SATELLITE AND SPACE COMMUNICATIONS SSC
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SSC Newsletter **Vol. 27, No. 1, May 2017**

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The Satellite and Space Communications (SSC) Committee is a volunteer group actively involved in advancing satellite and space communication technologies within the IEEE. This committee is approved by the IEEE Communications Society and is governed by the constitution and bylaws of the IEEE as well as the other twenty-three Technical Committees in the Society. The committee belongs to the Technical Committee Clusters of Communication/Signal Processing (C/SP).

SATELLITE & SPACE

- JOIN US -

All conference attendees are welcome to join us in the SSC Committee meeting.
Location: ICC'17, Paris, France
Room: Auteuil
Hyatt Regency Etoile
Date: Tuesday May 23, 2017
Time: 12:30-14:00

Future SSC Meetings

Dec. 2017, Singapore, Singapore
June 2018, Kansas City, USA

ICC 2017 SSC Committee Activities:

Symposium on Selected Areas in Communications:

Monday, May 22, 14:05 - 14:45
Room: Blue Amphitheatre Lobby (LCD screens from 3 to 10)
SAC-SSC-IS01: Satellite Communications and Networking
Chair: Jan Budroweit (German Aerospace Center, Germany)

Monday, May 22, 16:00 - 17:30
Room: 362/363
SAC-SSC-01: Satellite Communications
Chair: Andreas Knopp (Munich University of the Bundeswehr, Germany)

Tuesday, May 23, 09:00 - 10:30
Room: 343
SAC-SSC-02: Satellite Networking
Chair: Igor Bisio (University of Genoa, Italy)

Wednesday, May 24, 14:00 - 15:30
Room: 353
SAC-SSC-03: Next-Generation Satellite Networks
Chair: Marius Feldmann (Technische Universität Dresden, Germany)

IEEE International Conference on Communications
21-25 May 2017 // Paris // France
IEEE ICC' 17: Bridging People, Communities, and Cultures

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If you like to join SSC Technical Committee: Please send your name and e-mail address to the SSC Secretary, optionally include your mail address, telephone and fax numbers.
If you like to join SSC Mailing List: Instructions on how to subscribe/unsubscribe are available at https://comsoc-listserv.ieee.org/cgi-bin/wa?A0=ssc.

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MESSAGE FROM THE CHAIR

Dr. Tomaso de Cola

Considering that my chair mandate has started in July 2016, the forthcoming SSC meeting planned at ICC 2017 in Paris will correspond to the first year activity and as such gives the occasion to better analyse the achievements and the next steps planned for the second year. In particular, this first year has been very much based on the inspirations and lessons learnt collected during the previous mandates, where particular emphasis has been put on strengthening the position of our committee in the overall ComSoc TC portfolio, by improving the number of submissions to the satellite track (SAC-SSC) and by simultaneously promoting new editorial initiatives in top-ranked magazines. As reported in the short summary hereafter provided, important achievements have been recorded especially for what concerns the editorial initiatives, where two new ones have been finally approved. On the other hand, as far as paper submission to ICC/GC is concerned, I'm glad to see the good trend that our community is experiencing with a significant number of papers in the same order of magnitude as observed in the recent editions in 2016. Important points still to be tackled are to identify distinguished lecturers and take advantage of the working groups to promote new activities within the committee.

Participation to TC Meetings. The SSC TC last meetings have a quite satisfactory number of attendees. In both ICC'16 and GC'16 we had about 30-40 attendees, hence testifying the increasing interest in the TC activities and also confirming the stability of our TC. Nevertheless, we have to continue to publicize our meeting and to invite members, past and new, to attend.

Operative Policies and Procedures (OP&P). The possibility to have a recognition for people particularly active in the SatCom domain in addition to the service award given during Globecom is under discussion, by also taking as reference the examples of other TCs. If the case, a new version of the OP&P will be drafted for approval.

Membership Management. We proposed a two-fold approach: to continue with the acquisition of new members and, more importantly, to involve old and new members in the TC activities (as Symposium Chairs, Guest Editors, etc.). The former activity is proceeding at a slow pace, and we need more incisive action. For what concerns the second part, we deem it is producing adequate results: we nominate new representatives for IEEE ICC/GC and several members are working on interesting and prestigious editorial initiatives.

Extended Cooperation. It consists of strict cooperation with Industries, research institutes, standardization institutes (e.g., CCSDS, ETSI), and space agencies of several countries (NASA, JAXA, ESA, DLR). A first step is represented by the nomination of a Standardization Liaison coming from industry.

SSC Website and Mailing List. Maintenance and periodic update of mailing list and website are performed by the committee secretary, in order to guarantee up-to-date material and possibly attract new members interested in SatCom-related topics.

Current Journals/Magazines. Two important editorial initiatives have been eventually approved. First of all, a special issue about SatCom advances has been accepted for IEEE JSAC, with upcoming deadline on July the 1st. Then, a special issue about integration of 5G and SatCom has been recently approved by IEEE Network with submission deadline on the 15th of February 2018. Given the success of these initiatives, new proposals will be worked out by collecting ideas in the TC, as done during the past years.

Conference Activities (ICC/GC and others). In ICC/GC is consolidated the SSC Track. In the recent years the SSC track has been quite successful. The SSC track of IEEE ICC'16, chaired by our Song Guo, received around 50 submissions, GC'16 chaired by Tomaso de Cola received 41, whereas ICC'17 chaired by Igor Bisio received 58. The more recent GC'17 (with the SAC-SSC track chaired by Tomaso de Cola) submission record states that 56 submissions were received for the SAC-SSC track, hence confirming the good trend of the previous editions. Concerning other conferences, the SSC TC has endorsed SPECTS2017 and, CITS 2017 conferences.

Standardization Activities. During the meeting in Atlanta (IEEE GC'13), we appointed the Standard Liaison, Dr. Henry Suthon, Principal Senior Engineer at Boeing (h.suthon@ieee.org), who has recently confirmed his commitment in this role.

Dr. Tomaso de Cola, Chair
Satellite and Space Communications TC

SCANNING THE WORLD

Prof. Song Guo

The first half of 2017 has witnessed a lot of exciting news on the satellite and space technologies, such as earth observation, rocket reusability and space-based big data topics. Some representative news is summarized below.

Last December, Cloud Constellation Corporation has entered into a service provision agreement with Zettabox to help companies meet new European Union data protection laws as well as data sovereignty laws worldwide. Teaming with Cloud Constellation's SpaceBelt provides a global solution for companies to comply not just with new EU rules, but also to meet the rapidly growing number of data sovereignty regulations worldwide. As we have already known that the Cloud Constellation is building SpaceBelt, a secure space-based cloud storage network ring around the planet to provide infrastructure that is completely independent of the internet and leased lines, increasing data safety and removing jurisdictional concerns. By storing the corporate and government cloud high-value data on SpaceBelt's satellites, Zettabox will maintain data protection for Europeans and data sovereignty worldwide while giving businesses greater control and ownership of their data. For instance, with the Zettabox/Cloud Constellation offer, Office 365 users will be able to create content with the productivity tools they already use but store that content in space.

In the late February, one of the biggest story in the satellite industry broke with the news that Intelsat and OneWeb announced to merge, and Softbank would become a key player behind the new combined entity. It is believed that the merging would enable a combined GEO and LEO architecture or using multiple orbits gives the new combined company the ability to leverage the inherent strengths of each one of the constellations.

The other news worth noting is that by the mid-21st century, businesses in nearly every industry on the planet will have to leverage Big Data to stay competitive, according to a panel of experts at the 33rd Space Symposium in Colorado Springs. It is believed that without an in-house ability to analyze large datasets, running a business will become increasing difficult. However, most of the space companies are on average a little behind in terms of the adoption of big data technologies such as machine learning, and really using the data as a core part of the business. The company DigitalGlobe is viewed as an exception which has invested heavily into its analytical capabilities to make full use of its massive storage of Earth imagery in the last few years. Furthermore, DigitalGlobe announced a partnership with Esri and Harris Corporation, which will enable Esri users to access DigitalGlobe's 17-year, time-lapse library of high-resolution satellite imagery, the analytical and deep learning tools needed to unlock valuable insights from that imagery at scale.

On the late March, SpaceX made aerospace history with successful launch and landing of a reused Falcon 9 rocket which sent a commercial satellite into orbit. On the other hand, Blue Origin successfully tested its reusable booster using New Shepard rocket. The achievements made by both the two pioneering firms demonstrate the prominence of reusability among top industry officials.

In addition, a Swiss start-up ELSE has raised more than $4 million in funding the first in its 64-nanosatellite Machine-to-Machine (M2M) constellation, called Astrocast, which is putting the company on a track to launch two demonstration nanosatellites in the fourth quarter of 2017.

Although the capabilities of space assets continue to improve, the industry is constrained by what is able to lift up into orbit, especially in the context that many constellation plans are undergoing recently. Therefore, during the deep space exploration panel at the 33rd Space Symposium, the specialists concluded that the space industry needs larger, more powerful boosters to continue to progress.

Prof. Song Guo, Vice Chair
Satellite and Space Communications TC

FORTHCOMING GLOBECOM AND ICC CONFERENCES

COSPONSORING / RELATED CONFERENCES AND WORKSHOPS

MILCOM 2017
October 23-25 2017, Baltimore, USA
http://www.milcom.org
MILCOM 2017 celebrates the 36th anniversary of the premier international conference for military communications. At MILCOM, global security professionals face command, control, communications, computers and intelligence (C4I) challenges head on. They look at them from every angle and discuss them from end to end–research and development through future needs. The conference allows industry the opportunity to hear and understand the requirements, pace of change and state of play in a variety of C4I markets serving the military, federal agencies and multinational entities. Join military and industry communications professionals in this evolving conversation October 23-25 at the Baltimore Convention Center in Maryland. MILCOM features outstanding technical presentations, discussions and tutorials, as well as nearly 30,000 square feet of industry exhibits. Experts in C4I and cyber issues as well as science and technology developments will lead more than 300 unclassified and restricted sessions.

GLOBECOM 2017
December 4-8, 2017, Singapore, Singapore
http://globecom2017.ieee-globecom.org/
IEEE GLOBECOM is one of two flagship conferences of the IEEE Communications Society (ComSoc), together with IEEE ICC. Each year the conference attracts about 3000 submitted scientific papers and dozens of proposals for industry events. A technical program committee of more than 1,500 experts provides more than 10,000 reviews, and from this a small fraction of the submitted papers are accepted for publication and presentation at the conference. The conference attracts roughly 2000 leading scientists, researchers and industry practitioners from all around the world. IEEE GLOBECOM is therefore one of the most significant scientific events of the networking and communications community, a must-attend event for scientists, researchers and networking practitioners from industry and academia. IEEE GLOBECOM is a five-day event. Two days are dedicated to tutorials and workshops, while the remaining three days are dedicated to the IF&E program and the technical symposia. The program of the technical symposia includes oral or poster presentations of about 1000 scientific papers, grouped into 13 thematic symposia, and more than 15 parallel sessions. In addition to the technical program, IEEE GLOBECOM 2017 will feature an industry forum and exhibition (IF&E) program, including industry-focused workshops, tutorials, keynote talks from industrial leaders, panel discussions, a large exposition, and business and industrial forums.

ICC 2018
May 20-24, 2018, Kansas City, USA

The International Conference on Communications (ICC) is one of the two flagship conferences of the IEEE Communications Society, together with IEEE GLOBECOM. Each year the ICC conference attracts about 2-3000 submitted scientific papers, a technical program committee involving about 1500 experts provides more than 10000 reviews, the conference being finally attended by 1500 - 2000 professionals from all around the world. IEEE ICC is therefore one of the most significant scientific events of the networking and communications community, a must-attend forum for both industrials and academics working in this area. We invite you to submit your original technical papers, and industry forum, workshop, and tutorial proposals to this event. Accepted and presented papers will be published in the IEEE ICC 2018 Conference Proceedings and submitted to IEEE Xplore®.

CONFERENCES CALENDAR

CONFERENCE	DATE & LOCATION	INFORMATION
SPECTS 2017 International Symposium on Performance Evaluation of Computer and Telecommunication Systems	July 2017 Seattle, USA	http://atc.udg.edu/SPECTS2017/
ITC 2017 29th International Teletraffic Congress	September 4-8, 2017 Genoa, Italy	http://itc29.org/
ICTS 2017 International Conference on Computer, Information and Telecommunication Systems	July 21-23, 2017 Dalian, China	http://atc.udg.edu/CITS2017/
ICL-GNSS 2017 International Conference on Localization and GNSS	June 2017 Nottingham, UK	http://www.icl-gnss.org/2017/index.html
PIMRC 2016 IEEE International Symposium on Personal, Indoor and Mobile Radio Communications	Oct. 8-13, 2017 Montreal, Canada	http://sites.ieee.org/pimrc-2017/
Ka-Band/ICSSC The 23rd Ka and Broadband Communications Conference and the 34th AIAA International Communications Satellite Systems Conference (ICSSC)	October 16-19, 2017 Trieste, Italy	http://www.kaconf.org/
VTC-Spring 2017 2017 IEEE 85th Vehicular Technology Conference (VTC-Spring)	June 4-7, 2017 Sydney, Australia	http://www.ieeevtc.org/vtc2017spring/

To all SSC members: If your postal address, telephone or fax numbers have changed, please update them with the committee secretary. You can review our current records on our web page at http://committees.comsoc.org/ssc/.

Low-Earth-Orbit based Big Data Storage

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***Abstract* — Satellite-based communication technology regains much attention in the very near past few years. But the satellites still play the role as relaying devices to the communication net- works. Differently, we focus on the data storage leveraging the low-earth- orbit (LEO) satellite based cloud (also called space based cloud), which has been considered as a very promising secure paradigm to big data storage. However, we notice that the concept of the data storage leveraging space based cloud is still missing. Therefore, in this paper we first propose a layered architecture for such space based cloud infrastructure. We then discuss some potential challenging open issues for the big data storage architecture established beyond the LEO satellite based cloud.**

INTRODUCTION

Big data paradigm incurs the explosive growth of data required efficient storage and management. Referring to [1], the existing state-of-the-art big data storage systems mainly include Distributed File Systems, NoSQL Databases, NewSQL Databases and Big Data Querying Platforms.

Although these storage systems have been proposed to meet the stringent requirements on storage and management, it is widely admitted that today's Internet and data storage that are able to handle cloud operations and cloud storage, are very leaky and prone to cyber-attacks. Therefore, some pioneering companies are seeking new paradigms to provide real secure data storage and management. As a typical example, Cloud Constellation [2] intends to establish a LEO satellite based cloud infrastructure named SpaceBelt, which plans to offer secure data storage for internet service providers, large enterprises such as telecommunication businesses, and government organizations. To solve the widespread global crisis of data insecurity, this system will utilize a combination of LEO orbiting satellites and secure ground networks to allow customers store vast amount of sensitive and mission-critical data securely in space. The advantages of such system are easily recognized, because it can secure the high-value data by: (a) insulating it completely from the Internet and terrestrial leased lines; (b) liberating it from cyber-attacks and surreptitious activities; (c) protecting it from natural disasters and majeure events on the earth; (d) addressing all jurisdictional complexities and constraints; (e) avoiding risks of violating privacy regulations.

Recently, a number of studies and technologies emerging in both academic and industrial fields are focusing on the LEO satellite based communication networks (shown in Fig. 1). In the academic aspect, some

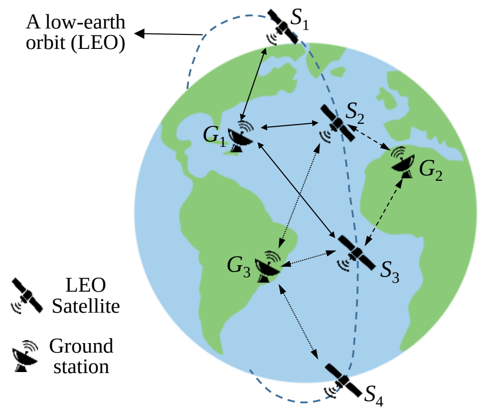

Fig. 1 A LEO-satellite based system with only one orbit illustrated.

related studies are given as follows. [3] studied the data transmission and downloading primarily using the inter-satellite links in the LEO satellite based networks. [4] proposed a selection algorithm to mitigate network congestion using the nanosatellites in the LEO based networks.

In the industrial side, several representative LEO satellite based projects have been well developed. For example, OneWeb satellite constellation is a proposed satellite constellation expecting to provide global internet broadband service to individual consumers as early as 2019. SpaceX has detailed ambitious plans [5] to bring fast Internet access to the entire world with a new satellite system that offers faster speeds and lower latency than existing satellite networks. Boeing will build a 702-satellite based project named GiSAT [6], [7], for Cayman Islands-based global IP with a new digital payload offering twice the capacity of previous digital payload designs. On one hand, it is not hard to find out that all the satellites mentioned in the existing studies above essentially play the role as "relaying devices" for the satellite based communication networks, which thus can be still viewed as auxiliary extensions of terrestrial core networks.

On the other hand, we also notice that the concept of space based cloud has never been formally proposed by the literature. To fill this gap, this paper is to propose a novel data storage architecture of space based cloud. We then envision some crucial challenges and open research issues on the big data storage under the LEO based space cloud.

LEO BASED DATA STORGE ACHITECTURE

In this section, with the illustration of Fig. 2, we present a four-layer architecture of data storage infrastructure built on the space based cloud.

A. *Explanation of each Layer*

We introduce each layer in terms of constitution and their functionalities following the sequence from bottom to top.

1) User Layer: The user layer contains all users coming from various terrestrial networks, like the Internet service providers, government entities and other multifaceted enterprises. Users upload data via its upper layer or submit data-downloading requests to the upper layer.

2) Ground-Station Layer: All the requests of uploading or downloading received by Ground-Station Layer will be led to an internal central Workload Scheduler, which then makes decision on workload allocation according to some specific policies such as load-balancing, first-in-first-serve, best-fit and other priority based algorithms. After allocation, the requests are delivered to certain designated ground stations, which upload data to or download data from the Data-Storage Layer.

3) Data-Storage Layer: In this layer, the datasets are stored in distributed server farms, which are deployed over LEO satellites. In each LEO satellite, one or multiple servers are embedded in the on-board unit. Then, each server hosts one or multiple virtual machines (VM), in which some popular data storage technologies such as Hadoop DataBase (HBASE), Highly Immersive Visualization Environment (HIVE) and Hadoop Distributed File System (HDFS), can execute to provide data management functionalities. We call such servers the LEO servers for short hereafter.

B. Essential Basics

Channel State: In particular, each channel between a LEO satellite and a GS is periodically available due to the reason that a satellite is periodical circling around the earth in a designated orbital plane. In the system where multiple LEO satellites exist in each orbital plane, a GS can connect with multiple consecutive satellites simultaneously, and vice versa. Normally, the transmission rate of a satellite-GS channel is affected by two critical factors [8]: the power-supply from the solar-board of satellite and the time-varying weather conditions. Although the latter one is uncontrollable, the bandwidth (i.e., channel rate) of an uplink or downlink could be still determined by manipulating the power-supply in the satellite based on the observed channel state.

Replication or Network-Coding: Giant amount of heterogeneous datasets originated from users need to be stored in the LEO servers. Each original user data is with a unique size and should be stored in the manner of replication or coding. If the resilience and robustness of data recovery are considered, each dataset need to be divided into multiple partitions, each of which should be with an appropriate size and stored in multiple replicas or in encoded chunks over the distributed LEO servers. When the Network Coding (NC) mechanism is adopted in the data storage, a dataset can be partitioned and encoded using many coding schemes such as the linear programming code and erasure code [9]–[11].

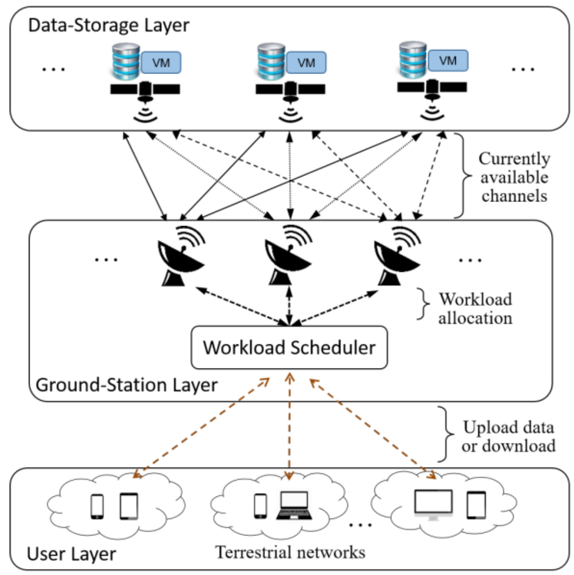

Fig. 2 The layered architecture for space based data storage infrastructure.

ADVANTAGES, CHALLENGES, AND OPEN ISSUES

In this section, we envision the typical advantages, challenges and open issues of the proposed space based data storage cloud.

A. Advantages

We then discuss the advantages of the proposed space based data storage architecture. On one hand, the biggest advantage is that it provides the absolute security for the customer's data. We can see from Fig. 2 that the data-storage layer is completely insulated from the terrestrial networks, cutting off all the threats such as cyber-attack, espionage and data theft, from terrestrial Internet and leased-line infrastructure. Besides, the proposed architecture would obviously benefit the big data storage on the complete immunity from natural disasters occurred on the earth.

On the other hand, as the jurisdictional controls are imposing ever growing restrictions on where data can go around the world today, our proposed space based cloud storage architecture will provide a safe haven for data storage without interruption to any unintended network jurisdictions. Furthermore, this architecture can offer opportunities to some cloud networks designed to move data around the globe without considering geographic boundaries as well.

B. Technique Challenges and Open Issues

Since multiple satellites are assumed to exist in each LEO, and the connection between a GS and a LEO satellite is periodically appearing and lasts only 20 minutes around. Thus, under such periodically available connections, there are a lot of technique challenges and open issues summarized below for academic research, industry and standards organizations.

1) *Data Storage Mechanism*: The first question is how data is going to be stored in the data-storage layer: in replication based or network coding based approach. If the former one is adopted, how each dataset is replicated, mirrored and deployed over the distributed LEO servers along an orbit? Otherwise, what network coding scheme will be used?

2) *Effects of Satellite Mobility*: LEO satellites have high mobility speeds relative to earth, resulting in that the topology of a satellite network dynamically changes all the time. Even though the time-varying topology changes are periodic and thus can be predicted, the handovers between LEO satellites and GSs are inevitable. This leads to higher operating expenditure (OPEX) and higher latency to the data flow transmissions for sure in the space based cloud.

3) *Power Allocation*: Since each LEO satellite is working under the power-supply by its solar panel equipped, the total power level is limited in a satellite. Also, the transmission rate of a satellite-GS channel is reported positively related to the power-supply [8] and affected by the current channel conditions when a GS is downloading data from a satellite. Given the current channel states, the energy-efficient power allocation in each satellite is a great challenge for all concurrently connected satellite-GS sessions when a large number of downloading tasks at hand.

4) *Support the Big Data Stream Processing*: As the data volume grows exponentially in today's big data era, and the real-time applications urge the stream processing paradigm. This is not a big deal in terrestrial networks. For example, one can implement a stream processing platform which is able to handle the batch processing, parallel computing leveraging Hadoop based system. However, achieving real-time data processing will become a huge challenge in the space based data storage cloud, since datasets are maintained over distributed LEO servers. It is not hard to imagine that a stream flow will suffer much larger latency in the space based cloud with periodically available GS-satellite channels than that in the conventional terrestrial networks.

5) *Fault Tolerance*: A data storage sever residing in a satellite will be down in case of some disasters in outer space such as radiation, strike by space junk or meteors. Thus a fault-tolerance mechanism should be provided to ensure the recovery of a data once some failures occur. However, fault- tolerance is a hard nut to crack. There is no 100-percent reliable fault tolerant software, especially for the space based server farm. Thus the main task is to reduce the probability of failures to a tolerant level when manufacturing the data storage hardware embedded in satellites.

6) *Consistency Maintenance*: Like in a traditional cloud storage, the data version management and consistency maintenance functionalities must be provided by the space based data storage infrastructure. Unfortunately, they are much more difficult than that in a terrestrial cloud, since a synchronization operation towards data version update and consistency will incur a large scale of data fluctuation over all the involved LEO servers. This requires cost-efficient management strategies in the system controller.

CONCLUSIONS

In this article, we have envisioned the challenges and opportunities for space based storage clouds. To satisfy the requirement of two crucial components of a data storage system, a layered architecture has been firstly proposed to establish such storage network infrastructure beyond the sky. Then, aiming to promote the proposed space based cloud from concept to reality, we summarized several open issues for academia, industry and standards organizations.

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