Fast, Simple and Open: The 10x ROI of Building Infrastructure in Layers
How physical provisioning automation, or “bare metal as a service,” eliminates virtualization and closes the IT execution gap
Executive Summary

RackN allows Enterprises to quickly transform their current physical data centers from basic workflows to cloud-like integrated processes. We turned decades of data center experience into data center provisioning software so simple it only takes 5 minutes to install and provides a progressive path to full autonomy. Our critical insight was to deliver automation in a layered way that allows operations teams to quickly adopt the platform into their current processes and incrementally add autonomous and self-service features.

Introduction

This short paper discusses the history and key architectural drivers for the RackN open source component known as Digital Rebar Provision. We describe how we designed independent architecture layers for Provision, Control and Orchestration that smoothly underlay popular tools like Ansible, Terraform, Chef and Puppet. We also discuss how RackN enhances the Digital Rebar Provision scaffolding with downloadable packages and a centralized management interface. Together, Digital Rebar Provision and RackN deliver a non-disruptive progressive approach to data center automation that can drives a 10x (or higher!) improvement in infrastructure ROI.

A note about our 10x claim: Using image deployments and our streamlined post-provision workflows takes server setup from 15 to 3 minutes in many cases, that’s a 5x improvement. Typical environments also require manual or loosely automated steps that add hours or days to simple provisioning tasks that RackN delivers in minutes resulting in 100x or better improvements. Since mileage may vary, we don’t want to claim 100x, so we’ll claim a 2x on that score for a total of 10x improvement.

What is RackN Digital Rebar?

At it’s core, RackN Digital Rebar is data center infrastructure provisioning software managing well known protocols including DHCP, PXE, IPXE, TFTP and HTTP to install operating systems on servers and switches via a network. The service includes critical hardware management extensions for multi-boot, conditional workflows such as image to disk, burn-in and decommission, out-of-band management and firmware configuration. The program runs as a service daemon on-premises as a data center utility with robust REST APIs for configuration and management.

While correct, this description fails to explain the critical role of automated provisioning plays in data center management. The Digital Rebar Provision architecture focuses on providing control hooks so that it can be part of larger data center orchestration and compliance reporting tools. Our RESTful APIs, clean CLI, plugin model and external websockets were designed to support high-level infrastructure requests such as “rebuild this server with that profile.”

For example, Digital Rebar Provision seamlessly integrates to configuration management such as Ansible, Terraform, Chef, Puppet and Saltstack. Digital Rebar Provision provides the missing physical controls for these tools and makes data center infrastructure “cloud equivalent.” It can also be easily integrated into a continuous integration / continuous delivery (CI/CD) pipeline where images are automatically generated and deployed.

The Digital Rebar Provision scaffolding is designed as a stand-alone service operated behind a firewall or without any external connectivity. To keep the design simple and lightweight, all the control configuration is managed as local data instead of relying on an external database. This design makes it trivial to massively distribute Digital Rebar Provision endpoints globally while keeping them synchronized.

The minimal scaffolding provides only the most basic built-in provisioning capabilities so RackN extends Digital Rebar Provision to advanced workflow and management using uploadable packages. The packages are a mix of scripts, templates and plugin extensions that work together to provide control functions. Our unique approach distributes these read-only automation packages to ensure field upgradability. The package pattern allows users to both customize to their needs and get high reuse from library packages.

In summary, Digital Rebar Provision is a provisioning application. RackN provides uploadable packages that enable autonomous control and integrations to popular orchestration tools.
Background: Decoupling is Hard

Making complex provisioning and control simple and lightweight is the result of years of innovation around a difficult, heterogeneous space where we have very limited ability to change our operating environment. In these environments, being less invasive provides more value.

The RackN team has been creating full stack data center automation since 2010. Now that we’ve delivered the first component of our fourth generation platform, it’s possible to explain the evolution in practical terms that readers can experience first hand.

Generation 1: Tightly Integrated (Crowbar)
Generation 2: Composable (OpenCrowbar)
Generation 3: Microservices (Digital Rebar Multi-Service Platform)
Generation 4: Layered & Distributed (Digital Rebar Provision & RackN Control)

The guiding principle of all of our scaffolding since Generation 1 is to work within the existing infrastructure requirements. We believe that being able to adapt to different environments, while difficult, enables innovation because we can embrace new along with legacy environments. Since it’s impossible to anticipate future needs, software that can drive upgrades must be flexible by design.

Embracing heterogeneity has a serious downside: complexity. While Generation 2 delivered on our vision of flexible and composable automation, it also required a significant investment to understand how the components were integrated. In Generation 3, microservices made it faster to deploy and possible to target limited functionality; however, the services were not designed to stand alone. This meant that the complexity of the full suite was exposed even for simple starter use-cases.

For this version, we decoupled the integrated suite into clear functional provision, control and orchestration layers that matched operator use cases. The layers approach adds progressive value so users can choose which layers add value and add their own tools into the mix.

For example, users can laterally replace their existing provisioning tools (typically Cobbler, Foreman or MaaS) with Digital Rebar Provision with minimal disruption or training. They can then add more advanced control functions or orchestration integrations.

This progression creates utility and value from basic IP assignment (DHCP) operating system provisioning (PXE) to controlling groups of servers through simple control sequences and then to complex orchestration activities within and between hybrid infrastructure resources. Our direct experience is that adding complexity in advance of need adds risk and distraction; consequently, a layered design improves user experience and velocity.

Decoupled Orchestration Enables User Choice

Separating control from orchestration is a major technical innovation in Generation 4.

Layering Digital Rebar Provision, control and orchestration provides significant benefits. Keeping provision and control services simple and lightweight reduces complexity and risk; unfortunately, orchestration adds significant complexity and overhead. Our design choice is to fully decouple the orchestration layer from Digital Rebar Provision.

Decoupling allows users to choose their own tooling for building and managing applications and clusters. For example, it is common to use Ansible, Puppet, Chef and Terraform on top of Digital Rebar Provision by building integrations directly to the control layer. These tools are typically deeply integrated into operator processes. Replacing them is not only political and disruptive, it often causes operational risk and cost. Digital Rebar Provision creates significant value by focusing on integration and collaboration instead of displacement.

Platforms and applications such as Kubernetes and OpenStack represent an additional layer above orchestration. They are typically installed by the same orchestration tools used in cloud deployments but with integrations for Digital Rebar Provision. Consequently, these overlay platforms are collaborative with the Digital Rebar Provision tool and are an expected part of deployments.

Note for Kubernetes v1.7 and above. Recent versions of Kubernetes include simplified provisioning triggers that do not require orchestration for installation. For these cases, RackN control extensions are sufficient to build and maintain a Kubernetes cluster.

Layers Enable Distributed Control

Layer decomposition makes it easier to distribute localized and independent Digital Rebar Provision services throughout a global infrastructure. This is because orchestration is generally centralized while control and provisioning actions can be localized. Digital Rebar Provision configurations are specifically designed to maximize this benefit.
RackN offers management software that creates a unified infrastructure from the distributed components. RackN management leverages the Digital Rebar Provision Services APIs and provides a synchronized storage location and multi-user API proxy for the on-premises services. Our service also offers reference managed automation downloadable content for Digital Rebar Provision.

Designed for Integration

Unlike other provisioning tools, Digital Rebar Provision was designed specifically to be integrated into a broader system. This decision comes from our experience building orchestration for the previous generation solutions. In Generation 3, we fully expected to re-integrate Digital Rebar Orchestration with the Provision function during the initial design phases.

Late in the implementation, the RackN team realized that we could implement sufficient Control workflows on top of the simple Provision architecture. These workflows handle hardware specific needs activities like acting across multiple reboots, mixing in-band and out-of-band actions and pre-install configuration. By solving these difficult problems in the Control layer, we were able to completely decouple Orchestration for the first time.

Since Digital Rebar Provision does not perform orchestration, it does not fight for control with popular configuration and orchestration tools like Ansible, Chef, Puppet, Saltstack or Terraform. Digital Rebar Provision provides infrastructure in a ready state for further configuration and does not expect to retain access to the systems. This unique design priority makes Digital Rebar Provision easier to adopt and integrate to other platforms.

Balancing API, CLI, and UI

Limited Digital Rebar Provision services to an API and CLI is another important architectural decision. This common cloud native pattern recommends that the key services are delivered as an API only with a companion CLI to help users interact with the API. The RackN team felt that a minimal embedded user interface (UI) was needed to simplify bootstrapping the DHCP service; however, all other UI has been removed. This practice keeps the service binary lightweight and reduces the need for patching functional changes only.

RackN offers a comprehensive user interface for Digital Rebar Provision to help users drive the system. In addition to advanced visualizations and wizards, RackN is able to help users manage and synchronize DLC between sites.

Digital Rebar Provision Features

The following items are critical features for the Digital Rebar Provision scaffolding:

- **Layered Storage System.** DRP storage model allows for layered storage tiers to support the content model and a read only base layer. These features allow operators to distribute content in a number of different ways and make field upgrades and multi-site synchronization possible.

- **Content packaging system.** DRP contents API allows operators to manage packages of other models via a single API call. Content bundles are read-only and versioned so that field upgrades and patches can be distributed.

- **Plug-in system.** DRP allows API extensions and event listeners that are in the same process space as the DRP server. This enables IPMI extensions and slack notifiers.

- **Stages, Tasks & Jobs.** DRP has a simple work queue system in which tasks are stored and tracked on machines during stages in their boot sequences. This feature combines server and DRP client actions to create fast, simple and flexible workflows that don’t require agents or SSH access.

- **Websocket API for event subscription.** DRP clients can subscribe to system events using a long term websocket interface. Subscriptions include filters so that operators can select very narrow notification scopes.

RackN Package Additions

The downloadable package model is an important design approach that highlights distinction between Digital Rebar Provision scaffolding and the automation artifacts that are needed to configure and run a data center.

There are three primary aspects to a running Digital Rebar Provision service: the service code (aka scaffolding), the configuration of the services and the automation artifacts (aka downloadable packages). The Digital Rebar Provision packages include items like operating systems ISOs, boot environments, template snippets, automation scripts and management plug-ins. While there is a wide range of pre-existing packages, the choice of package is highly environment specific and often customized by operators. For this reason, only a minimal community package is included with the Digital Rebar Provision scaffolding so users can choose their own path even in new installs.

The RackN management service provides a large, and growing, library of Digital Rebar Provision packages. The service also allows users to create and share their own content. Since managing the content is independent of the Digital Rebar Provision instances, it is not automatically covered under the Digital Rebar Provision Apache v2 license.

Leveraging Digital Rebar Provision, RackN has created the following control extensions.

- **Multi-path provisioning** including direct image, Preseed, Kickstart and Windows.
• **Resource pool management** to enable Terraform and similar cluster builders

• **Out-of-Band Management** (via IPMI) using secure access channels

• **Injection of SSH keys** during post-provisioning

• **Inventory systems** to local or central account

• **Live event notification** to publish activities to slack or similar systems

• **Post-install configuration** without SSH access to enable secure configuration or hand-off to orchestration platforms like Chef or Puppet

• **Burn-in** test as part of provisioning

• **Decommissioning** tasks like disk scrub

• **Integration with Chef, Puppet, Salt** and monitoring agents

• **RAID/BIOS configuration** via vendor tools in a flexible, heterogenous pattern.

**In Summary**

Digital Rebar Provision v3 reflects nearly a decade of evolving data center automation. We have worked hard to make it easy to understand and adopt without limiting the upper bounds of its capability. We also strive work collaboratively with existing tools and platforms so that operators can pick and choose how to change their processes.

Trying Digital Rebar Provision is easy - it only takes 5 minutes to install and 30 minutes to master.