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THE VALUABLE BUSINESS ADVANTAGES OF RESOURCE ORCHESTRATION TO THE SATELLITE OPERATOR

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Satellite payloads are increasingly becoming more adaptable and complex. As satellite manufacturers and operators design and build new satellites, there's a growing need to fully leverage this enhanced potential, particularly once the payload is on-orbit. Orchestrating satellite payload resources will enable enhanced services and quality of experience for fixed and mobility end-users and allows for dynamic, real-time management of resources to maximize efficiency—and ultimately sellable capacity—of these essential assets.

About Satellite Resource Orchestration

Satellite resource orchestration offers numerous business and technological benefits. Capacity on satellites is arguably an operator's largest asset. Capacity grows more abundant as businesses look to integrate a variety of constellations, orbits and new software-defined satellites (SDS), all of which have the potential to bring unheard-of levels of flexibility to service providers. The engineering challenge lies in harnessing that flexibility to optimize end-user services while maximizing sellable capacity.

Newer regional and national satellite operators, who may have less experience in managing complex satellite systems, face unique challenges in adopting SDS technology. For these operators, implementing and operating SDS can be particularly daunting. Regardless of the operator's size, service providers need the agility to adapt swiftly to customer and market demands, making the ability to respond to evolving business needs crucial.

Supporting satellite operators of any size, as well as satellite network operators and service providers, requires innovative technology to orchestrate these on-orbit assets. Resource orchestration is necessary to handle the management of payload resources and ensure synchronization with ground operations. Orchestration is crucial for bringing together SDS, NGSOs, multi-orbit networks and constellations, and hybrid connectivity with other telecom domains.

The Evolution of Satellites: Traditional, HTS, and SDS

Satellites have undergone a remarkable evolution, from the traditional satellites that broadcasted the moon landing in the 1960s to the high throughput satellites (HTS) of the 21st century, which expanded internet coverage and mobility services. The latest innovation in this evolution is the software-defined satellite (SDS).

Traditional satellites, with their fixed beams and limited flexibility, laid the foundation for global communications but were constrained by lower

bandwidth capacities and longer lifecycles. HTS marked a major advancement, offering significantly higher data throughput leveraging multiple spot beams and frequency reuse.

Now, software-defined satellites bring an unprecedented level of flexibility and efficiency. Unlike their predecessors, SDS can be reprogrammed while in orbit utilizing advanced software and reconfigurable hardware, allowing for dynamic adjustments to missions and payload configuration. This adaptability enables operators to respond quickly to shifting market demands and emerging opportunities.

What is satellite resource orchestration?

Satellite (or payload) resource orchestration refers to fully optimized control and management of the satellite resources on orbit and to the ground and back conveying dynamic changes in the form of information or decisions via a network management system (NMS).

What is a resource orchestration application?

A resource orchestration application is a software tool designed to manage and optimize the allocation and utilization of satellite resources, such as bandwidth, frequency and beam coverage, across a satellite network.

What is a radio resource control API?

A radio resource control (RRC) API is a programming interface that allows software applications to interact with and manage radio resources within a satellite network by exposing certain aspects via the NMS.

The Market for Satcom: an Industry on the Precipice

The satellite communications (satcom) market has undergone profound changes, driven by the demand for global connectivity and the expectations of a digitally connected world. This has spurred the growth of satellite-based solutions that can bridge the digital divide, providing connectivity in remote and underserved regions. The globalization of business has further amplified the need for reliable communication networks that can support international operations and data transfer.

The satcom industry is on the brink of significant transformation, influenced by the convergence of telecommunications domains and advancements in virtualization and cloud computing. Once siloed, the satcom industry is now witnessing increased collaboration with telecom players, creating opportunities for enhanced service offerings and network capabilities. The shift from measuring capacity in MHz to Mbps reflects a broader move toward data-centric services, aligning with the growing demand for high-speed internet and data-driven applications.

Multi-Satellite, Multi-Orbit Ka-Band Satcom Constellation for a Next-Generation Broadband Service

Calian and ST Engineering iDirect have worked closely with a customer to deliver the world's most advanced global Ka-band satellite communication service. This network provides high-throughput broadband service to aeronautical, maritime, enterprise and government sectors using a multi-orbit constellation.

The collaboration involved designing and developing a resource management and orchestration solution to operate a dynamic and efficient global network. This solution included payload configuration management, dynamic resource management, gateway switching and seamless service transition across a load-balanced network, demonstrating flexibility and effectiveness in managing HTS and very high throughput satellite (VHTS) payloads across space and ground segments.

The customer operated in a rapidly evolving business and technological landscape during the collaboration. The industry saw significant advances in satcom bandwidth, resulting in a substantial reduction in the cost per bit, allowing more users to afford satellite service.

As demand for satellite throughput grew, so did the need for gateway and network capacity. This drove the need for more satellites, gateways and larger bandwidths, necessitating the adoption of advanced waveforms and MODCODs such as DVB-S2X and Q/V feederlinks.

The customer encountered a series of unique challenges, including the need for a combined resource management solution with a dynamic baseband network management system capable of planning, managing and automating changes in satellite resources across the constellation. The resource management system needed to seamlessly integrate with the satellite and ground control segments to automate and optimize radio resource assignments within the space segment and ground networks.

To maximize the use of critical resources, the combined resource management and satellite broadband platform needed to autonomously adapt resource assignments in near real-time and apply mitigation strategies to alleviate the congestion by reallocating terminals and resources across beams and satellites. The collaborative approach between Calian and iDirect involved leveraging advanced technologies and methodologies to ensure the efficient operation of the satellite network. This included using global bandwidth management to optimize radio resource allocation augmented to global-level satellite load balancing, ensuring efficient bandwidth and spectrum use. Orchestration was employed to coordinate radio resource assignments and automate end-to-end configuration changes and gateway switching, streamlining processes, reducing manual intervention and enhancing overall network efficiency. The resulting resource management and orchestration platform effectively bridged the gaps between the space and ground segments. The software systems and technical support provided by Calian and iDirect were tailored to meet the customer's specific needs, ensuring efficient network operation at a global scale. Open APIs were used where available, ensuring extensibility to accommodate the evolving needs of the operator's network.

The collaboration highlighted the importance of flexibility and adaptability in addressing the satellite industry's evolving needs. The successful resource management system implementation

demonstrated the value of adaptive resource management and the need for customizable solutions to handle specific constraints. The experience underscored the significance of effective collaboration between Calian and iDirect, along with customers, to deliver a world-class network.

The Valuable Business Advantages of Resource Orchestration to the Satellite Operator

Resource orchestration simplifies mission reconfiguration, enabling a dynamic approach to operations that offers numerous benefits to satellite operators. The increased flexibility to manage and utilize space and ground assets is becoming increasingly valuable. Orchestration allows operators to rethink satellite operations throughout the payload's lifecycle, ultimately maximizing return on investment, reducing operational costs and swiftly identifying and exploiting new opportunities.

A commercial benefit of resource orchestration to operators is support for network reconfiguration. Implemented automatically or with minimal operator interaction, resource orchestration permits the satellite system to react quickly to changing user traffic demands or world events. Orchestration systems ensure rapid automated responses during failures or weather events, resulting in a robust network and a high-quality user experience. Prioritization of services enables the orchestrator to restore critical infrastructure or key revenue-producing services in priority order.

Over the longer term, resource orchestration systems encourage ecosystem interoperability. Acting as a central connection point and translation layer, the orchestrator enables greater vendor diversity. Partnerships or open interfaces are enabled, which permit maximizing network capacity or shared operation with multiple concurrent tenants on a payload, each with a distinct ground infrastructure. Collaboration leads to innovative solutions.

Resource orchestrators are central to network operations, receiving health and metrics data from both payload and baseband systems. Data visualization and reporting tools provide operators with a clear understanding of network status, including system health and resource utilization. Optimization algorithms ensure that existing customer demands are met efficiently, freeing up underused or wasted resources for other applications. This allows operators to easily identify and capitalize on new opportunities within their network, such as lease opportunities, thus maximizing revenue generation.

Simplifying and Automating Orchestration of On-Orbit Satellite Resources

A resource orchestrator provides a comprehensive set of tools for managing satellite resources without overwhelming operators. Routine operations are simplified or automated, while more complex activities are supported with robust traffic planning models that make resource plans easy to generate, validate and deploy. These streamlined tools enable quick, non-disruptive changes.

Orchestrator coordination ensures seamless configuration of baseband and payload systems to implement new resource plans. Confirmation of successful actions ensures that all necessary components are configured correctly and in order. Failure-handling routines address faults and take corrective action. The orchestrator, serving as the system's source of truth, initiates a synchronization process when unexpected responses are received from the baseband hardware or payload, ensuring the system maintains the correct state. It reconciles inconsistent configurations by applying missing or removing errant resources before resuming normal operations.

Depending on the deployed services and the capabilities of baseband and payload systems, dynamic channel allocations are driven by real-time user demand. When demand dictates an increase in capacity, channels are selected to maximize network capacity while minimizing interference. The orchestrator coordinates the allocation of new channels (and potentially new beams) on the payload and assigns the resources in the baseband platform, enabling a dynamic and efficient response to varying user demand.

Orchestration Features:

- **Dynamic Carrier Monitoring:** The orchestrator monitors active channels and carriers, measuring power, frequency accuracy, noise and interference. It configures

measurements at ground stations, on-payload, or through other methods as supported by the payload, ensuring carriers operate within specifications. Alarms are triggered for abnormal conditions or detected interferers.

- **Interference Mitigation:** Depending on system capabilities, interference can be addressed by locating the geographical source of intentional (jamming) or unintentional interferers. Techniques such as dynamic beam reconfiguration, frequency notching, or blocking frequencies in affected regions are used to mitigate interference.

- **Dynamic Gateway Switching:** The orchestrator monitors local weather conditions to optimize performance and reliability of weather-affected feeder links. Triggered by simple pilot or beacon power monitoring or AI-based regional weather forecast monitoring, the orchestrator ensures minimal customer service interruption by reallocating active channels across gateways. More advanced Ka or Ka/Q/V gateway diversity schemes, beyond classical 1+1 RF gateway diversity, such as N+M smart diversity, allows operators to optimize their total ground segment cost by reducing the required number of RF gateway antenna sites and antennas preserving the required user experience.

Overall, resource orchestration empowers satellite operators to optimize their operations and total cost of ownership of the overall network, enhance business value and fully exploit their system capabilities, all while monitoring critical system metrics. By integrating advanced features and automation, operators achieve greater efficiency and adaptability, ensuring their satellite missions are successful.

Two Types of Satellite Resource Orchestration Use Cases: Static and Dynamic

Resource orchestration use cases can be separated into static strategies and dynamic ones. Static strategies require no application layer and happen in a more controlled environment. They can be preplanned, or the outcome can be preplanned in the case of an anomaly. Dynamic strategies, on the other hand, usually require an application layer. Dynamic use cases would include scenarios that are ad-hoc or on-demand when automatic decision-making is implemented.

The static beam mapping and bandwidth reconfiguration use case is used to maximize sellable capacity by aligning with changes in user demand and traffic patterns, thereby optimizing system capacity. This approach allows for the reconfiguration of geographical or localized areas (footprints) to better support regions with high demand. Additionally, resource orchestration is crucial in developing spot beam patterns, frequency bands and carrier plans to effectively manage limitations in available spectrum resources.

Another static use case is in the context of gateway diversity and backup, such as rain fade diversity schemes to mitigate weather-related signal degradation at gateway sites. Resource orchestration also supports 1+1 gateway switchover and smart diversity, offering a cost-effective alternative to traditional site diversity, which often relied on redundant gateways. Additionally, backup gateway switching provides a reliable capability to mitigate service disruptions.

In the scope of advanced mobility, resource orchestration can enable a "follow me" capability, where beams are dynamically allocated to follow mobile platforms. This involves the positioning and assignment of beams to ensure effective usage in a follow scenario, managed in real time through orchestration applications. This dynamic approach is also essential for fulfilling traffic demands in real time, supporting changing user requirements.

On-demand orchestrated beams and service activation provide the capability to expand service footprints without relying on a dedicated beam grid coverage area. This allows for ad-hoc services to meet fluctuating demand. Resource orchestration in this context is also critical for managing congestion within a beam, ensuring optimal performance and resource allocation.

In NGSO (non-geostationary orbit) orchestration, handover management is crucial in a constellation environment. Orchestration facilitates seamless handover from one satellite to another, ensuring that user terminals are managed dynamically based on specific handover plans in real time.

Standards Can Create Greater Operational Efficiency and Resilience

Developing standards that ease implementation and promote interoperability across different systems is an important factor in resource orchestration. One key aspect to advance orchestration is the creation of open application protocol interfaces (API), which are designed to simplify customer decision-making in multi-vendor and multi-orbit environments. APIs, whether open or standardized, should be intuitive and easy to use, enabling customers to operate orchestration applications seamlessly across various vendors. Furthermore, these APIs must be capable of integrating with orchestration applications that support multi-orbit networks and multi-satellite strategies, ensuring flexibility and adaptability in a rapidly evolving technological landscape.

Vendor-agnostic solutions are increasingly important in the satellite industry, as they offer the ability to provide a satellite orchestration solution that operates across different satellite manufacturers' systems. This flexibility allows customers to integrate and manage various satellites within their network, regardless of the manufacturer. By supporting interoperability across different satellite platforms, these solutions enable customers to optimize their operations and reduce reliance on a single vendor.

This vendor-agnostic approach is equally relevant to ground segment infrastructure, where multi-vendor hardware can be orchestrated without being restricted by specific vendors. Such flexibility ensures that customers can choose the best available technologies and solutions for their needs, fostering a more competitive and adaptable environment. By limiting vendor restrictions, customers can achieve greater operational efficiency and resilience, ensuring that their networks remain robust and responsive to changing demands.

A single use system that encompasses multi-vendor, -orbit, -network, -frequency, -access, etc., could rely on resource orchestration to roam across the entire ecosystem. For a service provider, this design creates maximum value for the customer without traditional vendor and technology limitations.

Satellite Manufacturers Hold the Key to Space-to-Ground Interoperability

A satellite manufacturer depends on their buyer, the satellite operator, to provide detailed requirements for a new satellite purchase. As satellites become more sophisticated, the collaboration between the manufacturer and the ground system provider is emerging as essential for seamless integration and on-orbit functionality throughout the satellite's lifecycle

Interoperability between ground and space systems is fundamental to fully utilize the flexible capabilities of SDS. A strong partnership ecosystem further ensures that satellite

industry customers receive an end-to-end (E2E) solution capable of meeting both their short- and long-term requirements.
By fostering strong partnerships, risks can be identified and mitigated early in the process, ensuring reliable and seamless interoperability. This proactive approach enhances the overall performance and adaptability of SDS, providing customers with a robust, future-proof solution that meets both short- and long-term requirements.

To learn more about Calian, visit: https://www.calian.com.

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