Making Hardware as Easy to Manage as Software in Communications Service Providers' Distributed System Infrastructures

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Starting Point: The Telecom Industry's Pervasive Embrace of Cloud-Native Designs

The dominant model of application design today is the modular, micro services-based framework of cloud-native implementations. Numerous studies have highlighted cloud-native as the dominant framework being used in new application development, for example, a Rackspace survey of over 1,500 IT decision-makers showed 97% of those decision-makers either using cloud-native implementations currently in their applications or planning to use them moving forward.[1]

A parallel evolution of the software-defined infrastructures on which those workloads run has occurred, allowing them to be almost arbitrarily scalable in a distributed mode. Communications Service Providers (CSPs) have committed to adopting this paradigm in their large-scale, centralized data centers, as well as in their (increasingly) distributed mobile core and radio access network (RAN) deployments and in their edge application infrastructures.

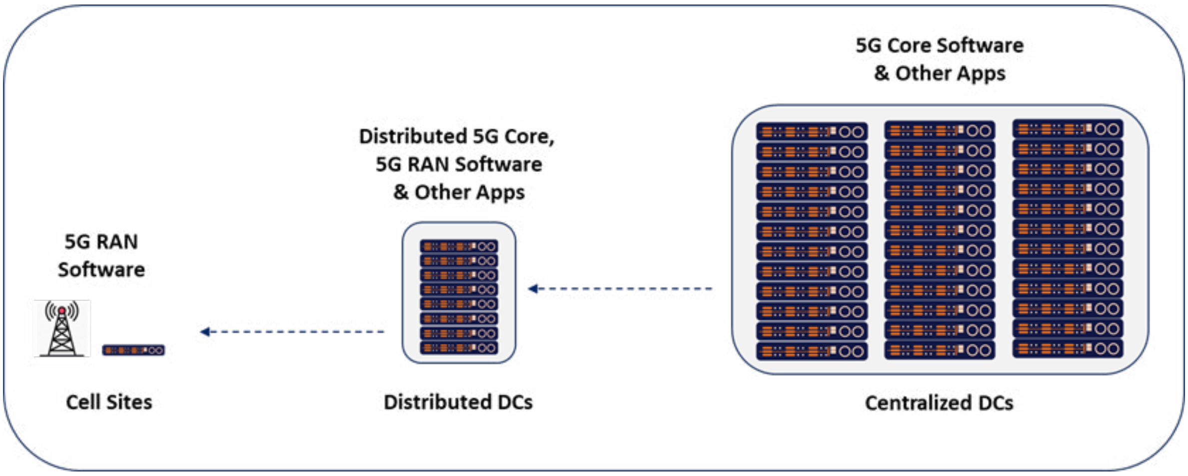

Figure 1. Example in 5G Implementations of CSPs' Increasing Distribution of Bare Metal Hardware in Their Infrastructures for New Services and Applications

By re-architecting their service delivery platforms in this way and integrating those infrastructures with the cloud-native applications they are supporting they are transforming their environments into large-scaled, distributed, and increasingly automated application delivery platforms that can work with a rich and diverse set of workloads.

[1] See https://www.rackspace.com/solve/dont-believe-three-cloud-native-myths for details.

Up Next: Making the Hardware in Next-Generation Deployments as Easy to Manage as the Software It Is Supporting

Although progress in making software infrastructures simpler to manage has been moving at an almost breath-taking place during the past five years, progress in simplifying and streamlining the operation of hardware infrastructures on which they run has been moving at a slightly more modest pace and in a more fragmented way.

For example, server vendors and the Distributed Management Task Force (DMTF) have made steady headway on bringing the Redfish architecture to fruition for open, automated management and orchestration of server deployments[2] , and vendors have been implementing functionality based on it to make their heterogeneous portfolios easier to run. Similarly, storage vendors and the Storage Networking Industry Association (SNIA) have made progress in defining open standards in line with Redfish to simplify the management of storage resources in its Swordfish specifications work.[3] Third, vendors and users taking part in the Open Compute Project have defined an Open System Firmware framework to help simplify the life-cycle management of servers' firmware.[4]

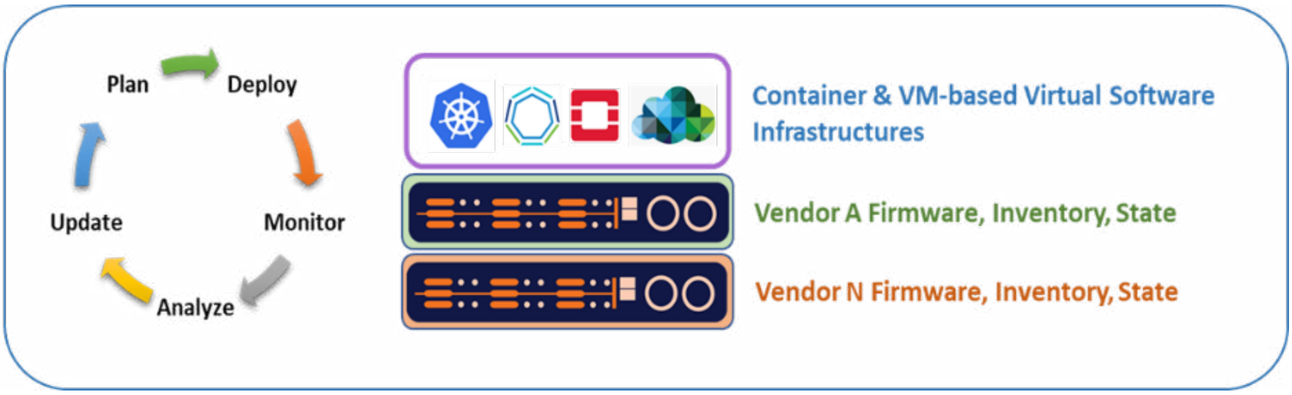

Figure 2. Illustration of Life-Cycle Management Applied to Bare Metal Hardware and Virtual Software Infrastructures in CSP Data Centers

[2] See https://www.dmtf.org/standards/redfish for details on the data models and reference architectures that are being used.
[3] See https://www.snia.org/education/what-is-swordfish for details.
[4] See https://www.opencompute.org/projects/open-system-firmware for details.

Although each is a useful building block in improving the efficiency of managing hardware underlays, the *scale-out* of service providers' infrastructures for software-driven networking has created increased urgency for making progress on a more holistic, logically unified, scalable, and software-driven approach to managing *massive fleets* of server, storage, and networking hardware providing the distributed underlay of CSPs' operations. To put this in perspective, many Tier 1 CSPs (including the world's largest in every geography) support 10s of *large, centralized* data centers, 10,000s of *distributed computing sites* of varying size (central offices re-architected into data centers, network aggregation sites, and customers' premises sites in managed services), and 100,000s of devices to be managed across these many locations.

Knowing these implementations require both consistency *and* scale in the management systems they use (to meet customers' diverse requirements), it is easy to see the imperative CSPs are facing to find simplified methods of deploying and managing these infrastructures well.

Moving Toward Solutions for Automating the Management of Large-Scale Distributed Bare Metal Fleets

Addressing these challenges has given rise to developments in open-source projects and in vendors' solution offerings that have the promise of simplifying operations. In most cases these developments are using principles that have been used in webscale operators' deployments and by implementers that have developed the software-defined solutions used in cloud-native software deployments in data centers and in virtualized networking over the past five years.

They utilize *openly defined reference architectures, data models, and protocols* to support the operation of hardware underlays. They are augmented by protocols and principles used in large scale, distributed networks today (such as geo-redundancy and support for temporarily air-gapped, isolated operations) to keep operators' infrastructures running. They are heading in the direction of supporting a logically consistent, versatile, software-defined, and scalable platform for simplifying the operation of distributed bare metal hardware fleets.

Leading Examples of Bare Metal Automation and Software Control

CSPs and vendors have each accelerated efforts to produce software control and automation for life-cycle management of their bare metal infrastructures over the past two to three years. Efforts are focused on supporting diverse combinations of hardware *as well as* a range of higher-level software implementations in large, distributed data center and network environments.

Two examples of these in the open source community are the *Anuket* and the *Open Distributed Infrastructure Management* (ODIM) projects hosted by the Linux Foundation[5]. Anuket is focused on deployment of cloud-native, software-based network functions in distributed CSP infrastructures, and ODIM is focused on simplifying the operation of distributed bare metal hardware underlays. Each is an example of user and vendor communities working to develop open software to use in running distributed network clouds.

An example from the service providers' perspective is interexchange operator Equinix's implementation of a software-driven bare metal infrastructure service (called *Equinix Metal*)[6] that provides automated deployment of bare metal infrastructures for a variety of workloads (including operators' network functions). Some vendors have also created their own proprietary bare metal infrastructure automation offerings that to date have focused on operations in individual data center sites (versus the distributed environments on which CSPs are focused).

Each of these efforts is evidence of end user, vendor, and service providers' engagement in developing automation for managing bare metal infrastructures heading in the direction required to meet CSPs' needs. They also show that developments toward meeting these requirements are in their relatively early stages.

CSPs' Perspectives on Using Automation in Managing Their Bare Metal Infrastructures

In our engagements with CSPs during the past several years, we have seen first-hand the challenges they face in building out virtual network infrastructures, contributing to their interest in obtaining scalable, flexible software to automate the management of their distributed hardware infrastructures.

CSPs are keenly aware of the challenges that scale and transformation introduce in their deployment of distributed infrastructures, at the same time maintaining resiliency and reliability in their offerings. They see consistent automation of their infrastructures helping to achieve that. Second, they understand how critical it is to bring innovative new services to their customers and their partners: mixing, matching, and blending their offerings within a mix of cloud-based services.

[5] See https://anuket.io/ and https://odim.io/ for details.
[6] See https://metal.equinix.com/ for details.

At a more detailed level a number of specific dynamics add color and detail to understanding the challenges they are striving to overcome.

One is that CSPs tend to have a *diverse mix of vendors'* products deployed across their sites, including multiple generations and models of the products within their suppliers' portfolios, making support of a mix of implementations and tool sets a costly current necessity. They also have a *wide range of configuration sizes* in those sites (from 1,000s of servers in central data centers to 10s of servers (or fewer) in more distributed locations. Across this footprint they also need to support *diverse sets of virtual software infrastructures* (virtual machine and container-based solutions) in varying combinations. On top of this they have widely varying numbers of personnel knowledgeable in supporting ICT hardware and software. This highlights the need to be flexible in mixing and matching responsibility assignments among teams.

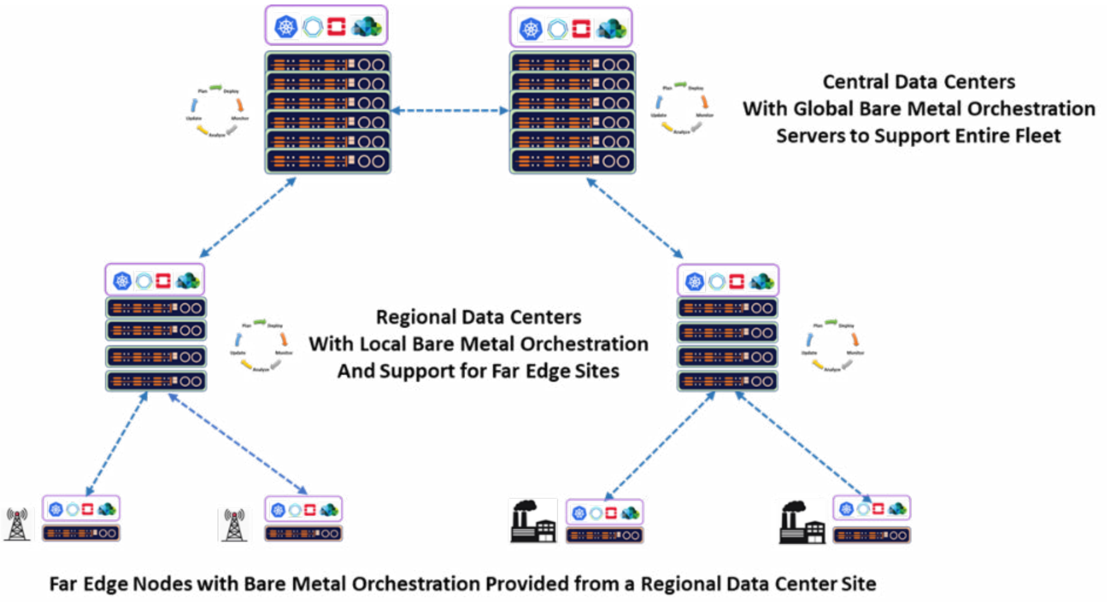

Figure 3. Idealized Design for a CSP's Global Bare Metal Infrastructure Orchestration System

Based on these realities CSPs have expressed a strong desire to work on converging workflows across their implementations into a more consistent and standardized approach to performing the same sets of tasks across their hardware fleets (versus continuing in the present mode of needing to support a fragmented combination of tool sets and procedures for supporting multiple vendors' systems). CSPs want to integrate support of both bare metal hardware and higher-level software at every site to ensure reliable and efficient delivery of services.

This goal is beyond being a pipe dream for CSPs; it is an absolute requirement for ongoing effectiveness and success.

Most Important Requirements to Address in Bare Metal Automation for CSPs

We have identified a clear set of requirements that solutions need to provide for CSPs to meet their goals. The most important are:

- An unwavering commitment to using **openly specified**, community endorsed **data models, protocols, APIs,** and **architectural frameworks.**
- Support for **multiple vendors'** server, storage, and networking hardware with **consistent functionality across each task** the automation system supports (discovery, inventory, configuration, monitoring, control, diagnosis, upgrade). This can include interworking with specific vendor management servers and functions in different configurations (done transparently from the automation system via standardized protocols, adaptors, and/or APIs).
- Support for automatic, transparent integration with **diverse virtual software infrastructure environments,** including Kubernetes, Open Stack, and VMware Cloud.
- Use of a scalable, **role-based interactive console** for access to and management of the functions of the solution.
- **Geographically redundant,** distributed control and operation.
- **Distribution of controls** to perform functions locally where possible that are hindered by latency. Support for **APIs to other management software applications** (in addition to the infrastructure managers previously mentioned) to reinforce CSPs' business and operations management (financial/asset management, customer experience management, others).
- **High availability** of the control and management nodes of the system.
- Cost when performed over wide area network connections.
- Scalable to **1,000s of physical operating sites** (up to 100,000 at largest scale).
- Scalable to **100,000s of physical operating nodes** (up to 1,000,000 at largest scale).

Automation Will Enable Highly Effective Value-Add in CSPs' Use of Bare Metal Infrastructures to Support Their Operations

Given the commitment of the CSP community to distributed, cloud-native infrastructure deployments, CSPs' use of diverse, high-performant hardware in supporting them, and the pace at which their distributed infrastructures will be deployed, it is clear that developing solutions to automate the consistent, efficient, and scalable support of these infrastructures will be an important element of their ongoing success.

To share a preview of the value these solutions are likely to deliver to the operators that deploy them: in an analysis of the improved total cost of ownership (TCO) and return on investment (RoI) for CSPs when they use a bare metal automation system of the type we are describing in this paper, we found that a suitably deployed solution would reduce the CSPs' operating expenses in supporting the deployment as much as 57% (in a large deployment), its TCO by as much as 55%, and would deliver an RoI up to 255% (based largely on accelerating time to market in delivering new services through accelerated deployment of their supporting infrastructures).[7]

Pursuing the use of automation solutions of this type in managing their distributed bare metal infrastructures will undoubtedly improve substantially the efficiency, agility, and pace of innovation achievable by the world's CSPs, compared with using a more silo'd or fragmented approach.

From our findings, the upside benefits of cloud-native designs can clearly be extended to the management of operators' bare metal hardware infrastructures and will clearly be an element of their best practices in operations moving forward.

[7] The CSP environment and the economic model of using automation in a CSP's distributed bare metal infrastructure that we developed are described in the companion brief to this industry perspectives brief, The Economic Benefits of Dell Technologies Bare Metal Orchestrator, Peter Fetterolf, ACG Research, September 2021.