Virtual USB Drive: A Key Component for Smart Home Storage Architecture

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ABSTRACT

As home digital data grow rapidly and some home digital data require storage management from household members, a smart home storage design becomes a critical issue. This paper proposes key requirements for designing smart home storage and analyzes existing storage solutions. Moreover, we demonstrate that our virtual USB drive, plugged into a USB port of any home digital device to give an easy access to pre-designated home shared storage (local disks of desktops) and further to outsourced cloud storage, can be adopted as a key component for the smart home storage design.

BACKGROUND & MOTIVATION

As home digital data has been increasing rapidly, each household is expected to retain about 12TB digital data at home in 2014 [1]. Moreover, higher quality (full-HD or beyond) of multimedia content will expedite the growth of home digital data. Home digital data, mostly multimedia data for entertainment and backup data [2], require almost the same types of storage management as enterprise digital data such as backup, capacity planning, even long-term data preservation with important data like family photos. However, there is a big difference between them: no storage administrators exist at home. Thus, family members should be in charge of their home storage management [3].

Our observations on diverse digital home environments show that many of the in-home digital devices with embedded storage (HDD or Flash) tend to be fully connected over network. Consequently, they can be easily inter-operable. Besides, key operations among them are data synchronization and sharing that can cause complicated data search as well as a waste of storage spaces due to data duplication. Most of the research on home storage has focused on efficient (i.e., fast) home storage data search and sharing [3,4,5] and little study has addressed effective data synchronization at home [6].

SMART HOME STORAGE REQUIREMENTS

Our extensive investigation of recent home storage trends and technologies [3-8] enables us to propose seven key requirements ([R1]-[R7]) for designing the smart digital home storage architecture as follows.

[R1]. Building home storage over existing in-home digital devices: A centralized storage server such as network-attached storage (NAS) can be a candidate. However, most of the household is unwilling to spend extra money to purchase and run any non-essential consumer electronic device (a storage device) [3]. Moreover, many technical terms and complex administration procedures distress them into turning their face away from the manuals. Therefore, it is reasonable to build any smart home storage on top of the existing devices at home, requiring easy setup. Online or cloud storage can be another solution with easy management; it is not free of charge.

[R2]. Efficient data synchronization: Many home mobile devices (digital cameras and camcorders) generate numerous home digital data. These user-created data are likely to be synchronized into any of family desktops or laptops at hand. This will distribute the data across multiple digital devices, making subsequent data search difficult. Thus, it is indispensable to design an efficient data synchronization platform for efficient data search. One possible way is to provide in-home digital devices with an easy access to pre-designated storage locations (e.g., local disks of family desk/laptops) for data synchronization.

[R3]. Seamless data sharing: Home data can be shared among desktops, laptops, and smart TV through wired/wireless networks. However, data sharing at home is mostly performed in a very primitive way via USB flash memory or external HDD. Since this simple data sharing creates many duplicates over multiple devices, necessary is seamless data sharing as if data would be stored in local disks. Most of the current home storage solutions focus on this issue [3,4,5].

[R4]. Easy & controllable storage management: Far from our expectations, fully automatic administration does not seem to be ideal for the home storage. It has been known that family members tend to feel bothered when they have no control over any process. Outsourced out-of-home storage like online or cloud storage can be a good candidate considering high availability and reliability required in backup and long-term data preservation. We also need to adopt data deduplication at home storage for capacity management.

[R5]. Privacy among family members: Unlike enterprise environments, home data storage has another characteristic: trustworthy users (i.e., family members). A previous work [8] shows that a traditional user account model is not an appropriate approach for home storage because of its inconvenience to login with different user IDs and passwords. Rather, family members prefer to share a single account with a limited privacy. Occasionally, people tend to store their private data in separate storage. Thus, the home storage requires an efficient mechanism to securely separate private data from other members. Finally, the home storage should not require
extra software and hardware changes to existing in-home
digital devices [R6]. The home storage solution should also be
as intuitive and simple as TV sets [R7].

**VIRTUAL USB DRIVE AS A KEY COMPONENT**

We introduce a virtual USB drive [6] as a key component
for the smart home storage design. The virtual USB drive
adopts a USB interface and works exactly the same as typical
USB flash memory. However, it supersedes NAND flash
modules with pre-designated shared storage of in-home
desk/laptops using iSCSI protocol and out-of-home cloud
storage (see Fig. 1). The virtual USB architecture mainly
consists of three software modules (USB device driver, seamless
USB/iSCSI module, and iSCSI protocol stack) and enables
seamless access from any digital device to pre-
designated home shared storage (see Fig. 2) (not showing
software stack for cloud storage access).

![Virtual USB Drive](image1)

**Figure 1:** Concept of virtual USB drive

![Virtual USB Drive Architecture](image2)

**Figure 2:** Virtual USB drive architecture with pre-
designated shared storage of desk/laptops in home [6]

Through the virtual USB drive, any in-home digital device not
only synchronizes the digital data into pre-designated storage
([R2]), but seamlessly accesses them ([R3]). Most noticeably,
the virtual USB drive can be conveniently attached to any
devices containing USB ports ([R1][R7]) without software
/hardware modification ([R6]). We prototyped the virtual USB
drive with ARM9 MCU, USB1.1, and 10Mbps network. The
prototype achieved 393KB/s read performance (633KB/s for
USB1.1 speed, 1.03MB/s for iSCSI speed). Note that since
this prototype was initially developed with USB 1.1 interface
to validate its feasibility, the read performance will increase to
1.84MB/s with USB2.0 and 100Mbps network. Furthermore,
we expect even better performance after more optimization
processes. In addition, after adding a cloud storage (e.g.,
Amazon S3) access layer and slightly expanding the functions
of the seamless USB/iSCSI module, the virtual USB drive can
make any home digital device access to cloud storage as the
pre-designated shared storage for data store or highly available
data storage for backup and long-term data preservation ([R4]).

**PERFORMANCE COMPARISON**

There exist a few home storage solutions: HomeViews [4],
Whole Home Storage [5], and Perspective [3]. However, they
do not meet many of the proposed seven requirements (see
Tab. 1). We found that the existing home storage solutions
mainly focused on data sharing issues (leaving data
synchronization out of account). Moreover, the solutions work
mainly in desk/laptops (or Linux-based devices) that permit
any software changes (not cooperating with any other in-home
digital devices such as digital cameras). Most importantly,
there still remain difficult installation and management
processes for the existing solutions. On the contrary,
the beauty of our virtual USB drive architecture is its simplicity
and applicability to most of the in-home consumer electronic
devices with no hardware and software modifications.

![Table 1: Comparisons among home storage solutions](image3)

**Table 1:** Comparisons among home storage solutions

**CONCLUSION**

In this paper, we have originally introduced the seven key
requirements for the smart home storage design. The feature
analysis and experiment on a prototype system have clearly
shown that the virtual USB drive would become a crucial
component for the smart home storage design.

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