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Future Trends In Data Center Infrastructure Management For Satellite Data Processing

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Abstract
Satellite data takes up digital space, as data acquired from satellites needs a place where it can be stored and processed. For satellite image processing also, this digital storage space comes with a cost. Data from satellitesgettingacquired are over 10TB per day at NRSC andfrom various ground stations across the globe, which equates to tens of millions of images. As the latest existing satellites and upcoming satellites to be launched are of high data rates, processing the large voluminous data being received from these satellites will require high computing power to process the data in real-time. Servers with multi-processors, large memory and direct attached storage are an option. The space industry is moving toward a service-based model, often referred to as the "Space as a Service" concept. With this shift, satellite data processing need storage solutions that are secure and allow for easy scalability. Also need to ensure high availability and provide a platform for executing different data processing algorithms for satellite data processing in the mentioned environments is to be ascertained. This number is further going to increase as the number of satellites is increasing. Hence satellite data processing organization are looking for new options like "Space as a service, Ground station as a service, co-location data centers and cloud computing etc. A new design proposal called collocation data centerwhich involves setting up of compute, storage and network infrastructure at a feasible location and in a shared environment for providing compute platform for satellite data processing and dissemination with a facility for scalability included is presented in this paper.

Keywords :*Api, Cpu, Datacenter, Gpu,Ram.*

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I. Introduction

Data captured by satellites are sent to a ground station . While the type of equipment found at a ground station varies, several common elements include an antenna system, RF receiving and transmitting equipment, data-user interface, station control center, Telemetry, Tracking & Command equipment. For processing a large amount of satellite data there is a requirement to securely store and process imagery. Some options include an in-house data center, cloud storage, or an off-site data center.

A data center is considered as heterogeneous because it contains servers with different types and generation of processors, varying in terms of the speed and capacity of the processors with different memory configuration, networks, coprocessors etc. The heterogeneity is acquired because servers have been added to the data center incrementally as per the new requirements of higher configuration or due to the obsolescence of the old infrastructure and provisioned to replace the existing machines already in the data center's infrastructure. Since the resources are of different configurations supporting varying computing tasks the performance of such data centers will be effected and will not be comparable to that of a homogenous data center. Ensuring the desired Quality of Service, which is a standard indicator of the performance of the data center may be difficult. Heterogeneous Computing environment is set up to facilitate the right tools for computing using the right and latest configuration, for the task to achieve optimal performance and, at the right time to meet the demand. The continued push to gain the best performance possible with the lowest costs, while trying to fully utilize the IT resources in the data center thathas servers, network based storage or block storage etc. has literally reached a tipping point. New applications like Artificial Intelligence, Deep learning, Machine learning etc. being developed are demanding to augment the data center with latest state of art technologies in addition to the existing infrastructure. It has now reached the point that in house data centers have hundreds of server nodes for the existing and new applications. Although the costs of computing power have considerably reduced compared to the past, for servers with CPUs, GPUs and gigabytes of RAM the requirement of adding new compute resources to the data center has not reduced. The new applications call for constantly adding more and more machines, with an ever-decreasing return on investment and this is causing organizations to rethink their architectural philosophies and look at other options [1]. The traditional data center architectures that are being used have reached the point of diminishing returns, even when scaled out to literally hundreds or thousands of machines to meet the demand requirement. By continuously and incrementally augmenting the data center itwill result in IT costs to skyrocket for organizations.

Another important factor is Energy conservation in data centers which is important for both economic and ecological reasons[2]. Since the data center comprises of resources of multiple configurations for different applications, large amount of the energy consumed in data centers is wasted because all servers will not be operational 24X 7 but will be idle between processes and still consuming half of their peak power. If the system is idle for considerable amount of idle time the power consumption can be reduced by powering down servers. Since data centers are designed for 24 x7 operations, shutting down and power-up operation of a server causes increased energy consumption and which is not intended for. Hence, holding an idle server in active mode for a short period of time is cheaper than powering it down and up again shortly after. With latest state of art systems, it is observed that, the energy consumption of a server is not constant but increases with load. If a machine is idle, the processor cock frequency is lowered in latest configuration servers to save energy. At higher frequencies, the processor voltage will be raised, which results in a superlinear increase in power consumption. The data center comprises of different components and no single vendor will deliver all the elements of a computing solution. Hence multiple vendors are involved in building data center which include a wide array of servers with different configurations, multiple types of networking equipment to integrate the servers with clients, various types of storage systems, and management software. The main aim will be to optimize utilization of the existing resources with new techniques like virtualization and strike a balance before an investment is made for augmentation of IT resources. Since multiple vendors are required for maintenance of the data center, management systems that allow us to tie together networking, computing, and storage resource pools needs to be explored and inducted. Comprehensive Annual maintenance contracts with equipment vendors who are capable and competent are key to keep the systems working and healthy, but again this comes from Facility Management.

II. Existing infrastructure at IMGEOS, NRSC.

As the number of remote sensing missions has increased and the scope of supporting emergency requirements and disaster monitoring has increased, there was a need to reengineer the total data acquisition, processing and dissemination chain in order to minimize the turnaround time [3]. Hence and integrated satellite data acquisition, processing and dissemination chain has been developed as shown in Fig1. Data reception and processing is carried out from seven antenna systems, and for 21 satellites in an automated mode with work flow manager guiding from user request to delivery of products. Data processing systems are capable of processing data as and when acquired and also support emergency product systems in near real time. Scalable three tier architecture to account for the increasing data volumes from the existing and new upcoming satellites is established. Processing support is made available for global data acquisitions like ANTARCTICA, SVALBARD and national ground stations like Jodhpur, Strategic ground stations etc. The main objective is to eliminate manual intervention as much as possible, monitoring the activity of satellite acquisition and processing, facility to remotely monitor the events at the ground station, connectivity to different domains like internet, NKN, VPN and satellite WAN through high speed and secure Data Exchange Gateway.

To meet the objectives mentioned the IT Infrastructure at IMGEOS was installed in the centralized data center for the satellite data acquisition and processing. The infrastructure is made up of servers, storage, work stations with operating system and application software customized as per the organizational use. All the IT infrastructure is integrated and interfaced with the required switching elements enabling multiple workstations to be connected in the network to be a part of the chain as shown in Fig 1. To outline the utilization load on IT Infrastructure, this segment further expounds the on-going major processes in the chain viz. Data Ingest, Ancillary data processing and Data processing. The utilization statistics are monitored for all of the servers as it is the key measure to work on resource optimization [3]. The resource utilization reports collected from most of the servers shows the utilization of the serves as against the actual provisioned capabilities. To optimize the resource across the silos of operation at IMGEOS the solution of Virtual machines was introduced to facilitate extra resources from the available physical resources. This concept of VMs improved the resource utilization and simplified manageability of these huge numbers of systems.

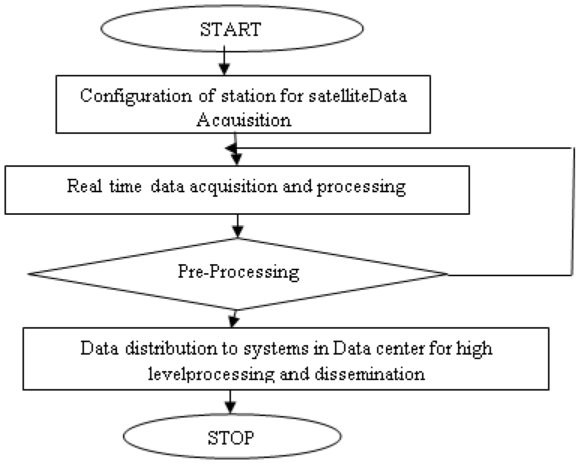

Figure 1. Data Flow in the existing data center.

The implementation involved deploying of huge number of computer systems of different configurations, three tier storage systems with 800TB of SSD as tier I, 3.2PB of NL SAS as tier II and 18PB LTO-7 Tape library as Tier III as shown in Fig 2. Network components like SAN Switches, Core Switches, Edge Switches and TOR switches along with racks were procured, installed, integrated and made operational for all the work centers. Now to house all these components a single storied building with required power, AC, partitions etc have been constructed and made operational. Some portions of the power was from Solar and hence solar plant was also established. Maintaining and operating in-house data center requires technical staff to be deployed in round the clock shifts ,for monitoring and attending to various data center components. This resulted in huge cost of installation and further maintenance cost on yearly basis for Facility Maintenance as shown in Table 1.

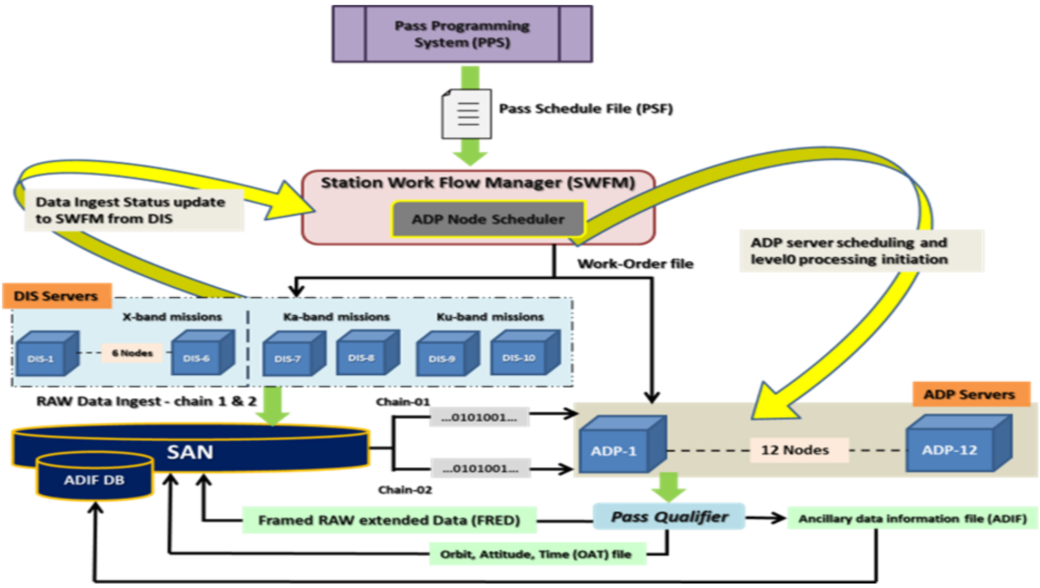

Figure 2. Heterogeneous data center with compute, storage and network

Compute Performance	Available Storage Infrastructure	Network connectivity Infrastructure	Maintenance costs (Power +AC+ Building+AMC)
> 150 Teraflops/second	Hierarchical storage of 36PB with proprietary software	100Gbps/40Gbps/10Gbps Network connectivity	8 % to 20 % of the asset costs

Table 1. Available infrastructure and performance.

III. Design of Relay data acquisition system

With the latest state of art type of data center established, the utility of the compute, storage resources should be completely utilized. While the type of equipment found at a ground station are common elements include an antenna system, RF receiving and transmitting equipment, data-user interface, station control center, Telemetry, Tracking & Command equipment etc. In order to reduce the IT infrastructure at the newground stations being designed and installed a new type of data acquisition system called as Data capture system was designed. The Data capture system comprises of server class machine with in house developed hardware for data acquisition and Direct Attach storage to archive the acquired data in real time. The Data capture system is interface to a Data Exchange Gateway for secure data transfer to the centralized data center at NRSC as shown in Fig 3. Thus only data acquisition at the relay ground station, archiving on local storage and forward it to data exchange gateway and using the high speed available bandwidth data will be transferred to the centralized data center for higher level processing, archival and dissemination [4].This concept was designed so as to increase the utilization of the centralized e.This concept had resulted in receiving large volumes of data from the relay stations and archival on the storage at the centralized data center.To cater to the increasing demands of data volumes the storage has to be increased regularly and also the facility maintenance contract for the higher volumes need to be subscribed and thus adding to the costs. Data acquired at global relay stations needs to be processed at the centralized data center; hence cost of bandwidth hiring was high.In an attempt to increase the data center utilization, the maintenance costs of the data center has significantly increased because of large volumes of data coming in from different stations national and international ground stations along with the local ground station and the establishment of communication bandwidth both terrestrial and satellite WAN.

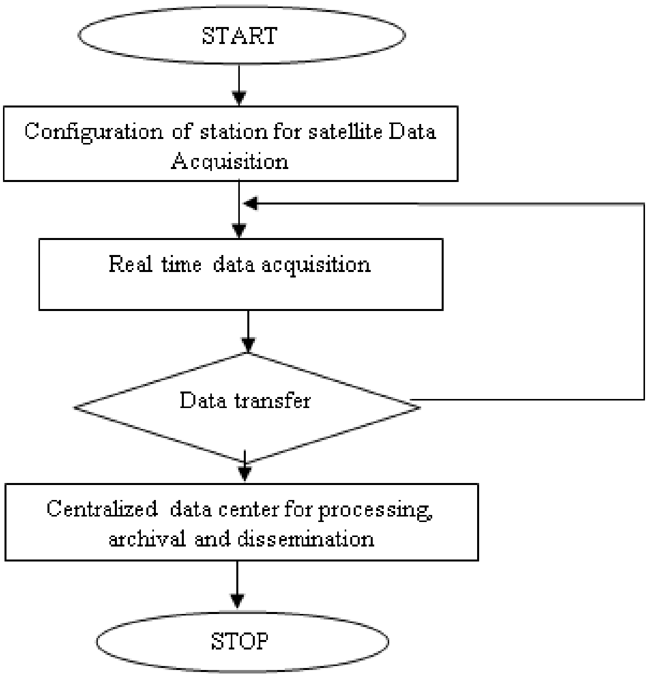

Figure 3. Data Flow in the relay station.

Ground stations installed and implemented at remote sites were configured as relay stations. Presently at the national level three stations are successfully installed and are operational. These three stations enable us to meet the demands of urgent data requirements during disaster and national calamity. Also the bandwidth required is being met by 1Gbps VPN connectivity, ensuring the data available at the centralized ground station for processing within the specified Turnaround time. Also such stations have been designed and deployed at Antarctica and SVALBARD international ground station. Data is regularly being acquired and transferred to centralized data center using the 45Mbps terrestrial network from SVALBARD ground station and 2 x 36 Mbps Satellite WAN network from Antarctica ground station to the centralized data center. The additional requirement of bandwidth costs is shown in Table 2.

Compute Performance	Available Storage Infrastructure	Network connectivity Infrastructure	Maintenance costs (Power +AC+ Building +AMC)	Additional Requirement of Bandwidth and costs
> 150 TeraFlops/second	Hierarchical storage of 36PB with proprietary software	100Gbps/40Gbps/ 10Gbps Network connectivity	8 % to 20 % of the asset costs+ Installation and maintenance cost of the VPN connectivity	High speed VPN will be the new requirement along with added installation and maintenance costs

Table 2. Improved Utilization but with additional cost of network connectivity

IV. Proposed new type of data center for satellite data acquisition, processing and dissemination.

The new idea is to establish a data center, by leasing space from a third-party who will provide system integration solutions and services for the infrastructure provided to him. In this new concept, the servers, storage and network infrastructure to be used by us for satellite data processing are procured, installed by our infrastructure team and handed over for maintenance to the collocated data center[5].The choice of colocation data center facility is made in such a way which allows flexibility to house ourIT equipment closer to our end users of satellite data or in a location wherenetwork connectivity is more reliable as this new concept requires high network bandwidth availabilityor a place which is not prone to disasters. This provides a higher availability of the infrastructure which may not be attained with in-house data center. When our IT infrastructure is installed at a co-located data center it will, reduce in-house technical personnel requirements since it will be maintained by the co-located data center personal.

In the new design, since the IT infrastructure is procured and installed by us, we will have more control on the resources while gaining benefits of collocated data centerbeing obtained from service provider [6]. The collocated data center is also planned to be utilized as Disaster recovery site and accordingly data mirroring software with tape library is being installed. The other advantages gained with collocated data centerisresources requiring capital expenditures to be incurred on facilities like UPS, Power grids and cooling units can be avoided as action will be taken by the collocated data center service provider. Also maintenance costs associated with maintaining and managing the in-house IT infrastructure will be the responsibility of the collocated data center service provider. If co located data centers support multiple customers along with us within the same facility, it enables us to enhance our computing power, storageand network integration at a lower cost compared to augmenting the in-house data center. Normally in-house data center's capacity is designed initially with provision for small scale future augmentation to a certain extent as there will be dependencies on the other related resources like space, power etc, but a collocation data center has the provision to support huge augmentations planned and at a lower cost[7].

In order to ensure faster data availability to the users and reduce the maintenance costs of the compute infrastructure, a change in the design to the ground station is proposed[8]. In this design the data is acquired from the satellite in real time and preprocessed at the local ground station at NRSC with minimum compute resources required and both raw and preprocessed data is transferred to a Tape library for permanent archival as shown in Fig 4. Now the centralized data center is converted to a low end data center with minimum compute resources and a Tape library for permanent archival as storage. At the relay stations established at different areas within the country and abroad data will be acquired on the Data capture systems and the raw data will be transferred to the local archival facility i.e. Direct Attached storage connected to the Data capture system. The raw data will be transferred to the centralized ground station at NRSC for permanent archival. The data flow from and to NRSC and collocated data center is through the secured in house developed Data exchange gate way.The higher level processing and product generation is carried out at the co-located data center and disseminated to the users. The data to the co-located data center is securely transferred, and as per the open data policy data products can be disseminated to users from the collocated data center. This will ensure that the security of the IMGEOS data center is not compromised as the users retrieve the data through the co-located data center. The compute infrastructure, storage and network for the collocated data center has to be procured and deployed at the collocated data center. By defining our latency and TAT requirements, the administrators of the datacenter should ensure our timing requirements and maintain the infrastructure thus reducing our organizations costs of maintenance and proprietary software like HMS etc.

The benefits of the new design are, reduced number of compute, storage and network infrastructure and hence less investment as shown in Table 3. Four CPU servers with 1TB RAM and GPGPU as optional are the requirements. The data processing software is in house developed using C, Python with RHEL as the operating system. As only archival and retrieval is planned, Tape library storage will suffice our requirement which is economical than the Hierarchical storage system. By installing a Tape library at collocated data center with mirroring software, the disaster recovery concern can also be addressed. Tape library with LTO-9 support is planned for archival and mirroring. Maintenance cost of the centralized data center of NRSC is considerably reduced.Since the resources as mentioned in Table 3 are only around 15 servers and 10 work stations with tape library the maintenance cost can be assessed as 8% of the resources compared to a data center with 140 servers and 60 work stations and 8% as maintenance cost. The building space is reduced from the existing 1000sq.mtrs to 70sq.mtrs and power requirement from 350KW to 80KW approximately. Maintenance manpower can be considerably reduced as it can be maintained by in house engineers.

The reduced compute resources are optimally utilized by planning the software modules to be developed with micro services and containerization by application developers for building scalable and maintainable applications as well as to manage applications in the underlying infrastructure[9].Micro services are light weighted, independent, and loosely coupled applications having specific functionalities within a bounded context and which communicate with each other using well-defined APIs. Containerization is a host OS virtualization technique which offers application direct access to system's computing resources without additional software layers. Containers are isolated, portable computing environment which consists application software along with binaries, dependencies and configuration files bundled into single package. Containerization of ground segment data processing software will lead to optimal utilization of infrastructure, better resource management and application deployment. Building this offline orchestration environment will enable the application developers to host their micro services in a robust, Load balanced and high available environment.

Collocated Data Center's main issue is that the bandwidth for communication with our organization computes resources needs to function properly and with high availability. The biggest concerns when WAN disruptions are encountered will lead to incomplete data transfer thus effecting the higher level processing, not meeting the product turn around time and data mirroring can stop which can effect DR although availability is clearly defined by a service-level agreement.The network bandwidth installation, high availability provision and maintenance cost is the only added expenditure.To provide networks in high available mode and ensure uninterrupted data transfer a scheme to alternate between high speed satellite WAN and terrestrial network is being planned. However potential challenges with respect to network latency is with satellite WAN weather conditions will affect the ku band communication and with terrestrial network multiple users of this network will slow down the bandwidth being achieved which may affect turnaround time.

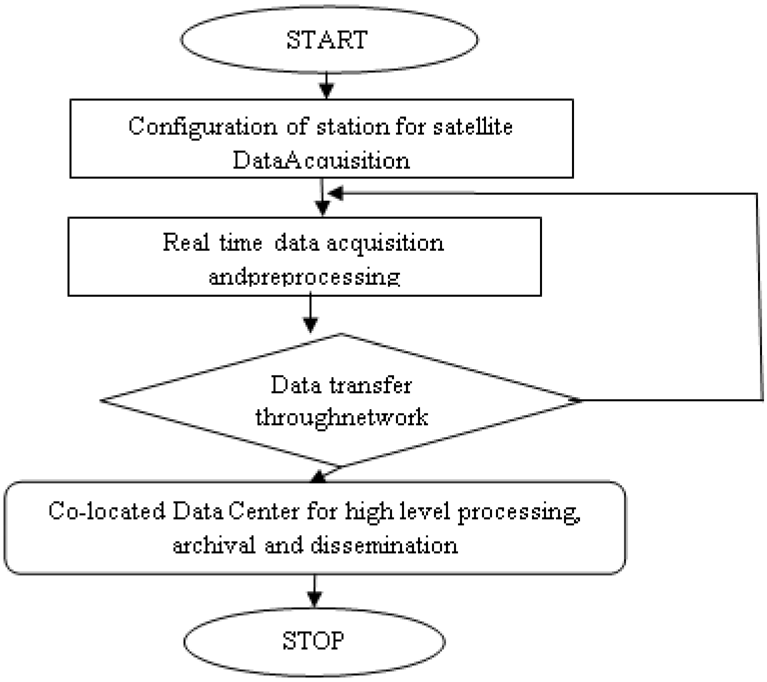

Figure 4. Data Flow in the new proposed design

Compute Infrastructure	Storage Infrastructure	Network Infrastructure	Bandwidth
15 servers and 10 work stations <10 Flops/sec compute power	Only Tape library will be required with necessary software for archival, retrieval and DR	Low configuration switches	High speed VPN will be the new requirement for communication to and from the collocated data center along with maintenance costs.

Table 3. Reduced Infrastructure and maintenance cost for in house Data Center because of colocation

V. Conclusion

For processing large amounts of satellite data, there are several benefits to utilizing a colocation data center. Many costs come with building, staffing, and maintaining a data center, hence a more affordable service fee to store IT equipment and data without taking on large upfront costs. Easily scale up or down when data processing needs change. As infrastructure needs grow, only need to upgrade space to accommodate more infrastructures. This type of data center provides higher level of security than most businesses could maintain onsite and are required to meet certain compliance requirements. In addition to offering physical security, data centers are built with infrastructure durability and advanced cooling systems, humidity control, heat removal, and fire protection systems to best maintain equipment. The colocation data centers handle all power needs, including power circuits, power infrastructure, and backup power sources and the task of maintaining the facility and offer a range of managed services, including remote technical support. Hence satellite data product costs also will have a downward trend. In the current scenario where satellite data is to be made free, such option will enable us to disseminate the data from external data centers to users while security of the data is still maintained as the satellite raw data and preprocessed data is still in our archival and only products are made available in the public domain.

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