Service Provider Network Control:
Dynamic Provisioning of Flat Networks

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1.0 Executive Summary

LTE, Machine-to-Machine communications, and IPv6 enabled device growth are converging to increase the operational requirements of wireless service provider networks. Together, these changes demand the rapid replacement of legacy, manual and/or isolated network provisioning processes by automated, virtual provisioning platforms that can more reliably, dynamically and quickly discover, configure and control the network resources needed by today’s IP based wireless communications.

These network resources are typically combinations of physical and virtual elements such as IP addresses, VLANs, DNS zones, DNSSEC keys, DHCP scopes, and tracking other device related data sets for integration into other platforms, billing systems or monitoring environments. This paper examines these trends and highlights how 6connect’s Dynamic Network Provisioning platform efficiently and effectively performs these important network operations functions at a much lower operational cost than traditional hardware or legacy homegrown solutions.

1.1 6connect Overview

Provisioning and configuring networks are normally manually intensive processes focused on individual, vendor-specific, network elements rather than the holistic provisioning of mobile network assets across distributed networks and virtual environments. These manual configurations cannot keep up with rapidly changing devices and networks, creating outage risks for network and data center that forfeit revenue, customer trust, and delay the introduction of new services. In addition, manual network provisioning limit the ability to holistically enforce compliance, concurrently update network policies and protocols, or manage or rollback network configurations because they are often done in isolation rather than across systems and only address vendor specific hardware or software elements rather than entire networks. As a result, networks cannot be provisioned and controlled at the pace required by our virtual and mobile business operations.

ProVision, 6connect ‘s unique Dynamic Provisioning control platform, overcomes the problems created by decoupling network control from network vendor hardware or software. This platform dynamically and holistically provisions all the network control factors needed to initiate and operate network and data center elements, including IP addresses, DNS zones, DNSSEC certificates, DHCP pools, VLAN and device level information. Available as either a highly scalable cloud or on-premise solution, ProVision automatically controls these factors across distributed and separate physical networks in order to reduce errors that can crash networks, cause compliance errors, and delay the creation of new services.
In addition, 6connect’s ProVision platform can embed virtual “EnVision” network agents that discover new devices, whether physical or virtual, as they appear on the network, and report on their network resource utilization and device level information. Beta versions of this product are being tested for feedback by a handful of select service providers and enterprises for more advanced discovery/control feature development. These advanced features enable network managers to understand and resolve the important operational challenges posed by the growing number of utilized IP addresses, network mobile devices, and virtual devices across their networks.

1.2 Envisioned Benefits

6connect’s IP and network resource provisioning platform fits perfectly with the emerging trend of IP networks. Built by service providers for service providers, 6connect’s ProVision Dynamic Network Provisioning platform enables significant time savings and operational benefits that would matter to service providers, including the following:

- Automated and accurate provisioning of IPv4 and IPv6 resources across the service provider’s entire network, that accelerates the creation of new services by 80%
- Systematic, multi-service provisioning of DNS and DNSSSEC credentials for all network devices and services
- Virtual agent based automated discovery of physical and virtual devices deployed across the network,
- Automated resource audits and reporting that enables consistent and accurate deployments of network resources as well reporting capacity utilization improvement opportunities

As this paper explains, these benefits are especially relevant to a service provider’s deployment of LTE services across its all IP transport network.

2.0 Drivers for change:

2.1 Market Changes Drive the Adoption of IP Core Services

4G advanced LTE services, Machine-to-Machine communications, and BYOD adoption are all creating unprecedented growth opportunities and operating challenges for service providers globally. As of March 19 2013, the Global Mobile Suppliers Association reported that 156 commercial LTE networks and that 666 LTE unique user devices have been launched globally, and that 68 million subscribers were actively using LTE at the end of 2012. Ever increasing use of smartphones, tablets, and machine to machine connected devices will escalate network access and backhaul demands on today’s wireless networks, requiring the rapid transformation of wireless network architectures,
radio access networks, and the core packet network and operational processes supporting them.

Signs of the need for rapid network change are appearing globally. Dell Oro Research predicts that LTE and service provider WiFi services will trigger a seven-fold increase globally in public access small cell equipment comprising service provider WiFi (SP WiFi), and evolved WCDMA/LTE and multi-mode WCDMA/LTE/WiFi small cell radios between 2012 and 2017. This growth will add additional complexity to network provisioning and operations because much of it will occur not in traditional outdoor coverage sites but instead in indoor sites and to boost cell site performance.

These changes accelerate the transformation of a service provider’s wireless network data and communications amongst all of its multiple radio access networks from a mixed circuit and IP core to an entire IP core network. By replacing circuit data, an IP Core network enables the establishment of data intensive and application central business models that create new revenue streams. IP core networks also create significant cost savings by replacing circuit switched voice with lower cost VoIP traffic. Hence, the growing adoption of Evolved Packet Cores (EPC): new, high-performance, high-capacity all-IP core networks that separate the control and data planes and through a flattened IP Cloud architecture, and reduce the hierarchy between mobile data elements.

![LTE deployment with EPC over conventional Transport](image)

**Figure 1 LTE deployment with EPC over conventional Transport**

The consolidated network provides additional carrier revenue opportunities along with reduced management costs compared to traditional technologies. However, provisioning and managing these elements across distributed and heterogeneous network architecture is a daunting task. With the addition of IP technologies like IPv6 and more “smart” devices leveraging the infrastructure, device tracking, management and auditing will continue to become even more of a challenge than they are today.
The flattening of service provider networks in LTE implementations has profound implications:

- Mobile services are all built on the IP protocol
- Joining of new mobile architectures with previous mobile technologies (2G/3G)
- Scalability required for increases in users, bandwidth and user/device mobility
- Service reliability and availability for uninterrupted service

Another reason for service providers automating their network provisioning processes is the rapid growth of IPv6 enabled devices, which is especially acute in the LTE mobile market due to LTE’s use of IPv6 addressing for endpoints. IPv6 mobile deployments will grow significantly according to Cisco’s Visual Networking Index February 2013 update. In 2012 14 percent of all mobile devices shipped globally were IPv6 capable, and that this will grow to 41 percent by 2017. These devices include all Internet connected mobile devices such as M2M end points and smartphones and tablets. IPv6 growth will be even more profound for smartphones and tablets. In 2012, 41 percent of these devices or 479 million units were IPv6 capable. Cisco predicts this could grow to 73 percent, or 2.2 billion, of all smartphones and tablets shipped in 2017. (IPv6 changes will also occur simultaneously on wire-line networks as well. In mid 2012 nearly 20 percent of the world’s installed base of routers was IPv6 capable. Synergy Research forecasts this to grow to 59% by 2016, creating additional provisioning and network control strains on networks).

To accommodate these trends, Service Providers will need to ensure that their radio access networks and EPC are both IPv6 enabled. This will mean new equipment and software supported by new operating procedures. And since there will be a prolonged period where the only new routable addresses will be available under IPv6, but most Web-based content will still only be available via IPv4, service providers will be forced to support both protocols concurrently via dual stacking, where both versions of the IP protocol run in parallel. However, older network infrastructures may not allow for dual stacking and will have to rely on some form of encapsulation technology, such as tunneling, in order to support both protocols.
2.2 Evolved Packet Core Provisioning Requirements

EPC’s provisioning and control requirements surpass the capabilities of legacy and internally developed network provisioning solutions typically used by service providers. Most legacy solutions were Command Line Interface (CLI) centric and focused on provisioning networks in isolated silos rather than dynamically provisioning, monitoring, and controlling the network from end to end. This fundamental mismatch between legacy network operations and provisioning approaches and the new common service delivery platform and IP services that are intrinsic to the EPC’s strategic value must be resolved for Service providers to achieve an acceptable ROI on their LTE investments.

However, many Service providers still extensively rely on legacy, manual procedures or hardware intensive solutions to provision their networks, slowing down their responsiveness to customer needs, network demand changes, and leading to inaccurate provisioning that can create resource conflicts between network resources and even outages. The shortcomings of these approaches are summarized in Figure 3 below.

The speed of network resource consumption, allocation and change within an EPC forces a break with this unproductive, legacy approach, which include the following:

- Lightweight, dynamic footprint that gets the provisioning and control job done without requiring extensive deployments of new, costly hardware across the core and edge networks
- The automated ability to rapidly discover and configure both IPv4 and IPv6 network resources such as IP addresses, DNS, and DNSSEC for physical and virtual network devices across the core and edge radio access network

Figure 3 Shift from manual processes to information silos
• Logical, integrated views of and provisioning of network resources allocated to customer service maps across multiple network domains and topologies
• A single management platform that provides instantaneous, integrated views of network resources across the edge and core networks; and applies privilege based user rights to provisioning and changing these resources per the design of the overall network architecture management team
• RESTful API connections to existing and new hardware management systems, order entry systems, third party applications that support new revenue generating services, and sales force automation systems to leverage existing reporting and management capabilities and streamline end to end processing of change requests

The solution is a decoupled, vendor agnostic control plane that automates network device configuration and control on a network wide scale, and also utilizes a web service built on a RESTful API structure for easy integration with existing systems and third party web services, as depicted in Figure 4.

![Dynamic Network Provisioning Platform](image)

**Figure 4 Decoupled network control plane to minimize vendor dependencies**

This level of flexibility allows service providers to align with their current challenges, while avoiding forklift upgrade scenarios as technologies and vendors change.

### 3.0 6connect Solution Overview

ProVision, 6connect’s unique Dynamic Network Provisioning (DNP) control platform, overcomes legacy provisioning’s ineffectiveness created by decoupling network control from network vendor hardware or software. This platform dynamically and holistically
provisions all the network control factors needed to initiate and operate network and data center elements, including IP addresses, DNS zones, DNSSEC keys, DHCP pools, VLAN and other device level information. Available as either a highly scalable cloud or on-premise solution, ProVision automatically controls these factors across distributed and separate physical networks in order to reduce errors that can crash networks, cause compliance errors, and delay the creation of new services. DNP delivers significant value and benefits in network functions virtualization, device configuration, and interoperability across heterogeneous network technologies.

Key highlights and capabilities delivered by DNP include the following:

- 80 – 90% time savings on most network resource provisioning tasks
- Secure, open RESTful APIs for easy system integration
- Customizable internal data analytics, with native MySQL support
- Carrier-grade scalability to accommodate billions of devices, hierarchies and end users.

![Diagram of 6connect Dynamic Network Provisioning Platform](image)

**Figure 5 6connect Dynamic Network Provisioning Platform**

DNP consists of 3 primary elements:
• 6connect ProVision – a cohesive platform that ties together IPAM with Asset Management. Integrates a DNS and DHCP control layer for managing multiple servers and related infrastructure along with a portal for delegated views and permissions.

• 6connect TaskVision – Currently manages BGP session configuration directly with existing router infrastructure and monitors status updates for peering exchanges. Providing the foundation for additional network device and control.

• 6connect EnVision (Alpha) – distributed network discovery agent for tying together IP utilization data along with device level information via TCP/ICMP/SNMP. Integrates with ProVision Asset Management. North American field trials of Envision are scheduled for Q2 2013. We welcome the opportunity for similar developments elsewhere as well.

The general attributes of DNP and the benefits are described in the next section. Deployment of 6connect DNP is flexible and can be provided as a hosted solution, VM or even installed on dedicated hardware. Since the application is based on standard LAMP technologies (Linux, Apache, MySQL, PHP), there are plenty of options for deployment, redundancy and high availability.

This section highlights the envisioned use cases for applying DNP to provisioning network resources across an Evolved Core Platform.

For a typical service provider, a sample use case would look like Figure 6 below.

**Figure 6 Detail of ProVision dynamic provisioning process**

In this use case, a service provider is most likely dealing with staff of varying skill levels and potentially multiple internal systems or information silos. 6connect’s DNP enables the service provider to have a single interface for managing the information, even if the
device elements are scattered around a global network and being managed by various personnel (or even customers).

With DNP, 6connect can automate the import process, provisioning tasks and subsequent reporting. The application architecture is built on PHP classes tied into a RESTful API. This means that the multi-tenant capable web application is built on the same API that is available for integration. This provides multiple deployment options in even the most complex environments.

### 3.1 Scenario 1 – LTE roll out (IP core)

When deploying an LTE environment with an EPC network, there a multitude of provisioning tasks that are still performed manually. With the rapid rollout of LTE services, providing a network infrastructure that is stable and compatible are key to ensuring a long-term revenue streams for users and related services.

A legacy provisioning approach could take the following steps assuming a centralized information repository exists:

1) Configure EPC deployment network architecture (typically in a spreadsheet or static document)
2) Train operations personnel on architecture policy for allocating v4 or v6 IP space, creating DNS zones/zone records, etc.
3) Subnet out space for allocations manually and add IP information to repository
4) Assign hostname/IP information per device and document in repository
5) Manually build out related DHCP configuration files
6) Manually build out related DNS infrastructure and zones including any DNSSEC zone signing and key generation/uploading
7) Repeat as needed for additional device assignments
8) Repeat as needed per cell deployment
9) Audit IP utilization by reviewing spreadsheets

With legacy approaches, these tasks could take hours or days. By contrast, 6connect’s DNP can accomplish the same functions in minutes with increased data validation since 6connect does all the subnetting internally along with RFC validation for DNS zone records and DNS templates for prepopulating data wherever possible. Current customers have reported that DNP reduced their provisioning time of network resources by 80 percent because of our virtualized control plane’s automation of provisioning tasks.

Maintaining architectural consistency across network deployments is critical to effective and consistent operations. 6connect takes this requirement seriously and has designed architectural service maps into all of its provisioning platforms, which guide the daily-automated provisioning tasks that users can control. Below, in Figures 7 and 8, you can
see a sample “network architecture” screen where even the most complex network is built out using regions, tags, and any other parameters. This layout powers key features like Smart Assign and Templates, which allows for service providers to ensure that various network management policies are part of the application, and transformed into easily automatable steps. 6connect has even automated the WHOIS update process with Regional Internet Registries (RIRs) that normally used to take hours and multiple emails/portal logins to complete what takes us one-click.

3.2 Scenario 2 – Service Delivery Platform (internal/external groups)

Service models for internal and external customers require a Service Delivery Platform that functions as a flexible web service layer. 6connect’s ProVision platform provides
this functionality out of the box for the operational provisioning team as well as external groups and customers. Ideally the solution in this area provides both a RESTful API for integration with other systems along with portal functionality to support more advanced permission based features typically requested by network users and administrators.

This allows flexible deployment of other infrastructure services to further increase reliability (DNS, DNSSEC), future proofing (IPv6), provisioning (DHCP configuration and IP device management), and control (network infrastructure management and automation).

As an example, See Figure 9 for a brief outline of the Smart Assign automated function for assigning IP space based on parameters requested. Note that the function is available in its entirety, versus requiring the developer to do additional customization to automate the task.

<table>
<thead>
<tr>
<th>Smart Assign</th>
</tr>
</thead>
<tbody>
<tr>
<td>URL</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Returns</td>
</tr>
<tr>
<td>Required Parameters</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>mask</td>
</tr>
<tr>
<td>rir</td>
</tr>
<tr>
<td>resourceHolderId*</td>
</tr>
<tr>
<td>resourceId*</td>
</tr>
<tr>
<td>type</td>
</tr>
<tr>
<td>*Either resourceHolderId or resourceId can be used, but only one must be provided</td>
</tr>
<tr>
<td>Optional Parameters</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>tags</td>
</tr>
<tr>
<td>region</td>
</tr>
<tr>
<td>Example URL</td>
</tr>
</tbody>
</table>

Figure 9 Smart Assign function - API detail view
Below, Figure 10 provides a GUI perspective on the same Smart Assign feature. In this screen, you can see multiple assignments to a particular resource holder. These allocation requests can be of various sizes in addition to tag/region capabilities. Note that it is designed to work consistently whether completed via the API or GUI with all requests logged and tracked by user/source IP and the workflow is the same whether dealing with IPv4 or IPv6 resources.

![Figure 10 Smart Assign detail view (GUI)](image)

For more information on the capabilities of 6connect’s RESTful API, please reference the documentation link below for the PHP SDK, code samples and additional configuration information.

### 3.3 Scenario 3 – ongoing tower asset audit/tracking

Part of any network build also includes management “post deployment”. This may include specific tools to audit key portions of the network or a combination of tools depending on the user base and the services expected (including location based services or device tracking for fraud/theft detection). By combining these device level data points with conventional network auditing and management tools, service providers can provide a very granular view to the internal or external customer to address concerns, reduce support costs and prevent incidents.

6connect’s “EnVision” product family is a distributed network discovery agent that is designed to be self sufficient, but report data back to a central instance. Initially, the focus is on IP space and utilization, but is quickly growing in scope to accommodate more complex scanning using TCP, ICMP and SNMP capabilities. With this level of detail,

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1 6connect API documentation can be found here: [http://cloud.6connect.com/Documentation/API/v1/index.html](http://cloud.6connect.com/Documentation/API/v1/index.html)
6connect can effectively scan multiple isolated network nodes, identify devices on the network and upload the details to a central ProVision instance. This solution is ideally suited for discovering, provisioning, and managing IP resources and their utilization across a distributed, flat network.

![Sample device-level scan of 1918 IP space showing devices found and ports open](image)

### 3.4 Scenario 4 – Deployment of smarter LTE cells

One of the tenets of LTE deployments is a more distributed LTE cell footprint. Two factors, the number of users, and the increased bandwidth requirements these converged networks will require this. Platforms like 6connect’s DNP can provision large and small-scale distributed deployments much more effectively than legacy approaches since the steps are intrinsically repeatable.

6connect has built out support for various router/switch vendors for their BGP session manager, and will leverage this integration as compatibility expands to address network devices in both virtual and physical infrastructure. In the case of the BGP session manager, it is also tied back to peeringdb\(^2\) in addition to providing a turnkey Communication Relationship Manager where the Peering Coordinator can manage all outbound communications for potential peers.

Below, Figure 12 shows a sample configuration approval push for a Cisco router. In this case, the customer is doing a one-click configuration push for a new BGP session and

\(^2\) [https://www.peeringdb.com/](https://www.peeringdb.com/)
does not have to log into a router at any time to do so. These pushes can also be automated or response based for additional automation.

![Sample BGP session configuration approval](image)

**Figure 12** Sample BGP session configuration approval before writing to Cisco router

### 4.0 Conclusion

With the rapid adoption of LTE services, Evolved Packet Cores, and IPv6, service provider network provisioning has becomes significantly more complex and difficult. A fundamental break from legacy provisioning and network control processes is needed for service providers to achieve significant cost advantages and time to revenue advantages over their competitors.

Service providers stand to gain considerable operational value from adopting an innovative, virtual software defined network control platform like 6connect's unique Dynamic Network ProVisioning (DNP) platform. DNP enables the discovery, configuration, and control of physical and virtual devices across distributed and mobile networks, cloud platforms, web-hosting platforms and data centers. Innovative customers like GoDaddy, DukeNet Communications, Verizon Terremark, iLand Cloud Infrastructure, and CyrusOne utilize DNP to accelerate service delivery time, accurately provision complex network protocols, and dramatically reduce network complexity and costs, while achieving industry change management and compliance requirements. We welcome enquiries about our solution and roadmap, and look forward to demonstrating our solutions’ advantages to interested service providers.