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SOLUTION BRIEF

Improving the ROI of Small Cells through Plannning

Compelling RF Analyses to Enhance Spectral Efficiency in HetNet Deployments

The Mobile Data Explosion Challenge

The mobile data explosion, driven by the uptick in smartphone, tablet and mobile PC usage, is a well-known fact in the wireless industry. Mobile operators are under immense pressure to deliver the high capacity demanded by their customers. Cost per delivered payload (i.e. $/bit) is going down, and operators' core revenue streams, such as voice and messaging, are threatened by Over-the-Top (OTT) application providers. Forced to increase network capacity, mobile operators are looking for cheaper and more efficient ways of satisfying customers' data hunger—this is leading them to reshape their wireless networks, and look to small cells and Wi-Fi data offloading, as part of heterogeneous networks (HetNets).

Mobile Data Growth

According to Cisco's latest Visual Networking Index[1], global mobile data traffic in 2017 will exceed 11 exabytes (1018) per month, a 13-fold increase over global mobile data traffic in 2012. An additional nine exabytes of data per month will, according to the report, be offloaded from mobile devices, mainly via Wi-Fi. Mobile video now makes up 50 percent of the traffic and is expected to continue to dominate over the next five years. Even with this growth, mobile data traffic will continue to be about 10 percent of the total data traffic in the world[2], but to provide wireless data access everywhere, mobile operators faces many challenges.

Recent usage data shows that LTE deployments drive more LTE data traffic and relatively less off-loading to Wi-Fi, compared to 3G deployments, as smartphone users are getting used to and increasingly relying on the high bandwidth provided by LTE.[3]

THE RISE IN MOBILE DATA DEMAND

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SMALL CELL TECHNOLOGIES EVOLVE RAPIDLY

According to the Small Cell Forum, small cells are “low-power wireless access points that operate in licensed spectrum, are operator-managed and feature edge-based intelligence.”

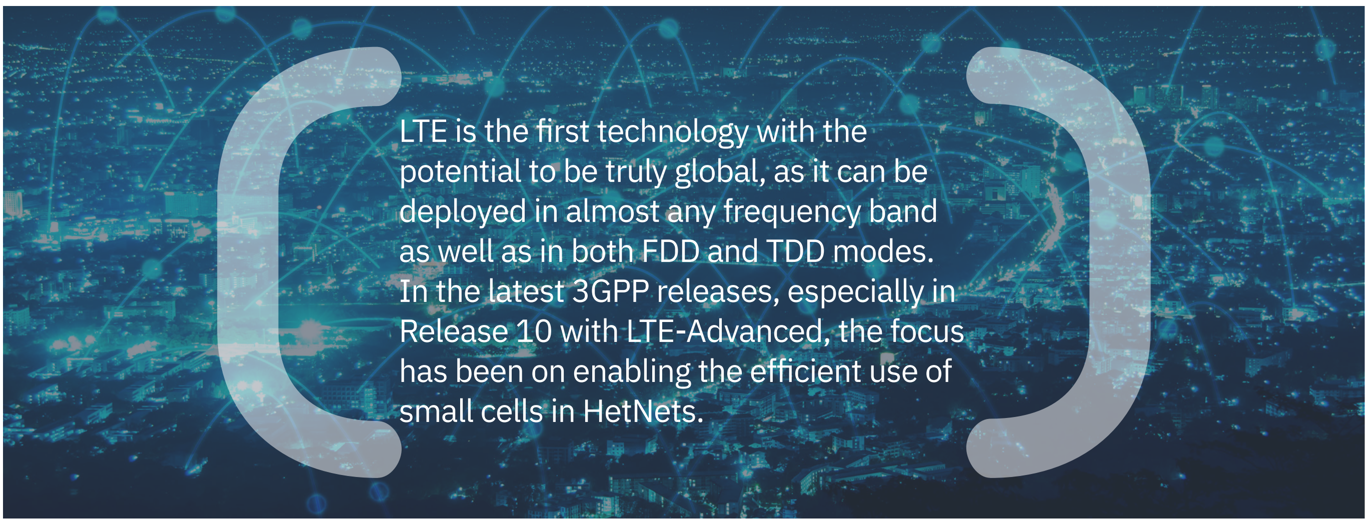
This umbrella definition covers femto-, pico-, micro- and metrocells with technologies ranging from 2G to 4G. The big buzz in the industry is about the metrocells designed for high capacity metropolitan areas as part of a HetNet. For capacity reasons, the focus is on HSPA+, LTE and LTE-Advanced. Infonetics Research predicts that a quarter of the mobile data traffic will be carried over small cells in 2016.[4]

Based on licensed spectrum requirement, Wi-Fi falls outside the Small Cell Forum’s definition, but Wi-Fi is currently used extensively for data offloading and will be part of many mobile operators’ HetNets. So, the question becomes: to what extent will Wi-Fi be integrated from commercial and technical points of view? Some operators today are already relying on SIM authentication of Wi-Fi. Multi-standard metrocells (i.e. small cells that combine HSPA+, LTE and Wi-Fi into a single unit) is a solution that some operators are aiming for.

The Wireless Broadband Alliance is also working actively to make Wi-Fi more integrated with mobile networks and aim for the same hassle-free user experience.

LTE is the mobile technology that has had the quickest uptake on the mobile market; today, 415 operators in 124 countries are investing in it.[5] LTE is the first technology with the potential to be truly global, as it can be deployed in almost any frequency band as well as in both FDD and TDD modes. In the latest 3GPP releases, especially in Release 10 with LTE-Advanced, the focus has been on enabling the efficient use of small cells in HetNets. One issue that has been tackled in LTE-Advanced is the imbalance between the downlink from macro cells and the downlink from small cells. The macro cells have high output power and high antenna gains, causing high interference for user devices that potentially could be connected to small cells. It limits the benefit of the small cells, and therefore, as part of enhanced inter-cell interference coordination (eICIC), the concept of Almost Blank Subframes (ABS) has been introduced, allowing extended coverage areas for the small cells. Other important new standardized system features in LTE Release 10 are carrier aggregation, support for higher orders of MIMO and relay nodes.

HSPA micro- and picocells have been used to fill in cover holes in HSPA networks. With HSPA+, true small cell deployments, with the aim to boost capacity, will become more common. HSPA+ is under development, and higher bitrates are expected in upcoming releases.



THE FREQUENCY DILEMMA

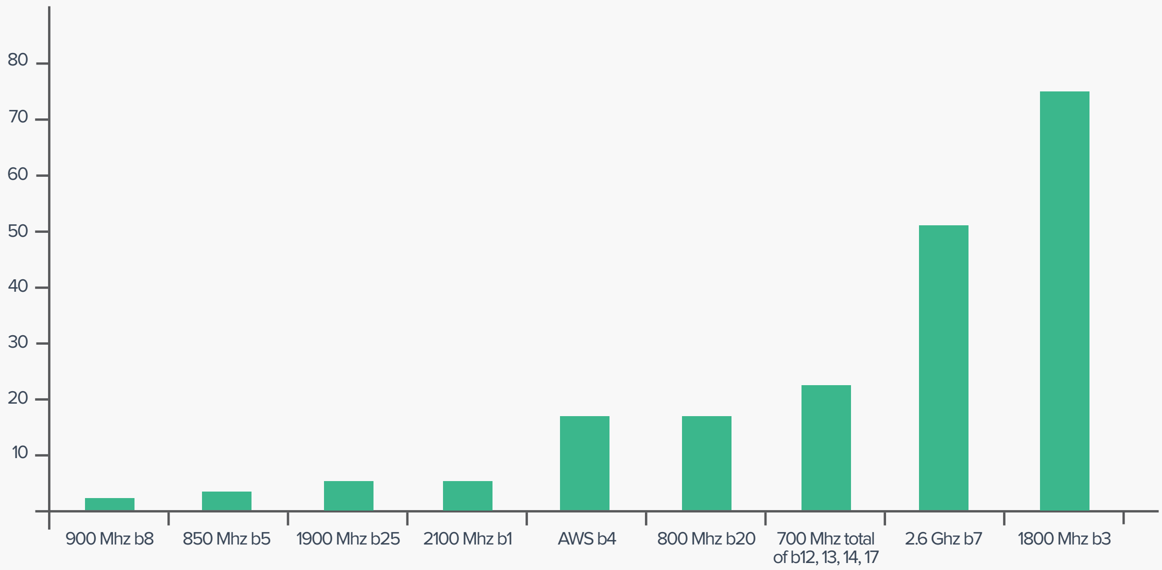
The frequency spectrum is a highly regulated resource; by nature, it is limited and re-usable. The challenge for a mobile operator is how to utilize the available frequency spectrum in the most efficient and economical way. New frequency bands are also made available around the world; in most cases, this is in limited portions at frequency auctions. How valuable is additional spectrum for each mobile operator to achieve their strategic goals?

Spectral efficiency increases with every technology step. For example, the maximum spectral efficiency for HSPA in 3GPP Release 6 is 8bps/Hz. LTE Release 8 offers 16bps/Hz, and LTE-Advanced in Release 10 promises 32bps/Hz. The dilemma for the operator is: how long should they remain dedicated to the investment in the current network and its spectrum allocation, and when should they start refarming spectrum to make room for new, more promising technologies? Perhaps a portion of the GSM spectrum should be used for HSPA+ or LTE-Advanced instead? Should small cells be deployed on the same carriers as macrocells (in-band deployment), or should some carriers be set aside for the small cells (out-band deployment)?

What's more, operators can deploy LTE networks in different modes and frequency bands. But, if they choose a frequency band that is less commonly used among other operators around the globe, they will run into a few problems—perhaps the biggest of which would be a lack of available options from mobile device vendors. These decisions could open or close doors to a rich ecosystem of user devices for operators. Backhaul capacity requirements are also growing rapidly. Ericsson is reporting that in 2011, a vast majority (80%) of the sites in a mobile broadband backhaul scenario demanded 20 Mbps.[10] In 2015, 100 Mbps per site is expecting to be the required capacity; some sites are expected to require 1 Gbps. The big trend is that copper is being replaced with microwave links and microwave links with fiber. Microwave links will continue to dominate the mobile backhaul market with a steady 50% market share, according to Ericsson.

It is clear that backhaul threatens to be a bottleneck for small cells—both in the rollout phase and from a capacity point of view. It is, therefore, tremendously important to consider backhaul solutions as early as possible in the network design process.

Figure 1. The first 163 commercially launched LTE FDD networks are spread over different frequency bands according to GSA's Evolution to LTE report, April 2013. The most used frequency bands so far are: 1800 MHz (band 3), 2.6GHz (band 7), 800 MHz (band 20) and AWS (band 4).



AVOIDING THE BACKHAUL BOTTLENECK

In an Informa report last year, backhaul was ranked as the number one concern for small cell deployments.[6]

This might be surprising, but a number of reasons can be identified:

- Small cells will exceed the number of macro cells in a HetNet. In November 2012, the total number of deployed small cells in the world already passed the number of cells in the macro layer.[7] The industry expectation is that 5-10 small cells will be deployed per macro cell.
- The typical placement of a small cell site is low, well below rooftops, in urban environments, making it harder to find line-of-sight (LOS) connections for microwave links than to classic macro sites.
  Other identified wireless backhaul options are non-LOS (NLOS) below 6 GHz and higher frequency bands like 60-80 GHz (“millimeter wave”), requiring LOS. Different types of topologies such as chains, point-to-multipoint and mesh are suggested.[8] In addition, NLOS connections at frequencies above 20 GHz, has been proven by Ericsson as a viable solution for short distances in urban environments.[9] Fiber connections, if available, are, of course, the preferred solution.
- Bigger differences in traffic load for small cells between peak hour and average traffic load are to be expected based on the fact that a small cell will have a smaller coverage area with fewer users than a macrocell. An ongoing debate is how to account for the traffic load variations when dimensioning the small cell backhaul.

HOW TO ESTABLISH A SUCCESSFUL SMALL CELL STRATEGY

A small cell strategy is a key question for operators, and it involves many aspects, both commercial and technical.

Market position, customer base, pricing schemes, as well as network structure, technology choices, frequency costs and network sharing options are some of the areas to think through. Different deployment scenarios must be modeled, evaluated and compared in exercises where the goal is to establish the best business case.

With more HetNet deployments in the world, it becomes obvious that there is not one small cell strategy, but many different ones depending on each mobile operator's prerequisites.

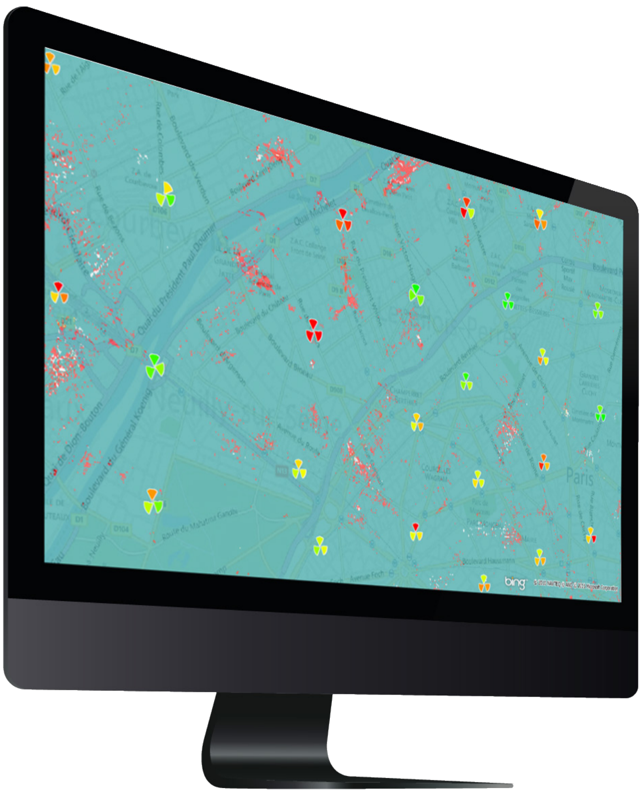


Figure 2. Spectral efficiency maps and reports in Planet can be used to evaluate and compare different frequency allocations. Here is an example of a spectral efficiency map of a LTE network in Paris. Areas in red show where the spectral efficiency is low.

Figure 3. An example of a 3D-analysis of LTE Reference Signal Received Power from one site in an urban area, displayed in Planet. High signal levels are in red, low signal levels are in blue.

From a technical point of view, it is important to remember that small cells are primarily used to build out cellular networks and capture more traffic, while providing relief for the macro layers of those networks.

Operators should first look into whether or not the networks are fully optimized and are utilizing the entire available spectrum. The true nature of small cells, how they interact with the current network and how they serve to optimize it, must be understood to fully realize the benefits they bring. This knowledge will have a significant impact on operations, and could very well mean the difference between missed opportunities and potentially huge gains. There are four questions operators must ask themselves.

THE 4 QUESTIONS OPERATORS MUST ASK THEMSELVES

Q1: Is the current network optimized?

Evaluate the current network to see if it can be optimized to carry even more traffic.

The current network should be optimized first, as small cells will be added, and their location will depend on the macro layers' coverage and capacity.

Q2: Where is the traffic load so high that small cells make sense?

Evaluate, per area or city, the traffic demand, now and in the near future, to determine in which areas the traffic load is so intense that it motivates the need for small cells. Where and when are additional resources required?

Q3: How can you use the frequency resources?

Evaluate and optimize the current use of frequencies by analyzing the spectral efficiency. Figure 2 shows an example of a spectral efficiency map.

Is it more efficient to use the available frequencies for another technology, i.e. spectrum refarming? Are additional frequency resources required?

Q4: What technologies, cellular and backhaul, should I deploy?

Evaluate different frequency, technology, topology and backhaul scenarios.

Compare the scenarios based on CAPEX, OPEX, throughput, quality, spectral efficiency and time-to-market.

Which technology options are best from those points of view?

To fully evaluate the scenarios of interest, typical areas need to be modeled and analyzed with network design and optimization software. Strategic decisions would be enabled with the following capabilities supported in Infovista's Planet:

- Support for all technologies currently deployed in the network;
- Support for the latest 3GPP releases to be able to model the latest network technology advancements;
- Support for Wi-Fi;
- Automatic network planning features to quickly create and evaluate different scenarios;
- Flexible traffic load management to enable the efficient creation and scaling of traffic maps;
- Advanced simulations including spectral efficiency maps;
- Integrated analysis of backhaul solutions;
- Strong, built-in, what-if functionality for easy comparison of different scenarios; and
- Professional graded GIS to enable further analysis and combination of data from other sources.

A successful small cell deployment is all about investing in the right places at the right times. By leveraging the capabilities listed above, strategic network planners will be able to evaluate scenarios for optimal small cell deployment.

HOW TO CREATE AN OPTIMAL SMALL CELL NETWORK DESIGN

STEP 1: OPTIMIZE THE MACRO NETWORK LAYER

The macro layers of the network should be optimized first, as they will determine the need for and placement of small cells. For some operators, this will prove to be a large project if spectrum is refarmed at the same time. The most efficient way to optimize the network layer is to use an Automatic Cell Planning (ACP) tool integrated with the network design and optimization solution. An ACP allows you to quickly optimize the network configuration, providing several benefits, including the ability to minimize cell overlap and interference levels. The goal is to maximize the overall spectral efficiency in the macro layer.

A prerequisite for optimizing the macro network layer is a good propagation model suited for urban environments, specifically one that has been carefully tuned based on an accurate set of telecom-graded geodata. Support for the applicable technologies, 3D network traffic maps, coverage and performance modeling are a must. In Figure 3, an example of 3D modeling of LTE coverage is shown.

STEP 2: CREATE A 3D-TRAFFIC MAP

The purpose of small cells is to off-load the macro layer and, without a good understanding of the current and near-future traffic loads, that is not feasible. A 3D-traffic map reflects the geographic traffic load and hotspots. It is created from several sources.

The current traffic per cell in the macro layer can be combined with geo-localized measurements, high-resolution geodata for accurate traffic spreading in 3D, scaling of traffic load, and more dynamic inputs, such as geographic use patterns of social media information.

With these inputs, you can achieve a good understanding of the geographic variations in traffic demand, not only in two dimensions, but also in 3D with traffic demands at different heights inside buildings.

An example of a 3D traffic map displayed in 2D can be seen in Figure 4.

Figure 4. A total traffic map for Manhattan in Planet. Social media traffic, carried traffic and high-resolution geodata combined to make an accurate traffic model. Showing areas with the high (red) and low (blue) traffic demand

STEP 3: EVALUATE WHERE SMALL CELLS WILL BE MOST BENEFICIAL

In a HetNet, a small cell will capture traffic that would otherwise be handled by the macro layer. It relieves the macro layer from that traffic and frees up significant resources. The amount of resources freed up depends on the area in which the small cell is deployed. The gain is two-fold: the capacity the small cell offers itself and the more efficient use of the resources in the macro layer. The most effective approach is to deploy small cells in areas with low spectral efficiency, which is typically the result of a combination of low signal levels and high interference levels.

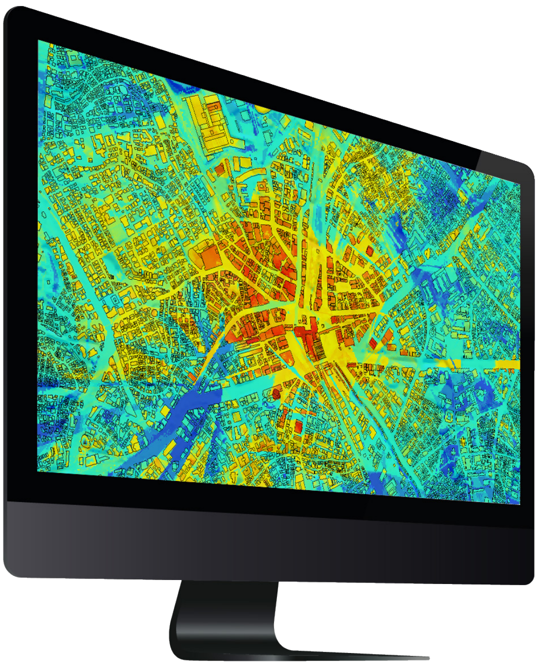


Figure 5. A Resource-Need map of a dense urban area in Planet, combining traffic data and spectral efficiency. Showing areas with high need for additional capacity (red and yellow). The current network can handle the traffic demand in the blue and green areas.

You find these conditions in an urban environment, for example, indoors and at the border between two cells in the macro layer. By combining the macro layer's spectral efficiency map with the traffic map, a resource-needs map can be created. It shows the areas where small cells deployments would be most beneficial. See Figure 5 for an example of a resource-need map.

STEP 4: SELECT POTENTIAL SMALL CELL SITE LOCATIONS BASED ON BACKHAUL CRITERIA

Based on the selected backhaul solutions—in most cases, several solutions will be combined—possible locations for small cells should be analyzed. This process will depend on the selected backhaul solutions and the available input data. Here are two examples of how a subset of potential small cells locations can be created.

The number of potential locations should be higher than the final number of small cells identified in Step 5.

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Example 1: Small cells should be deployed on light poles along the streets in a city. A database, with light pole coordinates and heights, has been acquired. Combined with other detailed geodata, the light poles with LOS conditions to sites in the macro layer have been identified as potential candidates. See figure 6 for an example.

Example 2: Small cells are to be deployed in an urban area, but no information about possible site locations has been identified. An automatic site placement tool can be used to create a database with a surplus of possible site locations. Out of the created list of locations, the sites that are capable of connecting to a NLOS system (below 6 GHz) are selected as potential candidates.

STEP 5: DETERMINE SMALL CELLS PLACEMENT AND CONFIGURATION

The optimal number of small cells, their location and configuration can be determined with an ACP, and is preferably based on spectral efficiency in order to maximize the capacity gain in the whole network. The ACP will select which locations to use and the optimal configurations of the small cells. It will also give you the optimal number of small cells to deploy. Additional small cells beyond that number would be of limited benefit, and could even cause interference that would decrease network capacity. See Figure 7 for an example of capacity evolution when adding small cells in an urban area.

Advanced multi-technology neighbor list generation, as well as code or Cell ID planning, can also be performed - preferably with automated features. The desired site locations should be contracted and final design of the backhaul can then take place.

Figure 6. A database with street lights in Washington, D.C. has been analyzed for backhaul connectivity in Planet. The street lights with line-of-sight to access points (green dots) are potential locations for small cells. The street lights lacking line-of-sight (red dots) are not candidates for conventional microwave links areas.

STEP 6: VERIFY THE CAPACITY AND COVERAGE IMPROVEMENTS

The final network design should be verified with network analyses and Monte Carlo simulations to verify the network capacity and coverage improvements, both in the macro layer and by the small cells themselves."

See Figure 8 for an example of the improved network capacity, before and after adding small cells. Outdoor small cells will improve the indoor coverage. Based on the new capacity and coverage baseline, the need for indoor systems can be analyzed.

By performing the analysis in the planning process outlined above, the ROI of small cell deployments is optimized. The pre-requisite is a network design and optimization solution that efficiently supports all the steps and evolves with new technologies.

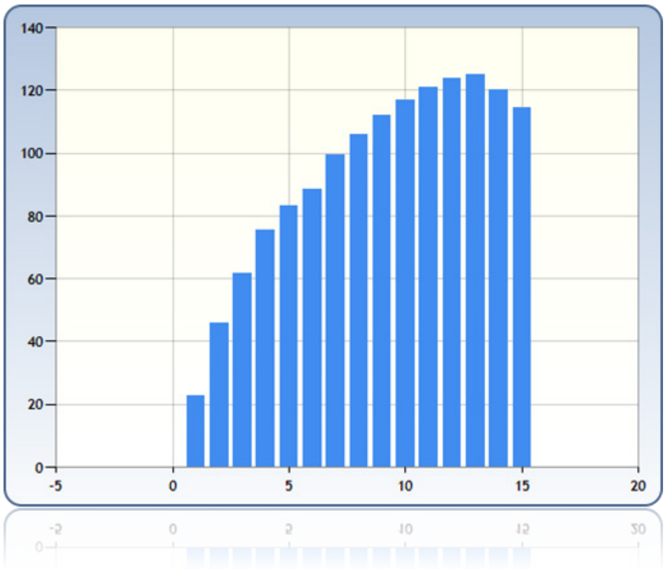

Figure 7. The capacity gain (in %) is biggest for the small cells added first in an urban area. In this example, adding cell number 14 and 15 would decrease the capacity in the area due to rising interference levels.

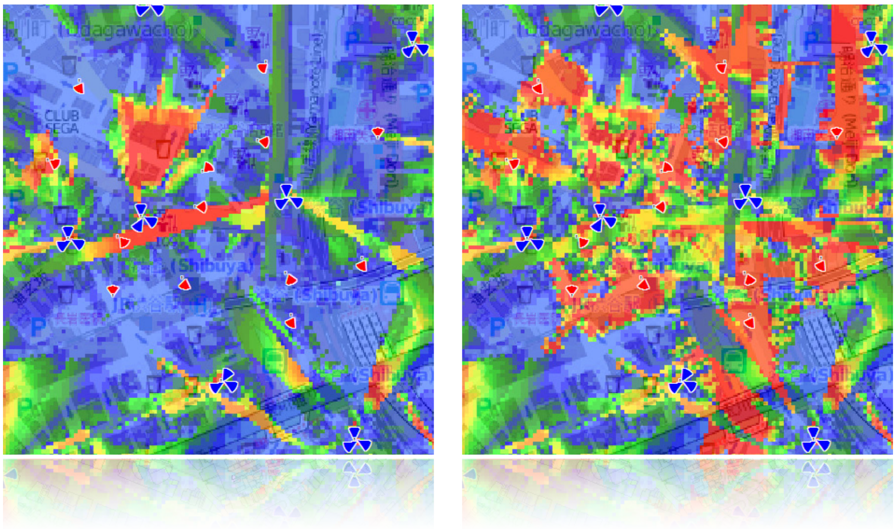

Figure 7. Optimized deployment of small cells increases the network capacity; before (left) and after (right) the addition of small cells. The high-capacity areas, in red and yellow, have expanded. Lower capacities are shown in green and blue

SUCCESSFUL SMALL CELLS DEPLOYMENTS WITH PLANET

Planet is a network design and optimization solution that gives you the best opportunity to maximize your network return-on-investment (ROI). During the last 2.5 years, the development focus has been on providing operators with outstanding support for the planning of small cells and HetNets. With Planet, you are assured to have a network design and optimization solution at the forefront.

Planet® gives you:

- Support for the latest technology enhancements, including LTE-Advanced, Release 10 and 11.
- Support for integrated mobile and Wi-Fi network design
- A toolkit to automatically and accurately design high-quality LTE-Advanced and small cell networks
- Propagation models for both urban and rural areas with the best accuracy on the market
- Access to a vendor-managed online antenna library
- Advanced creation of Traffic Maps, also in 3D, from multiple sources, such as network data and social media information
- 3D coverage and capacity analyses
- Viewing of geodata and the ability to analyze results in 3D
- Scenario management and what-if analysis
- Automatic site placement and selection
- Automated network optimization (ACP) with the unique spectral efficiency improvement goal
- Integrated analysis of backhaul solutions
- Different deployment options, from laptop to centralized and hosted solutions
- A reliable partner with a strong roadmap for the future

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