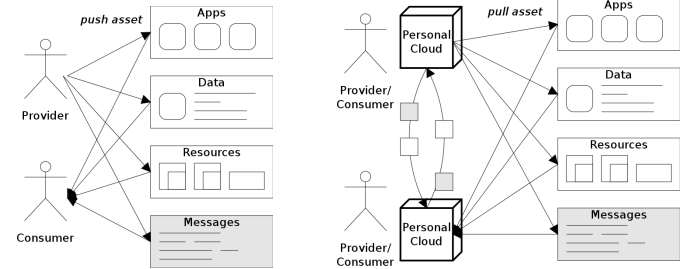


Fig. 1. Asset distribution models: To the left, a set of centralised exchange sites; to the right, a decentralised structure with federation and remaining centralised appearance of open markets for cloud assets.

concept collection WSMO4IoS by developing domain ontologies for cloud resource services (computation and storage) as well as DaaS and SaaS. Figure 2 shows the asset management screen presented to the user in a personal cloud.

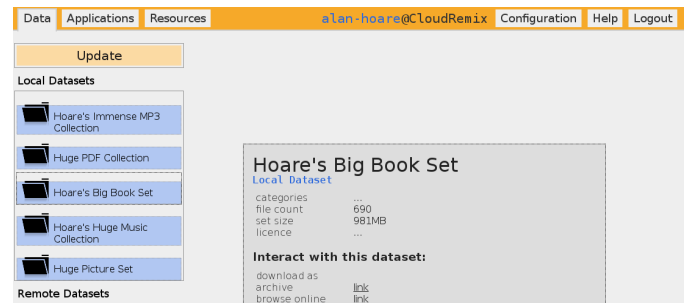


Fig. 2. Screenshot of the CloudRemix user interface

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