JDSU Solutions for Small Cells

Pushing the EDGE with small cells
Why Small Cells?

Users expect app availability everywhere, at any time, on their smartphones, tablets, and mobile-enabled devices. This demand is driving mobile service providers to deploy new mobile infrastructure using small cells that:

- Increase capacity and coverage, ensuring content and application delivery and high performance
- Offer improved depth of coverage and boost LTE and 3G services in busy urban areas
- Improve the customer user experience, increasing typical available data rates
- Easily enable value-added services, particularly those requiring high-precision location information

Small cells are vital to 3G data off-loading, and mobile operators see small cells, rather than macrocells, as the key to efficiently managing LTE spectrum.

Small cells have come a long way in recent years. Initially, they were used as a way to expand the coverage of a mobile network in remote locations. However, small cells now increase network capacity in densely-populated urban areas.

According to Informa Telecoms and Media, 97.5 percent of mobile-operator respondents believe that small cells are key for the future of mobile networks. In addition, Informa estimates that the number of small cells deployed overtook the total number of macro cells between October and November 2012.

According to ABI Research, sales of outdoor small cells will grow at a 53.8 percent compound annual growth rate (CAGR) by 2017, with 9.3 million units sold. Outdoor femtocells will be the fastest growing class of small cells, growing at an 81.5 percent CAGR and reaching 1.5 million units worth $5.4 billion by 2017.

Small cells provide a small radio footprint that can range from 10 meters within urban and in-building locations to 2 km for a rural location. With its smaller range, small cells can provide in-building and outdoor wireless service.

Small cells encompass femtocells, picocells, and microcells. Small-cell networks can also be realized by means of distributed radio technology consisting of centralized baseband units and remote radio heads. A common factor in all these approaches to small cells is that they are centrally managed by mobile operators and network equipment manufacturers (NEMs).
Small-cell deployment challenges broadly agreed upon by mobile operators include:

- Determining how best to manage backhaul delivery to small cells to obtain appropriate performance, cost, and location
- Dealing with site logistical issues, including placement locations, aesthetics, power, and planning issues
- Obtaining, in actual practice, the overall radio performance that small cells theoretically deliver
- Delivering the higher data speeds to support the mobile app explosion
- Reducing cost-per-bit
- Creating differentiation and adding value for the end user
- Monetizing over-the-top (OTT) applications
- Retaining and upselling value to customers

Small cells also face challenges, particularly outdoors, with respect to backhaul, deployment, and radio performance.

- Backhaul challenges — how to cost-effectively link small cells into the core network without compromising performance
- Radio performance — how to ensure traffic is balanced between small cells and macrocells in a way that maximizes small-cell benefits without creating unacceptable interference
- Deployment issues — how to acquire and use suitable sites at the right cost and in short timescales

The following diagram depicts major network elements used for indoor and outdoor small cells:

![3GPP Architecture Diagram]

**Radio network subsystem (RNS)**
- Small cell
- Iub
- IuPS
- Packet switched (PS)
- Internet

**Home node B subsystem (HNS)**
- Femtocell
- HNB gateway (HNB-GW)
- Security gateway (SeGW)
- HNB management system (HMS)
- Iuh
- IuCS
- Circuit switched (CS)
- Packet IMS core network

**3GPP Architecture**
Overview

Small cells are the best solution to expand capacity and coverage and meet customer expectations.

Deploying small cells translates into many more network elements to be commissioned, maintained, and monitored. It is now even more important to focus on efficient test and monitoring solutions, take control of operating expenses, and minimize time-to-revenue.

JDSU Solutions for Small Cells deliver unmatched visibility to help you plan, protect, and profit from your deployments.

**PLAN** to reduce OpEx, get the job done right the first time, dispatch to fix not to find, and minimize time-to-revenue with solutions that:

- Provide automated and efficient roll outs of the exponentially scaling number of network devices
- Resolve performance, capacity, and functional issues dramatically faster
- Minimize the cost and time of cell deployment and turn-up
- Optimize networks to cost-effectively scale traffic capacity and rates

**PROTECT** network performance and customer quality of experience (QoE), identify OTT apps that compromise network performance, identify chatty apps, and prevent traffic surges that cause 3G and LTE networks to crash or perform poorly with solutions that:

- Scale network visibility and monitoring without scaling costs
- Improve network performance and SLA compliance
- Reduce time to identify, isolate, and troubleshoot performance issues

**PROFIT** by improving QoE, reducing customer churn, adding high-value services, and enabling new revenue opportunities with solutions that:

- Ensure QoE for VIP customers
- Monetize small-cell investment
- Reduce time to revenue

The following sections describe JDSU solutions for:

- Rollout Planning
- Cell-Site Turn-Up
- Field-to-Lab Correlation
- Mobile Backhaul
- Mobile Service Assurance
- Customer Experience
Solutions for Rollout Planning

Operators can get the most out of small-cell deployments through precise placement and by mastering the interaction between the small cells and the traditional macro layer of the network. To maximize return on investment, small-cell site locations must be determined based on actual, localized data-traffic demand.

Using geo-located information is also important to reveal data hot spots and customer experience “black holes.” This intelligently drives the process of planning small cells and data-offload solutions. Efficient planning leads directly to a significant improvement in both the customer experience and the return from capital investments.

As understanding and optimizing wireless networks becomes increasingly complex, the impact of small cells on the macro layer is challenging to determine. By revealing the true customer experience along with detailed RF KPIs for all calls and data sessions, rollout-planning solutions such as ariesoGEO* let operators accurately assess and optimize small-cell placement.

ariesoGEO locates, stores, and analyzes data from billions of mobile connection events, giving operators a rich source of intelligence to help boost network performance and enrich the user experience. This intelligence transforms the effectiveness of network-performance engineering; enables customer-centric self-optimizing networks; creates true understanding of the customer experience; and, enables the monetization of unique insights.

Customers who are today making use of ariesoGEO-generated location intelligence as part of their planning process report that in over 50% of cases, they select a candidate site that will deliver better performance than one chosen by traditional methods. This leads directly to a significant improvement in the customer experience and a greater return on capital investment.

* arieso — A JDSU Mobility Solution
Solutions for Cell-Site Turn-Up

JDSU has a broad portfolio of analyzers and instruments that support the installation and maintenance of small cells:

- **CellAdvisor**
  - Cable and Antenna Analyzers
  - Base Station Analyzers
  - RF Analyzers
  - Signal Analyzers
- **RANAdvisor** (Indoor/Outdoor Optimization)
  - Handheld
  - Backpack Solution
  - Vehicle Based

**CellAdvisor**

Most wireless-network problems occur within the base-station infrastructure: the antenna system, cables, and connectors. It is essential to have the optimal instrument for properly servicing or installing cell sites.

CellAdvisor analyzers are an ideal small cell site field testing solution that combines portability due to its lightweight design and battery, extended operation, and performance with its multifunction capability.

The CellAdvisor analyzers have all the necessary functions integrated to effectively test small cells. This combined functionality includes spectrum analysis, cable and antenna analysis, power meter, interference analysis, channel scanner, E1/T1 analysis, and signal analysis.

**Applications**

- Reflection measurements (VSWR, return loss, or smith charts)
- DTF - Distance to Fault Measurement
- Cable loss measurement
- RF power meter with external power sensors
- Unique Optical power meter with external optical power sensors
- Insertion gain/loss measurement
- RF source verification
- Demodulation of all wireless technologies up to LTE
- RF and Modulation analysis presented in a summary screen provided through the easy to use auto-measure function
- Spectrum analyzer
- Interference analyzer
- Channel scanner
- CW signal generator
**RANAdvisor**

The JDSU RANAdvisor platform is the industry’s most flexible, customizable, and scalable solution for the optimization of wireless networks and data services. The platform includes a receiver with up to eight frequency bands and software that can simultaneously measure and troubleshoot network RF coverage and service delivery across all existing 2G, 3G, and 4G technologies including WiMAX™, LTE, and VoIP. Going beyond vehicle based testing, the most demanding indoor locations are now easily tested via the JDSU backpack—the lightest and most comfortable indoor solution available as well as with our handheld solutions based on Android phones.

A handheld version of the solution is also available on Android phones with the latest models of LTE Samsung Galaxy S3 available.
Solutions for Field-to-Lab Correlation

JDSU solutions collect critical measurements in the field; analyze the data in the lab; and, deliver actionable intelligence to continuously improve wireless networks—from wireless silicon to service providers.

To ensure service performance before deployment, these solutions are used in the lab to model real field environments. QoE and E2E application-aware testing resolves interoperability and service issues before deployment. As shown below, these solutions are segmented in six product lines:

- **Active Test** — The Remote Cellular Active Test System (RCATS) is a patented, end-to-end service-quality monitoring solution for mobile service providers. Using a distributed architecture of probes, test controllers, and subscriber identity module (SIM) servers, the RCATS solution automatically tests a variety of voice, data, messaging, and billing services from an end-user perspective. The solution is typically deployed across multiple geographic locations, providing a consolidated view of service quality and detailed reports for each individual service and geographical location. As the leading solution for end-to-end service quality monitoring for wireless networks, RCATS lets service providers meet their challenges with real-time, network-wide performance and availability information, leading to increased service quality, increased revenue, reduced costs, and improved customer satisfaction.

- **CellAdvisor (base station test)** — The JD7105B and JD745A Base Station Analyzers are the optimal test tools for installation and maintenance of cell sites. The analyzers include all the necessary functions to effectively test cell sites. Combined functionality includes spectrum analysis, cable and antenna analysis, power meters, interference analysis, channel scanners, E1/T1 analysis, and signal analysis.

- **CapacityAdvisor** — JDSU has the industry's most advanced and scalable wireless subscriber simulation and test systems for 3G and LTE technologies. CapacityAdvisor provides advanced load generation for 3G/4G mobile networks, giving customers an unmatched ability to test equipment and services under realistic traffic scenarios in their labs.
• **RANAdvisor** — The JDSU drive test platform is the industry’s most flexible, customizable, and scalable solution for the optimization of wireless networks and data services. The platform includes a receiver with up to eight frequency bands and software that can simultaneously measure and troubleshoot network RF coverage and service delivery across all existing 2G, 3G, and 4G technologies including WiMAX®, LTE, and VoIP. Going beyond drive test, the most demanding locations are now easily tested via the JDSU backpack—the lightest and most comfortable indoor solution available. A handheld version of the solution is also available for the HTC Desire (UMTS and CDMA) and HTC Thunderbolt (LTE). The version also supports multiple Nokia Symbian devices.

• **Protocol Test** — JDSU protocol test platforms and applications include:
  - **SART**, the JDSU Signaling Analyzer Real Time, is a high-performance solution for 2G, 2.5G, 3G, and 4G system verification, troubleshooting, and radio access network (RAN) optimization. Its intelligent call trace-centric approach enables distributed call trace, performance measurements, and drill-down problem isolation. It enables complete testing of network and individual call performance across mobile networks, which simplifies the resolution of the most complex interoperability problems in telephony. PacketPortal extends SART capabilities to let operators see the network the way customers experience it. PacketPortal provides immediate visibility and reach, right to the network edge, making it possible for any optical transceiver in the network to analyze packets. The combined SART-PacketPortal solution unlocks network blind spots, letting users quickly troubleshoot call handover issues, performance problems, dropped calls, packet loss, voice-quality issues, and network errors before they become significant service interruptions.
  - **PacketInsight** is a revolutionary, real-time network monitoring and diagnostics tool designed for the retrieval of historical data. It offers a unique ability to intelligently capture network traffic of interest while performing lightning-fast, real-time post-capture flow analysis of correlated control- and user-plane traffic. PacketInsight can be integrated with SART and PacketPortal.
Solutions for Mobile Backhaul

Conducting complex tests in short time frames without errors and return visits is vital for service providers to maintain profitability and establish a competitive advantage. JDSU products perform the right tests at the right place at the right time. From network installation and turn-up to service provisioning, troubleshooting, and maintenance, JDSU instruments, systems and software help service providers and technicians quickly roll out small-cells networks, transported services, and apps.

As shown below, small-cell backhaul can be based on microwave, fiber, copper, and other technologies. Current JDSU solutions support fiber, copper/xDSL, and HFC:

JDSU has a wide portfolio of products and services to accelerate backhaul deployment, activation, and turn up. JDSU solutions also continuously validate mobile-backhaul SLAs and prioritize issues for business efficiency.

JDSU also addresses the importance of a good and solid backhaul connection to ensure a high-quality end-user experience and avoid unnecessary bandwidth consumption, for example, that caused by retransmissions. Our solutions:

- Improve Ethernet mobile-backhaul activation by over 60% with automated test and turn-up time
- Provide scalable, open software solutions including multi-vendor performance management systems, which can be integrated into existing third-party operating support systems (OSSs), preserving existing tool investments
- Obtain granular performance analytics to monitor backhaul-network SLAs to detect issues before they affect customers and reduce backhaul-network costs
- Improve network performance, reduce troubleshooting time, and optimize network performance using industry-leading microprobe technologies to obtain granular insight into network and service performance

JDSU is uniquely experienced with full life-cycle management, from the handset to core, to enable reliable and scalable small-cell networks.

The following sections describe solutions for mobile backhaul:

- Physical Installation and Troubleshooting — Sub-6 GHz Backhaul, Qualifying Fiber, Copper, and HFC
- Ethernet/IP Commissioning and Troubleshooting
- Ethernet/IP Service Assurance
Physical Installation and Troubleshooting—Sub-6 GHz Backhaul

Small-cell backhaul is a major challenge because wired backhaul availability is limited and traditional microwave and millimeter-wave line of site (LoS) wireless backhaul cannot guarantee availability to street-level small-cell installations.

Non line of sight (NLoS) and near line of site (NrLoS) wireless backhaul using sub-6 GHz bands are promising candidates for ubiquitous small-cell backhaul. However, the spectrum below 6 GHz is limited compared to higher frequencies and it is also more sensitive to interference.

Sub-6 GHz links support two types of architecture:

<table>
<thead>
<tr>
<th>Sub-6 GHz</th>
<th>Point-to-Multipoint</th>
<th>Point-to-Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>Hub-and-spoke</td>
<td>50-100 Mbps (shared)</td>
</tr>
<tr>
<td>Capacity (full duplex)</td>
<td>50-100 Mbps</td>
<td>50-100 Mbps</td>
</tr>
<tr>
<td>Mini-antennas feasible</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Spectrum generally unlicensed</td>
<td>Unlicensed but licensed options possible</td>
<td>Unlicensed but licensed options possible</td>
</tr>
<tr>
<td>Spectrum cost</td>
<td>Free when unlicensed, moderate to high when licensed</td>
<td>Free when unlicensed, moderate to high when licensed</td>
</tr>
<tr>
<td>Line-of-Sight needed</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Test needs</td>
<td>LOS: Power and frequency testing</td>
<td>LOS: Power and frequency testing</td>
</tr>
<tr>
<td></td>
<td>NLOS: Power, frequency, and modulation testing</td>
<td>NLOS: Power, frequency, and modulation testing</td>
</tr>
<tr>
<td>Typical latency</td>
<td>3 to 8 ms (depending on LOS)</td>
<td>3 to 8 ms (depending on LOS)</td>
</tr>
<tr>
<td>Installation cost</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

JDSU CellAdvisor supports sub-6 GHz backhaul testing that is applicable for any implementation, P-P or P-MP, or LOS and NLOS:

- Channel power
- Occupied bandwidth
- Spectrum emission mask
- Spurious emissions
- Adjacent channel power
Physical Installation and Troubleshooting—Qualifying Fiber

The first consideration to ensure reliable small-cell service delivery starts with the correct qualification of fiber-plant cabling and terminals. A series of measurements are performed to ensure fiber cable integrity and to analyze the ability of the cable and equipment to function at peak performance, assessing its ability to survive network aging and environmental affects.

Applications

- Certify fiber connector end-face quality for all terminal components and interconnects
- Fiber acceptance testing using an optical time domain reflectometer (OTDR) to measure fiber length, signal loss, connectors, and splice joints during construction
- Verify optical power levels at terminals: insertion loss and optical return loss and channel loss during terminal provisioning
- Fiber monitoring analysis, monitoring of network performance, and SLA management

Fiber Inspection — Connector Certification

Dirty connectors are the number-one cause for troubleshooting in optical networks. Microscopic particles of dirt can create enough signal loss and back reflection to cause significant downtime and network damage. Typically, they create random bit errors that make them the most difficult items to troubleshoot.

The increasing bandwidth requirements in today’s mobile networks leave little room for errors caused by dirt.

Using the JDSU P5000i, the world’s most versatile and reliable analysis microscope, you can easily overcome these problems and adopt the best practices when handling fiber. The P5000i microscope is used to certify connector end-face quality in accordance with IEC standards or the customer’s specification. This certification guarantees the link will perform at the highest level possible.

OTDR Measurements — Fiber Acceptance and Maintenance

During network construction, fiber may be rolled out in a variety of ways: in ducts, direct-buried, or aerial-strewn in elevated locations. The location of the cable often limits the ability to determine installation quality or to see any direct impairment on the cable itself. The T-BERD/MTS-2000 is an OTDR that characterizes the quality of cable, splices, and terminations and measures fiber loss, locates events and impairments, measures the impact (loss) of each, and provides the distance to the event. SmartLink Mapper (SLM) is a field-installable software application that removes any complexity from OTDR testing and results interpretation. Using advanced software, SLM analyzes the passive elements, impairments, and faults on the optical fiber link and displays each of these in a simple icon-based map view that is understandable at any skill level.
Optical Power Measurements

During network provisioning and troubleshooting, a power meter ensures the performance of network devices by measuring transmitted and received optical power at end terminals. It also confirms that the completed cable subsystem is suitable for the intended transmission system between the serving terminals. A SmartClass Fiber OLP-82 is an optical handheld system that integrates a power meter with pass/fail fiber inspection in a single, portable device that can verify receipt of the correct range of power (not too little, not too much), ensuring that equipment functions at peak performance. Some transmission devices are sensitive to back reflection and an optical return loss (ORL) meter ensures that return power is within system specifications. Where backhaul networks integrate a CWDM or DWDM system, an optical channel checker (OCC) scans the xWDM and automatically records all channels with the wavelength and the related power level.

Fiber-acceptance testing often generates a report to prove the quality of work, and the performance of the network, and establish a reference birth certificate for the system installation. Birth certificates can be centrally stored and securely accessed from anywhere in the world via the JDSU StrataSync cloud-enabled asset, configuration, and test-data management platform.
Physical Installation and Troubleshooting — Qualifying Copper and XDSL

Because small cells are typically located in dense urban environments, they let wireline operators take advantage of their remote DSLAMs to create new revenue streams. However, maximizing existing infrastructures also requires qualifying the copper access plant to carry high-speed small-cell services.

- Planners must test for foreign voltage, leakage resistance, capacitive and longitudinal balance, loop-length wideband noise, and wideband impulse noise
- Identification of wide band noise and analysis of pair balance is increasingly important to facilitate higher bandwidth through the use of wider frequency spectrums
- Technicians need to qualify copper pairs and fix chronic impairments that would otherwise cause repeat dispatches. They must fix it right the first time.
- Backhaul SLAs are tighter than consumer-grade data services

Technicians worldwide use the HST-3000 Handheld Services Tester or the SmartClass Triple Play (TPS) to carry out these important tests. The HST-3000 is the industry’s most versatile multilayer field test tool, combining compete copper qualification tests, advanced TDR, and RFL. The HST-3000 also performs wideband noise and impulse noise analysis for fault-finding. It emulates CPE devices to perform xDSL (for example, ADSL2+, VDSL2) testing combined with application layer IP video, IP class of service, and VoIP phone-emulation testing—all in a single, modular, portable platform.
Physical Installation and Troubleshooting — Qualifying HFC

Because small cells are deployed in dense urban environments, cable TV operators are well positioned to take advantage of their existing HFC network to create new revenue streams. However, maximizing the utilization of these infrastructures also means qualifying the RF portion of the network for high-speed data services.

- Operators must verify HFC alignment, signal (QAM) quality, upstream noise and ingress levels, plus DOCSIS channel bonding and throughput performance
- To cover SLA requirements, a close watch must be kept on HFC node RF performance including downstream and upstream carrier health
- Tools must proactively identify and locate network issues as well as certify any install or repair immediately to eliminate OpEx-consuming callbacks

JDSU has a wide range of test-and-measurement products and services with signature features including advanced functionality, reliability, portability, ease-of-use, and value. Superior customer service and strong support adds value by helping technicians get maximum use from their JDSU equipment.

- Coaxial RF performance and sweep testing — SDA 5500, DSAM 6300
- System monitoring — PathTrak return-path monitoring, PathTrak video monitoring
**Ethernet/IP Commissioning and Troubleshooting**

**JDSU Handheld Solutions for Ethernet backhaul**

Advanced JDSU solutions for 10/100 Ethernet and Gigabit Ethernet testing support RFC-2544 traffic testing as well as ITU-T Y.1564 service-activation testing to verify structured video, voice, and data services. The JDSU solutions offer flexibility to perform across various network infrastructures and tunneling technologies (VLAN Q-in-Q and MPLS) to quickly analyze jitter, throughput, and latency to assess QoS. Revolutionary TrueSpeed™ (RFC-6349) automated TCP testing validates TCP performance to end customers to accurately validate SLA performance. These easy-to-use tools are application specific to help any field technician quickly turn-up and test Ethernet and IP services.

As an example, the T-BERD®/MTS 5800 is the industry’s smallest 10 G handheld instrument that supports testing throughout the entire Ethernet service life cycle including installation, troubleshooting, and maintenance. It addresses the challenges of carrier Ethernet evolution. The T-BERD/MTS 5800 ensures successful mobile backhaul transitions by validating new Ethernet synchronization deployments (1588v2 and SyncE) that guarantee successful mobile handoff between cell sites, thereby avoiding service degradation.

All of this is done using automated test sequences that can guide technicians at all skill levels though the test, ensuring fastest possible operation and consistently reducing the risk of human errors. The tester produces clear pass/fail results based on the SLA criteria and documents the result in auditable test reports for clean handoffs between different groups or operators.
**Service Assurance**

**Small Cell Backhaul Assurance Solution**

The JDSU Small-Cell Backhaul Assurance solution addresses the complete life cycle of challenges faced by mobile network operators, starting with backhaul service activation, performance assurance and optimization, and monitoring. JDSU offers operators a comprehensive suite of products and software applications to automate backhaul network activation, centrally troubleshoot, and monitor backhaul performance to service level agreements.

It eliminates the need for costly and impractical external instrumentation providing significant space and power savings, and dramatically reduced total-cost-of-ownership and helps mobile operators accelerate rollout and improve time to revenue and service while addressing the unique backhaul networking challenges introduced by small cells. The JDSU solution specifically automates the backhaul test and solves the network-visibility challenges at aggregation points in the network, minimizing test time, eliminating field dispatches, and obtaining key network performance indicators including one-way latency without having to re-architect their networks or deploy additional equipment.

The JMEP SFProbe™, the latest addition to the PacketPortal family, is a micro-probe complementing the existing Intelligent Visibility SFProbe. Both are based on industry-standard small form factor pluggable (SFP) gigabit Ethernet transceivers. PacketPortal SFProbes meet or exceed standards and can be deployed inline in existing network equipment such as NodeB/eNodeB and cell-site routers. PacketPortal-distributed SFProbes deployed at the network edge are centrally managed and controlled by a software platform, supplying centralized tools and software applications.
The JMEP SFProbe addresses the unique requirements for activating and monitoring next-generation Ethernet services, including not only small-cell mobile backhaul but other markets using Ethernet services such as business services. The JMEP SFProbe supports industry standards such as RFC-2544, Y.1564, and Y.1731 test methodologies. When combined together with Intelligent Visibility SFProbes, PacketPortal provides a highly-scalable approach to overcome the complex service activation, performance monitoring and assurance, and network troubleshooting/segmentation that new multi-vendor hub-and-spoke topologies introduce.

Together with NetComplete EtherAssure service-aware OSS and the QT-600 centralized test probe, the Small Cell Backhaul Assurance solution delivers the necessary applications to ensure backhaul services meet the most stringent performance requirements of the industry. These applications let backhaul providers verify whether circuits are performing in accordance with SLAs at turn-up. They rapidly segment the network, demarcating the location of quality issues between the network of the mobile carrier and the backhaul network, and they monitor both service and network performance that includes alerting the provider of SLA threshold violations.
Solutions for Customer Experience

When the “Voice of the Customer” is not enough, providers need all-around insight into a customer’s experience and usage. The current mobile network environment is experiencing a ramp in the use of smartphones, downloaded applications, and OTT services, especially video. Likewise, with new mobile-network technologies such as LTE offering greater service bandwidths and multiple QoS levels, the opportunities for new mobile revenue sources have never been greater. However, there are downsides to this environment where customer service usage and QoE become individualistic and highly impacted by the choice of smartphone and downloaded applications. Also, service volumes are growing almost exponentially while the revenue-per-data-unit carried is dropping. To maintain profitability, service providers must find new or incremental revenue sources and/or reduce operational costs.

JDSU is a long-term leading supplier of assurance and customer experience management (CEM) solutions, providing real-time monitoring, troubleshooting, and reporting for 2G, 3G, and LTE networks and services. In support of the evolving needs of mobile-service providers, JDSU recently introduced the following innovative solutions addressing the growing importance of customer usage and experience insight to:

- Optimize marketing and customer care with real-time granular intelligence
- Collect and correlate meaningful intelligence across the end-to-end network
- Prioritize data analytics by customer value and priority
- Maximize service quality through application-aware performance assurance, real-time troubleshooting, and granular customer QoE insight

**InTouch™**

InTouch is a JDSU monitoring and reporting application focused on customer-experience and usage insight.

InTouch delivers subscriber-level usage and experience data to mobile-service providers, enabling more effective ways to manage their networks, services, and customers. Using network-signaling and user-plane data from JDSU assurance probes, the InTouch application provides deep insight into mobile usage and experience with profiling by individual customer, handset, cell location, and core network element. In this way, the solution provides key subscriber-level insight. InTouch not only improves customer satisfaction and retention, but also lets providers make operational management decisions with the customer in mind.

InTouch functional diagram
Using collected network and reference data, InTouch scores every service transaction (call, SMS, or data session) for QoE, providing MOS-like scoring from 1 through 5. InTouch then stores this QoE score along with the transaction usage information and provides usage and QoE reports, both individual customer and aggregated, based on the stored data. InTouch offers hundreds of pre-defined reports, but users can also define their own reports to provide custom views and interpretations of data specific to their interests.

### Sample InTouch QoE scoring

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Data Average Throughput (Mbps)</th>
<th>Total Records</th>
<th>Total Traffic (MB)</th>
<th>Throughput (Mbps)</th>
<th>Average Downstream (Mbps)</th>
<th>Average Upstream (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G Phone 1</td>
<td>5.94</td>
<td>236,771</td>
<td>3.32</td>
<td>3.46</td>
<td>2.72</td>
<td>0.74</td>
</tr>
<tr>
<td>3G Phone 2</td>
<td>4.37</td>
<td>199,442</td>
<td>1.14</td>
<td>1.00</td>
<td>0.64</td>
<td>1.10</td>
</tr>
<tr>
<td>3G Phone 3G</td>
<td>5.06</td>
<td>13,347</td>
<td>1.25</td>
<td>2.52</td>
<td>1.32</td>
<td>0.89</td>
</tr>
<tr>
<td>3G Phone 4G</td>
<td>5.06</td>
<td>19,726</td>
<td>2.14</td>
<td>4.07</td>
<td>1.78</td>
<td>2.04</td>
</tr>
<tr>
<td>3G Phone 5G</td>
<td>2.00</td>
<td>140,889</td>
<td>1.14</td>
<td>1.00</td>
<td>0.64</td>
<td>1.10</td>
</tr>
<tr>
<td>3G Phone 6G</td>
<td>5.06</td>
<td>19,726</td>
<td>2.14</td>
<td>4.07</td>
<td>1.78</td>
<td>2.04</td>
</tr>
<tr>
<td>3G Phone 7G</td>
<td>5.06</td>
<td>19,726</td>
<td>2.14</td>
<td>4.07</td>
<td>1.78</td>
<td>2.04</td>
</tr>
<tr>
<td>3G Phone 8G</td>
<td>5.06</td>
<td>19,726</td>
<td>2.14</td>
<td>4.07</td>
<td>1.78</td>
<td>2.04</td>
</tr>
<tr>
<td>3G Phone 9G</td>
<td>5.06</td>
<td>19,726</td>
<td>2.14</td>
<td>4.07</td>
<td>1.78</td>
<td>2.04</td>
</tr>
</tbody>
</table>

### InTouch GIS Map
Solutions for Mobile Service Assurance

JDSU mobile data assurance solutions monitor and troubleshoot GPRS, UMTS, CDMA 2K, and LTE networks (including interoperability) and are a key tool for monetizing data bandwidth with unmatched business intelligence (BI) functionality.

With a JDSU assurance solution delivering an integrated suite of monitoring and troubleshooting applications, you are never more than three clicks away from diagnosing problems. You get unparalleled scalability, up to 80 percent reduced problem-resolution time, and the ability to cost effectively re-allocate resources. Your customers win with high-quality and consistent service; your company wins with substantial savings and more revenue; and, your employees win with greater job satisfaction.

The JDSU mobile assurance portfolio includes accessLTE to assure LTE mobile networks and services.

Converged assurance solution
Summary

Deploying small-cell services brings vast complexities and challenges to network planning, testing, maintenance, service assurance, and CEM. A comprehensive, application-aware test and service-assurance strategy that covers installation, provisioning, and management is needed to address these challenges. JDSU is a single source for all these solutions. With complete ability to verify and troubleshoot the physical plant, the network circuit, and the full range of services and apps, JDSU competitive advantages are clear.

Small-cell challenges include:
- Lab pre-deployment testing
- Turn-up and deployment
- Backhaul quality
- End-to-end assurance

JDSU is building on its extensive mobile experience and is partnering with NEMs to help service providers manage the deployment and OpEx costs of small cells, as well as time-to-revenue while maintaining service quality. From pre-deployment planning through turn-up and assurance, service providers and NEMs can ensure small cells deliver the capacity and coverage needed to enhance the overall end-customer experience. Service providers and NEMs can be sure the physical transport of small cells, as well as content-aware real-time customer intelligence, can be leveraged across a range of JDSU customer and partner applications.

Benefits include:
- Minimize the cost of small-cell deployments
- Minimize time-to-revenue
- Measure user experience before the customer does
- Simple one-touch modes combine with engineering modes
- Integrated solution set from silicon to apps, RAN to core
- Content aware for application analysis
- One device verifies RF and backhaul
- One-touch service verification/service assurance
# Products and Solutions

## Rollout Planning

<table>
<thead>
<tr>
<th></th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ariesGEO</td>
<td>Indoor/outdoor 3G/4G/WiFi</td>
<td>Indoor/outdoor 3G/4G/WiFi</td>
<td>Indoor/outdoor 3G/4G/WiFi</td>
</tr>
</tbody>
</table>

## Cell-Site Turn-Up

<table>
<thead>
<tr>
<th>Product</th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CellAdvisor Cable and Antenna Analyzers</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>CellAdvisor Base Station Analyzers</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>CellAdvisor RF Analyzers</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>CellAdvisor Signal Analyzers</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>RANAdvisor solutions</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
</tbody>
</table>

## Field-to-Lab Correlation

<table>
<thead>
<tr>
<th>Product</th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active test (RCATS)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>CellAdvisor Base Station Analyzers</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>Capacity Advisor solutions</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>RANAdvisor solutions</td>
<td>Outdoor 3G/4G</td>
<td>Outdoor 3G/4G</td>
<td></td>
</tr>
<tr>
<td>Signaling Analyzer (SART) — wireless protocol test</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Packet Insight</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

## Mobile Backhaul

<table>
<thead>
<tr>
<th>Product</th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>StrataSync™</td>
<td>All technologies</td>
<td>All technologies</td>
<td></td>
</tr>
<tr>
<td>DSAM Digital Service Activation Meter</td>
<td>Outdoor HFC, RF, Ethernet, IP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber inspection and test</td>
<td>Outdoor/indoor fiber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HST-3000 Handheld Services Tester</td>
<td>Outdoor/indoor copper, VDSL, Ethernet, IP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PathTrak™ return path monitoring system</td>
<td>HFC, RF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro/Business Ethernet services test tools</td>
<td>10 Mbps/100 Mbps/1 G Ethernet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-BERD/MTS</td>
<td>OTDR, FTTx, fiber characterization, Ethernet, BERT, 40 G, OTN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Mobile Service Assurance Solutions

<table>
<thead>
<tr>
<th>Product</th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetComplete® EtherAssure</td>
<td>Ethernet</td>
<td>Ethernet</td>
<td></td>
</tr>
<tr>
<td>Packet Portal</td>
<td>Ethernet, signaling</td>
<td>Service-usage Ethernet, signaling</td>
<td></td>
</tr>
</tbody>
</table>

## Mobile Service Assurance

<table>
<thead>
<tr>
<th>Product</th>
<th>Plan</th>
<th>Protect</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>InTouch</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packet Portal</td>
<td>Ethernet, signaling</td>
<td>Service-usage Ethernet, signaling</td>
<td></td>
</tr>
</tbody>
</table>
JDSU Services

**Consulting Services** — Small-cell deployments create the need for more equipment, more manpower, more expertise, and unbiased test results. Support your current workforce with experienced test engineers or automate your method of procedures (MOPs) to reduce testing time and testing complications.

**Education Services** — Renewed education is a must-have for the rapidly changing environment created by small-cell deployments. The JDSU education services team provides training and development on new method of procedures (MOPs) in addition to hands-on and virtual training on new technologies, testing practices, and products.

**Test-Equipment Management** — Solutions spanning calibration and repair to detailed test equipment tracking let installers, providers, and equipment manufacturers achieve the highest return on investment by increasing utilization and internal efficiency in tracking equipment.