

# Towards the Development of Personal Cloud Computing for Mobile Thin-Clients

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**Abstract**—The phenomenon of cloud computing has been driven largely these days. Personal Cloud, as the cloud computing for personal usage, has come to the forefront. Compare with traditional operating system, personal cloud shifts individual computing "from being device-centric to information-centric", which create a bridge between operating system-based computing and the more service-oriented approach to IT. Also, the mobile thin-client has brought mobility to cloud computing. In this paper, we provide a reference base for the development of methodologies tailored for personal cloud computing. Besides, we also provide a security architecture for personal cloud based on the security requirement analysis.

**Keywords**- *Personal Cloud, Cloud Computing, Security Architecture, Thin-client.*

## I. INTRODUCTION

The Personal Cloud [1-3] is a popular concept these days, it offers a range of task-oriented applications that users can retain full control of their data, and are free to tweak the available functionality to their likings [6]. Like everything, "Personal Cloud" has a rather fuzzy meaning, or at least one that is very changing, depending on the context. The analyst in Forrester Research, Frank Gillet, describes it as "an internal resource for organizing, preserving, sharing and orchestrating personal information and media[7]." He believes that digital devices and services will combine to create the Personal Cloud, which will shift individual computing "from being device-centric to information-centric". Similarly, Steve George[4], Canonical's vice president of business development, told InternetNews.com that the personal cloud, from the consumer's perspective, is to convert the operating system from a window to internet services. However, some researchers do not think that personal cloud computing is much different from the cloud computing from businesses view. They believe the only differences are the types of features that are available to the users. Researchers in BusinessCloud [5] concluded the notion of personal cloud as "one of the segments which refined and segmented from the cloud", which has a repository for personal information that enables users to organize and access. Essentially, the personal cloud describes a user-centric model of cloud computing where an individual's personal content and services are available anytime and anywhere, from whatever device they choose to access it.

Today, most people have to juggle multiple devices to access all their services. What the personal cloud could provide is a single and portable access-point to multiple clouds. And in emerging economies, where people often share mobile devices, each individual would be able to log into their own clouds from the shared device. Meanwhile, with the increasingly development of cloud technology, the server side of thin client is applied to cloud, thus makes the full use of the features of the cloud, for example, virtualization, flexible, security and dynamic management.

This paper presents a brief review of personal cloud computing and a discussion about the security architecture of the personal cloud. Our ambitious objective is to provide a reference work to assist researchers in the definition of personal cloud and methodologies addressing the problems in the personal cloud, including the ecosystem of personal cloud and the requirements for the security framework.

The remainder of the paper is structured as follows. Next section presents the background of personal cloud including the characters, types and ecosystem. Section 3 gives security model of personal cloud and the proposed security architecture is discussed in Section 4. Section 5 concludes the paper with final remarks.

## II. BACKGROUND OF PERSONAL CLOUD

The following definitions and taxonomy are included to provide an overview of personal cloud computing concepts.

### A. Types of Personal Cloud

There are three categories of personal cloud computing: online storage, online desktop, and Web-based applications. Each of these categories free up resources, either in processing power, as in the case of Web-based applications, or in the case of an Internet-based desktop (known as webtop) any computer with an Internet connection can become "our personal computer" via a Web browser.

- Online Storage

Online storage gives users a place to store information that is available to us wherever there is an Internet connection, or provide a safe and secure place to back up our important information. In the last year or two there has been a major technological leap in online storage, attributed to the increased speeds at which we can transfer information, as well as

improved security to protect this information. These two factors have created an industry that seeks to provide individuals and businesses with backup solutions that are secure, reliable, and offsite. If your data is compromised, either through viruses or other online threats, or even if your computer itself gets damaged, online storage keeps your data safe and secure as backup is done offsite.

- Web-Based Applications

This is another very recent innovation in cloud computing. The idea of software as a service is not new, but improvements in bandwidth and increased speeds in the transfer of information has now made this option feasible. Some companies offer a hosted software application that you do not have to download and install on your computer, but rather a service you subscribe to and, in a sense, rent. Instead a user buys a subscription to the software. In fact, a user doesn't even have to use his or her own computing power to run the software, as it is housed by the vendor. As part of the subscription fee, Web-based applications provide users with assistance when something goes wrong. The other distinct advantage to Web-based software is a significant reduction in the up-front costs to utilize the software, as users gain access to the program at a fraction of the up-front cost of purchasing it outright. This means that you are assured future versions of the software as upgrades are no longer something packaged as a separate product, but part of the service contract you already own.

- Webtop

This service is slightly different to the two mentioned above, as its goal is to recreate the highly personalized setting of our own desktop with an online version we can access anywhere we can connect to the Internet. For example, a user has tried several of webtops, and while he prefers some to others they all strive to offer a completely personalized and familiar desktop experience. When the user is away from his desk, the webtop allows access to information formally found only on the desktop of his own computer, such as contacts, e-mail, and files. Many of these Web-based desktops even have synchronization tools to make it easier to share information between personal desktop and the Internet version..

## B. Characteristics

The basic characteristics of a personal cloud can be summarized as follows.

- Ease of use

It simplifies deployment, maintenance and portability.

- Instant availability

Users can access the server via a direct cable connection, over the local network, and the Internet.

- Subset of functionality

Users just use a simple blog engine to maintain a personal blog rather than a full-blow blog application like WordPress.

- Absolute privacy

User has the full control over when, how, and to what extent people will know about his information.

## C. Personal Cloud Products

The purpose of this section is to present the current state of the best known personal cloud products.

- The My.Pogoplug Service

Pogoplug [9-11] is a robust personal cloud application that lets users connect any external hard drive from anywhere in the world, and then access and share their information over the internet. Users have access to their content wherever they go, all files can be viewed, downloaded or streamed through any web browser, no technical expertise or advanced networking knowledge required. All interaction with the Pogoplug is through a single web site, which is able to access users' devices, and present users with an easy-to-use web interface. Moreover, users don't even need to know their devices' IP addresses. Pogoplug is also great for working professionals who need to share information with clients and partners. Allow others to view and download or give them full access, users can pick and choose who has access to what files and folders.

- Tonido

Tonido [12-14] is a robust personal cloud application that offers many features for personal cloud computing. It can share large files, stream users' music and videos, balance the checkbook, and so on. Tonido allows users to access and share all of their desktop's files, documents, photos, music and videos from any where through a web browser or smart phone. Their data is stored locally for optimal protection.

- Zumo Drive

Zumo Drive [15, 16] offers similar features as Tonido, only it was built specifically to sync between users' mobile devices and their netbooks. Users can import all of their music from iTunes to any device without having to download the songs, which will help them to save the hard disk space. Zumo allows users to access any file from any of their devices without having to go through the painstaking process of downloading them first, they just need to simply access files through the ZumoDrive application.

- iCloud

iCloud [17] is a free online computer with desktop, applications and storage which consists of a desktop with applications and files that users run through the web browser. As it's running in the cloud (the internet), it can offer impressive features such as easy sharing and rich collaboration.

- inXtron's Personal Cloud Server

inXtron [18] believes the digital home is evolving into a place where there are no barriers or limits. Based on this belief, inXtron developed the personal cloud server series. It provides the user the ability to seamlessly store, organize, share, and access their music, movies, and photos.

The personal cloud server, as defined by inXtron, is the next step up in the evolution of home network attached storage drives. It is no longer a PC centric product that requires a skilled system administrator to set up and maintain but a

product that is designed to be user friendly and connected, anywhere and anytime.

#### D. Personal Cloud Ecosystem

The rise of personal cloud services will shift the focus of innovation in personal computing from device to service, enable device and operating system players to compete, and overhaul the client virtualization market, enabling a broad range of thin and robust personal computing devices. Strategists at personal computer device makers, independent software vender, and online service providers need to plan how customer buying preferences will shift as they align around the emerging personal cloud ecosystem.

Research on the personal cloud ecosystem produced several insights.

- (1) Security is under-represented. As more companies enable the building, deploying and hosting of personal data in the cloud, security will become an increasing concern.
- (2) Necessary access control . When every one holds their personal, financial or health data in the personal cloud, consumers and small businesses should control access to their data and would grant it to anyone or any application they chose.
- (3) Identity management is an emerging challenge. In the last era identity management was something handled by directory service-based single sign-on systems. Several startups have emerged to tackle this challenge in the cloud.

### III. PERSONAL CLOUD SECURITY REQUIREMENT ANALYSIS

As the security for personal cloud is still in its infancy, there is an urgent need for an approach to cloud security that is holistic, adaptable, and reflects client requirements. Brock et al [8] proposed a security model which could be applied to Personal Cloud. Generally, there are two main security elements, a Gateway Server (GS) and a Single Sign-on Access Token (SSAT). GSs are hosted in clouds and manage the security of their host clouds. A SSAT is a time limited, non-forgeable and non-transferable entity that is granted to cloud clients. It is constructed and used according to the Information Flow Control model. This token identifies the client, services the client wishes to use and also verification tokens to prove the SSAT itself is valid. Only the intended client can use the token and once it expires, it cannot be reused. This addresses revoking rights. To ease management, the classification of services, and the resources behind them, is inherited from their providers.

We apply the related security technologies to each step in the Personal Cloud Model, which meets the requirements for Personal Cloud Security concern. The personal cloud security

analysis is shown in Figure 1. A client program is installed on or downloaded to every endpoint (laptop, cell-phone, etc.)when user accesses the client end (phase 1). A server or gateway hosts the centralized security program, which verifies logins and sends updates and patches when needed. In the second phase, the user contacts the Gate Keeper (GK) service in the Gateway Server(GS) where the communication with the GK (or any other service) uses Transport Layer Security to protect against eaves-dropping attacks (phase 2). The GS needs to securely identify their users through authentication and after that, a user must gain authorization for doing certain tasks. With the single sign-on access control token, a user logs in once and gains access to all systems without being prompted to log in again at each of them. The Clearance Verifier (CV) checks the validity of the token. If there is no verification in the SSAT, that service should contact the CV (phase 3). This step is a precaution against SSAT forging. If the CV reports back that the Gateway Server did not generate the SSAT, the request is blocked. If the SSAT is examined and proved valid, the CV attaches a verification token to the SSAT (phase 4). Client can now make use of the services.

### IV. PERSONAL CLOUD SECURITY FRAMEWORK

In this section, we present the security framework for personal cloud based on the above analysis. The proposed framework is illustrated in Figure 2.

Users could access the client side (i.e.: web browser or host installed application) via diverse devices like PDA, laptop, or mobile phone with multi-factors authentication provided by End-User Service Portal. The client side is the portal where users get their personal cloud. Multi-factors authentication based on certification issued by 3rd party CA. When clearance is granted, a Single Sign-on Access Token (SSAT) could be issued using certification of user. Thus, user could use services without limitation of service providers through the end-user service portal.

The security manager in the end-user portal provides significant protection for access control, security policy and key management against security threats. In the service configuration panel, the service enabler makes provision for personalized cloud service using user's profile. The user's profile is provided to the service management in cloud service provider for the integration and interoperation of service provisioning requests from user. The service monitoring system guarantees a high level of service performance and availability. The SPML [11] can be used to share user's profile. The asset manager requests user's personalized resources with {user's profile}SPML to the service manager in the cloud service provider, and configure service via VPN connection. The service gateway manages network resources and VPN on the information lifecycle of service broker.

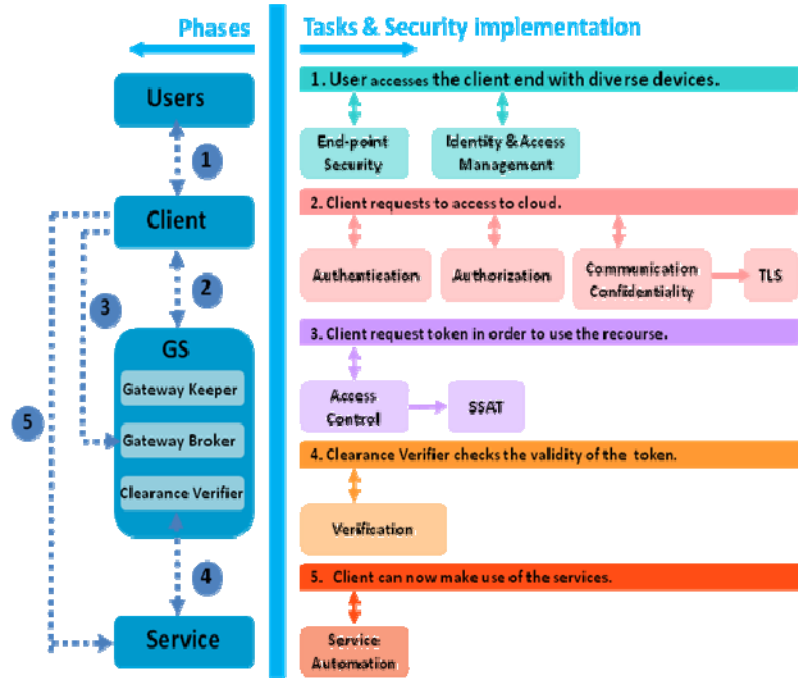


Figure 1. Personal Cloud Security Requirement Analysis

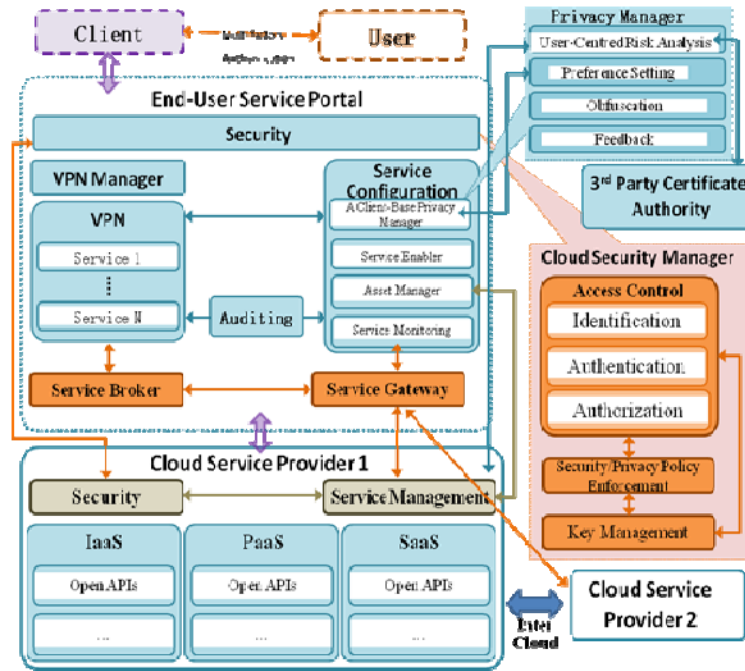


Figure 2. Personal Cloud Security Framework

#### A. Privacy Manager

The purpose of privacy manager is to reduce the risk of data leakage and the loss of privacy on sensitive data processed in the cloud. The privacy manager is on the client side used to help the user to protect his privacy when accessing cloud services. Nonetheless, the privacy manager requires the help

from a server-side component for effective operation. However, the privacy manager needs the full cooperation of the cloud service provider. Besides, cloud service providers that sell the user data to advertisers, may not be willing to allow users to preserve their privacy. Generally, it consisted by four components, user-centered risk analysis, preference setting, obfuscation and feedback.

- User-centered Risk Analysis

Users may benefit from cloud computing, in such areas as enhanced service accessibility, other technical technologies, and reduce up-front and/or operational costs. The purpose of risk analysis is to consider the downsides of cloud computing, from the user perspective.

- Preference setting

The preferences feature allows users to set their preferences about the handling of personal data that is stored in an unobfuscated form in the cloud. It communicates these preferences to a corresponding policy enforcement mechanism within the cloud service. The preferences can be associated with data sent to the cloud, and preferably cryptographically bound to it.

- Obfuscation

The idea is that instead of being present unencrypted in the cloud, the user's private data is sent to the cloud in an encrypted form, and the processing is done on the encrypted data. The result of the processing is de-obfuscated by the privacy manager to reveal the correct result.

### B. Cloud Security Manager

The cloud security manager provides significant protection for access control, security/privacy policy enforcement and key management against security threats. The following paragraphs focus on the options and challenges in implementing an identity and access control architecture for cloud computing.

- Identity Management

Identities may be associated with human resources hiring and firing, new or changing partner and contractor relationships, or new servers or applications being setup. Processes may include identity creation and role/group addition, credential issuance, audit and compliance, and on-going management and eventual deletion.

- Authentication

Authentication in the cloud requires user identities and claims to be available to the cloud applications.

- Authorization Services

Authorization is the means for ensuring that only properly authorized principals are able to access resources within a system. A Principal can either be a human, machine, or an application.

- Security/Privacy Policy Enforcement

Policy enforcement panel must exhibit features that enable server and user privacy policies to be declared, server privacy policies and user privacy requirements to be compared, and cloud usage to be precluded where the requirements are not satisfied.

## V. CONCLUSION

Personal cloud computing provides an efficient, scalable, and personalized way for individual information organizations. Meanwhile, the flexibility and openness of personal cloud have created a number of security issues. In this paper, we provided a personal cloud security framework based on the security requirement analysis. This work intends to serve as a technical reference for the development of security requirements methodologies aiming to the personal cloud.

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