Small Cell Cluster Case Study

September 2011
1 Introduction

Drop-In, High-Density Mobile Capacity

SpiderCloud Wireless has produced an industry breakthrough – the SmartCloud® Cluster – the industry’s first Small Cell Cluster. The SmartCloud Cluster is the most compact and efficient mobile broadband system ever built, and delivers unprecedented mobile broadband capacity and performance. SpiderCloud’s Small Cell Cluster ushers in a new era of rapid and targeted deployment for mobile broadband infrastructures – an era of drop-in, high-density capacity for mobile operators.

The Small Cell Cluster is a new product category and will change the industry’s view of the mobile infrastructure hierarchy. Because Small Cell Clusters are so efficient at delivering targeted performance and capacity, macrocell infrastructure will soon function as an umbrella, or fill-in layer in the hierarchy. As a result, the emergence of Small Cell Cluster products will turn traditional thinking on its head and will emerge as a new and “defining” layer in the mobile broadband hierarchy.

This Case Study uses data from one of several live installations of the SmartCloud Cluster. All users were using commercial SIMs and the SmartCloud Cluster was integrated with a mobile operator’s live production core network.
2 Executive Summary

Operational results from a live installation show that SpiderCloud’s Small Cell Cluster – the SmartCloud Cluster – automatically manages challenging RF environments, operates with true commercial stability, and efficiently delivers breakthrough capacity and performance.

Challenge

The SmartCloud Cluster was installed in a three-story office building where requirements included:

- Providing reliable mobile broadband for an all-mobile work environment with no PBX or traditional desk phones;
- Offloading the building’s 600-800 commercial users from surrounding macrocell base stations;
- Integrating the system with the operator’s live core network, not a trial core;
- Delivering the system at a fraction of the cost of a Distributed Antenna System (DAS);
- Deploying the system rapidly – and without disruption – in a 100,000 sq. ft. office building;
- Controlling cell-to-cell RF interference in an open office plan with few walls, and a center atrium that exposed all floors.

Solution

The SmartCloud Cluster controls small cells as a coherent cluster and consists of two elements: a controller, and the small cells – each of which is a complete UMTS base station (NodeB). In this installation, the SmartCloud Cluster covered three floors with 18 small cells – six per floor – utilizing a single controller (see Figure 1).

Figure 1: SmartCloud Cluster Deployment
Results

The SmartCloud Cluster proved to be a robust, scalable system. Operating at 38% capacity, the cluster replaced an existing two-sector Distributed Antenna System (DAS) and provided uninterrupted and trouble-free broadband service for an all-mobile work environment. In addition, the SmartCloud Cluster performed at breakthrough levels in all categories (see Table 1).

<table>
<thead>
<tr>
<th>Category</th>
<th>Result</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>Simple</td>
<td>Comparable to Wi-Fi installation, used same contractor</td>
</tr>
<tr>
<td>Configuration</td>
<td>Rapid</td>
<td>RF self-configuration, optimization, and commissioning in 45 minutes after physical installation</td>
</tr>
<tr>
<td>Capacity</td>
<td>Voice Calls</td>
<td>3,000+ voice call daily average, served 600-800 commercial users in all-mobile-phone work environment with no blocking</td>
</tr>
<tr>
<td></td>
<td>Data Sessions</td>
<td>50,000+ HSPA session daily average</td>
</tr>
<tr>
<td>User Experience</td>
<td>Voice Quality</td>
<td>Soft Handover resulted in voice quality PESQ scores of 3.7 – higher than typical commercial macrocell scores of 3.25</td>
</tr>
<tr>
<td></td>
<td>Data Performance</td>
<td>High-density deployment with low RF interference allowed individual users to sustain downlink data at 5-10 Mbps and uplink data at 2 Mbps – much higher than typical shared macrocell environment</td>
</tr>
<tr>
<td>Macrocell Offload</td>
<td>High</td>
<td>Operating at only 38% capacity, replaced the capacity of a two-sector macrocell DAS system</td>
</tr>
</tbody>
</table>

Table 1: SmartCloud Cluster Operating Results
3 Vision for Small Cell Clusters

SpiderCloud believes that small cells operating as coherent clusters – called Small Cell Clusters – are the most efficient way to deliver mobile broadband capacity. Through an architecture that leverages a local unified cluster controller managing resource allocation and mobility events at each venue, mobile operators can now easily and efficiently deploy highly targeted capacity at specific points of mobile broadband consumption. Key deployment use cases include any indoor environment where high concentrations of users consume mobile broadband: college campuses, high-rise buildings, airports, hotels, and convention halls.

The SmartCloud Cluster is a high-density and high-performance architecture for licensed spectrum, and consists of two elements (see Figure 2):

- **Cluster Controller.** The SmartCloud Services Node is a cluster controller that provides traffic aggregation and session management for all mobile sessions delivered through small cells. It is responsible for access control, radio node management, auto configuration, self-optimization, interference management, local data offload, soft-handover, and core network integration.

- **Small Cell.** The SmartCloud Radio Node is a high performance small cell. It is a complete UMTS base station supporting up to 16 voice and data users and is compatible with 3GPP R99, Release 5 & Release 6 UEs.

Typical SmartCloud Cluster configurations involve integration with a mobile operator’s core network via the Services Node. In this case, the SmartCloud Cluster was integrated with the operator’s commercial core network and served users on existing billable accounts.
4 Operational Details

4.1 Installation

The SmartCloud Cluster was dimensioned to cover three floors of a 100,000 sq. ft. commercial building with 18 small cells. The cells were installed six-per-floor using the same cable trays as the Wi-Fi infrastructure and were mounted by a contractor familiar with LAN and Wi-Fi installations. To control the building-wide cluster, a single controller was installed in an IT server room. The cells were connected to the Services Node via Power Over Ethernet (PoE) connections via existing layer 2 switches.

Since the facility relied solely on mobile phones for communication, SpiderCloud chose a high-capacity deployment with each cell covering 5000 sq. ft., or 33 employees. This was an unusually dense configuration – roughly twice the density required to support a facility with traditional desk phones.

Strong Requirement for Soft Handover

The building featured a central atrium open to all floors. This resulted in some interesting RF challenges. For example, once installed, any cell in the cluster was able to “see” virtually any other small cell in the facility. As a result, the cluster detected a large number of cells, a high percentage of which were measured at similar power levels. This made Soft Handover (SHO) a critical feature to ensure high call quality. In addition, SHO enabled cells to operate with much less overlap than a Hard Handover (HHO) system and reduce cell-to-cell interference. Without SHO, a small cell system deployed in a building such as this would face high levels of self-interference, low call quality, and reduced data performance.

Rapid Commissioning

In this environment, the cluster’s ability to adapt to the RF environment was especially important. SpiderCloud’s local controller, the Services Node, coordinated topology discovery, optimal assignment of Primary Scrambling Codes (PSCs), power tuning, and the on-going optimization of the cluster. This locally controlled architecture allowed the Small Cell Cluster to self-configure and startup live operation in only 45-minutes, a commissioning time easily an order of magnitude faster than any other licensed spectrum broadband system in the market. Beyond initial commissioning, the cluster also made use of live user UE-based measurements for on-going optimization. This allowed the system to validate coverage through closed-loop measurements by actual end-users of the system, and provided optimization for on-going changes in the environment.

4.2 Capacity

Voice Calls

On a daily basis, the overall voice call capacity of the SmartCloud Cluster proved to be very robust. Compared to any indoor mobile system on the market, the cluster delivered breakthrough voice call performance. The cluster handled an average of 3,000 or more voice calls in typical 8 to 10 hour workday. A single day’s performance is detailed below (see Figure 3).
**Data Sessions**

Data sessions were also handled at very high levels, much higher than can be accomplished with any other licensed spectrum indoor system. On average, the cluster handled more than 50,000 HSPA sessions per workday. A single day’s performance is detailed below (see Figure 4)
4.3 User Experience

Voice Quality

Voice quality on the SmartCloud Cluster scored high – in the range of 3.7 using PESQ – better than an average 3G macrocell score of 3.25, or a 2G score of 3.0. This was largely attributable to the accurate and stable Soft Handover available throughout the SmartCloud Cluster (see Figure 5).

![Figure 5: SmartCloud Cluster Voice Quality PESQ Scores](image)

Data Performance

The SmartCloud Cluster handled high data loading in production. Load testing focused on the impact of data loading on the cluster’s voice quality – with data traffic injected on six simultaneous cells in the range of 5-10 Mbps on the DL and 2 Mb/s in the UL. Testing yielded very high average DL and UL performance in both stationary and mobile testing – and in all cases maintained excellent voice performance. Overall, it was clear that an average of at least 5 Mbps (DL+UL) could be maintained simultaneously in each of the 18 cells in the building, yielding over 100 Mbps of aggregate capacity.

4.4 Offload

Since the maximum capacity of the SmartCloud Cluster is 50 cells, the installed 18-cell system was only operating at 38% of its design load. Even so, the cluster replaced an existing DAS system that represented two full sectors of a macrocell base station operating on two different frequencies. Since the facility’s users were conducting all their business via mobile devices, it is fair to characterize the offload of macrocell traffic as very significant. Even with such aggressive utilization, the SmartCloud Cluster operated at a fraction of its capacity and still handled 600-800 users – often identifying as many as 1,000 unique UEs in a single day.
5 Conclusion

Small Cell Cluster Requirements

SpiderCloud’s live deployment shows that efficient Small Cell Clusters such as the SmartCloud Cluster, can deliver breakthrough performance when they meet the following requirements:

- **Robust Self-Organizing Network** – The system must automatically learn the topology of the external and internal network, intelligently assign cell powers and PSCs, and easily adapt to changes in the network. In addition, a robust system must provide on-going self-optimization that correlates small cell data with measurements collected from live UEs.

- **Local controller architecture** – To scale, a small cell system should form a natural cluster to manage SoN and Soft Handover. Without a local controller, shared or hosted systems would need extensive partitioning to support self-organizing network calculations for individual facilities, and critical mobility features such as Soft Handover would burden backhauls with significant signaling traffic.

- **High call capacity and off-load** – A Small Cell Cluster must deliver performance that significantly off-loads a macrocell system. Operators are seeking Small Cell Clusters that can add significant capacity and perform better than their current macrocell systems.

- **Soft Handover** – This is a mandatory feature for Small Cell Clusters. Soft Handover adds stability in challenging RF environments, reduces self-interference, and yields excellent voice quality. Solutions that rely solely on Hard Handover will suffer from low voice quality and high self-interference.

Competitive Comparison

By comparison, the SmartCloud Cluster exceeded the capabilities of two competing technologies, DAS and Multi-Femtocell deployments, in several categories (see Table 2).

<table>
<thead>
<tr>
<th>Category</th>
<th>SmartCloud Cluster</th>
<th>DAS</th>
<th>Multi-Femtocell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Configuration</td>
<td>45 minutes</td>
<td>Weeks</td>
<td>Days</td>
</tr>
<tr>
<td>Non-Disruptive Install</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Voice Call Capacity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Data Session Capacity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Voice Quality</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Data Performance</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Macrocell Offload</td>
<td>High</td>
<td>None</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Table 2: Product Comparison
Small Cell Cluster Case Study