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Small cell siting challenges

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SMALL CELL FORUM

Solving the HetNet puzzle

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SMALL CELL FORUM

RELEASE 9.0

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Small Cell Forum accelerates small cell adoption to drive the wide-scale adoption of small cells and accelerate the delivery of integrated HetNets.

We are not a standards organization but partner with organizations that inform and determine standards development. We are a carrier-led organization. This means our operator members establish requirements that drive the activities and outputs of our technical groups.

We have driven the standardization of key elements of small cell technology including Iuh, FAPI, nFAPI, SON, services APIs, TR-069 evolution and the enhancement of the X2 interface.

Today our members are driving solutions that include small cell/Wi-Fi integration, SON evolution and automation, virtualization of the small cell layer, driving mass adoption via multi-operator neutral host, ensuring a common approach to service APIs to drive commercialization and the integration of small cells into 5G standards evolution.

The Small Cell Forum Release Program has now established business cases and market drivers for all the main use cases, clarifying market needs and addressing barriers to deployment for residential, enterprise, rural & remote, and urban small cells.

The theme of Release 9 is Commercializing Hyperdense HetNets, which looks at practical solutions to help operators transform their network capacity and performance, and which are deployable and cost-effective right now.

The Small Cell Forum Release Program website can be found here: www.scf.io

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About 5G Americas: The Voice of 5G and LTE for the Americas

5G Americas is an industry trade organization composed of leading telecommunications service providers and manufacturers. The organization's mission is to advocate for and foster the advancement and full capabilities of LTE wireless technology and its evolution beyond to 5G, throughout the ecosystem's networks, services, applications and wirelessly connected devices in the Americas.

5G Americas is invested in developing a connected wireless community while leading 5G development for all the Americas. The association prepares numerous white papers and reports on key initiatives, challenges and opportunities for the industry with a particular focus on those of greatest importance to North America and Latin America and the Caribbean. The reports are accessible on the association's website www.5gamericas.org

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Scope

The scope of this document is to raise awareness of the siting and deployment challenges that accompany densification of the radio access network, summarize key lessons learned from small cell deployment so far, and recommend solutions that can enable efficient deployment of small cells in a 5G environment. The large scales driven by massive densification anticipated in 5G will result in many challenges in deployments, and particularly in siting.

Executive summary

The 5G HetNet should not just be about yet-higher peak rates and new services, but about making the overall customer experience smoother and more predictable, increasing user satisfaction levels while keeping the network scalable and cost effective. Good customer experience must be a starting point, not an afterthought.

No matter how 5G technical specs are defined, small cells will be an important part of delivering that experience, but they introduce significant deployment challenges once they are implemented at huge scales, as in a hyperdense network.

The three key issues to consider from a deployment perspective, are: site location, backhaul and O&M. New approaches will be needed, but these can build on current deployments. In many cases, the issues are already present today in 3G and LTE networks today, but they will be magnified with the new data demands and use cases of 5G, which will drive far greater density.

Getting access to huge numbers of sites in the right place, and economically, is key to a commercially viable dense HetNet. Proper siting close to where the consumption of data is taking place will be a key enabler of an excellent user experience, delivering maximum throughput to customers in data-heavy scenarios.

It is therefore necessary to lower barriers associated with site selection in local municipalities or at a national level. Hyperdense networks also require the automation of many aspects of the delivery process. This will make SON a key enabler for 5G hyperdense networks, to lower the cost and speed up deployment.

Table 1 provides a summary of the recommendations for simplifying deployment of hyperdense networks, now and in the 5G era.

Challenge	Solution
TCO and cost of capacity	Advanced capacity planning, spectral efficiencies, shared or neutral host networks, automation/SON
Coverage and QoS	Flexible standards and regulations to cover non-traditional cell sites – e.g. rural, public buildings, street furniture, underground car parks
Backhaul and power	Standardized frameworks/agreements with fiber or copper owners; mixed toolkit of backhaul and power options
Pre-deployment: site acquisition and equipment approval	Common rules on which equipment classes can be exempt or subject to fast track approval; a batch process for groups of cells; new base station design
Deployment and maintenance processes for large scale	Create simplified common frameworks for access to sites; simplify installation procedures; automate maintenance; site sharing

Table ES–1 Key challenges of dense deployment, and recommended solutions

When it comes to siting and deployment, some further, more specific recommendations are important:

- Small cell siting should be streamlined where possible to use local infrastructure policies and design guidelines, as small cells are similar to access points and should not be considered large pieces of network equipment (such as macro cells), and thereby no specific planning permissions should be required to roll out such networks.
- To simplify and provide uniformity of networks, national rules should be established for rights-of-way for the deployment of small cells. This is for both the access to the property as well as the administrative paperwork – whereby the same policies should apply nationally.
- Scaled down administrative processes should be used for instances of small cells deployments; this will also speed up the administrative flow of documents through local planning.
- Standard deployment procedures for small cells should be developed and established.

With the collaboration/participation of industry groups, service providers, and manufacturers, the national and local authorities can work together to facilitate the deployment and adoption of small cells as part of the mobile networks that respond to the growing demand for wireless data connectivity.

In the end, the deployment of a dense small cell network will provide mobile services to communities, improve the quality of life and safety of its citizens through enabling better coverage and capacity for new applications, while considering aesthetics of the local landscape by blending into the environment due to the small form factor of the small cells.

SMALL CELL FORUM
Solving the HetNet puzzle

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1. Introduction: A vision for 5G

Mobile data demand has been growing rapidly and that growth is likely to accelerate further with the introduction of 5G, which will enable even higher data rates.

The rise in data demand is driven by the introduction of new services, enabled by faster, more reliable mobile connectivity; by the shift of many services and markets, especially in the enterprise, from fixed to mobile-first; and increased usage of existing services such as video streaming and gaming.

All this is driving new levels of mobile data and video consumption. As Ericsson's most recent Mobility Report (among many other forecasts) indicates, the rise in usage of mobile data shows no sign of slowing. According to that report (see Figure 1–1), between 2016 and 2022, smartphone traffic will increase by 10 times and total mobile traffic for all devices by eight times, with video accounting for about three-quarters of the 2022 total of almost 70 Exabytes per month.

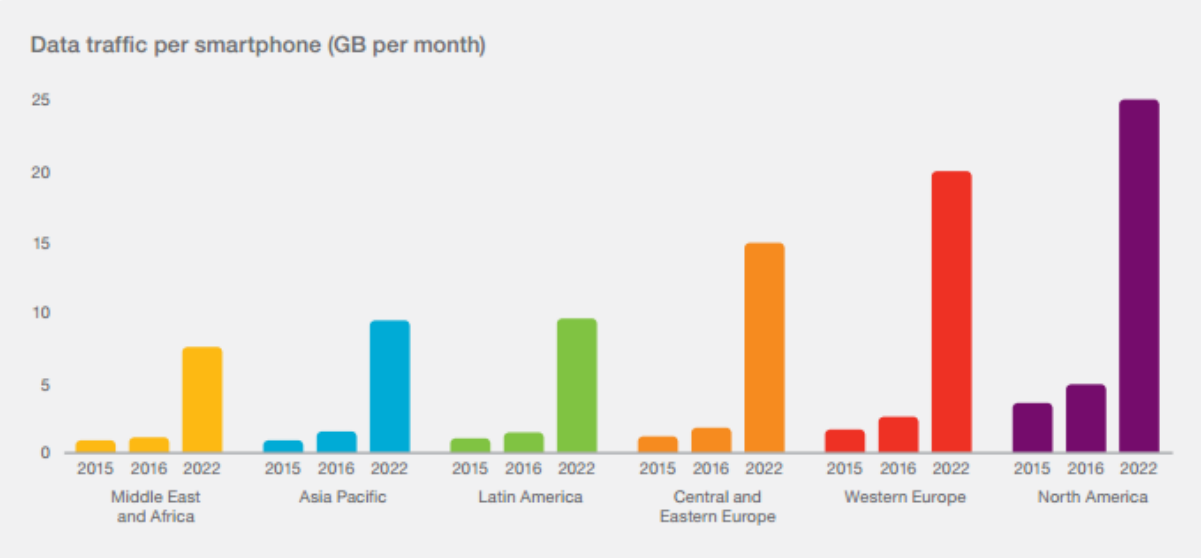

Figure 1–1 Rising in data traffic per smartphone to 2022, by region

Source: Ericsson

That data growth will be combined with increased use of other mobile services with very different traffic patterns and demands on the network. For instance, some Internet of Things (IoT) applications will require low latency and complete ubiquity.

The need for high capacity, especially in targeted areas, combined with ubiquitous coverage, low latency, predictable throughput, and support for very large numbers of devices, will all drive mobile deployments towards very high levels of cell densification (>200 cells per square km for hyper-dense deployments [SCF170] [1]).

Densification is not just about capacity. Because of the close proximity of the cells to the user and one another, it also supports ubiquitous coverage, as well as low latency, high throughput, predictable quality of service (QoE) and large user numbers.

In principle, then, small cell HetNets offer a solution to many looming 4G and 5G deployment issues. But the huge numbers of small cells needed will require significant

enhancements to the planning, building, and operating processes of many operators [SCF190] [2].

The key changes required are:

- enhancement of initial set-up/provisioning procedures
- new and innovative methods of cost effective site selection and site approval, including more focus on site-sharing
- developments in base station design to ease equipment and deployment approvals. For instance, designing base stations that fit into local sites unobtrusively, simplified site solutions, and further development of plug & play base stations and self-organizing networks (SON).
- Changes to municipal and telecoms regulatory frameworks to allow for repeatable, standardized and streamlined small cell approval.

Key enablers:

As well as process changes, there will be several technical and spectrum developments which will help enable dense networks.

In order to meet the increased requirement for bandwidth and higher user density new spectrum resources are needed. In many cases densification will be enabled by new radio technologies which can harness increasingly high frequency bands (2.5 GHz, 3.5 GHz and 5 GHz today, millimeter wave and centimeter wave in future – see Figure 1–2).

5G must seamlessly handle a broad range of spectrum (600 MHz– 80 GHz) in order to gain the maximum benefit from newly-available resources, and even in LTE, there is increasing support for carrier aggregation over as many as five bands; 256QAM modulation; 4x4 MIMO and beyond; and supplemental downlink (e.g. for LTE 'licensed assisted access' small cells in the 5 GHz band, with a licensed-band macro as an anchor).

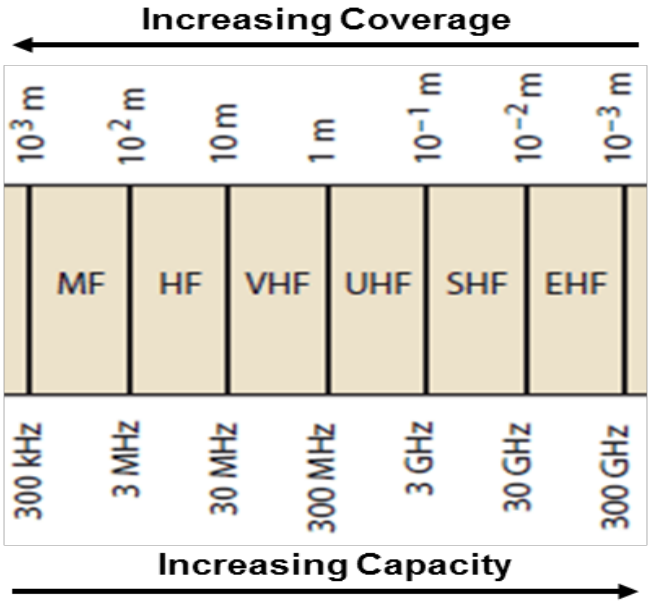

Figure 1–2 The 5G dense HetNet must embrace a wide range of spectrum bands to achieve the best balance of coverage and capacity

This combination of technologies can greatly enhance the capacity and performance of a small cell network.

Spectrum sharing amongst operators can also be used to make use of additional spectral resources and may reduce the overall number of base stations needed by one operator.

Multiple RAN technologies will be an operator reality – 5G must stitch them together with no customer impact and offer seamless inter-RAT mobility in a true HetNet fashion.

5G networks will not be based on one specific radio-access technology. Rather, 5G is a portfolio of orchestrated access and connectivity solutions addressing the demands and requirements of mobile communication beyond 2020.

All this feeds into Small Cell Forum's vision of the dense HetNet – a 'multi-x environment – multi-technology, multi-domain, multi-spectrum, multi-operator and multi-vendor. It must be able to automate the reconfiguration of its operation to deliver assured service quality across the entire network, and flexible enough to accommodate changing user needs, business goals and subscriber behaviors.'

Many of the building blocks are already emerging in the commercial 4G market, but with a clear path to 5G.

1.2 5G – it's all about the experience

The 5G HetNet should not just be about yet-higher peak rates and new services, but about making the overall customer experience smoother and more predictable, increasing user satisfaction levels while keeping the network scalable and cost effective.

Quality of experience (QoE) is the factor which drives nearly all a mobile operator's most important performance KPIs. It is more important than pricing in driving churn or levels of service uptake, and the higher value the subscriber, the more this is true.

Voice is a good example. Voice is a declining source of revenue for mobile operators, but over 90% of them believe that cellular voice will remain significant to the business model until 2020 and beyond. Voice services like VoLTE and VoWiFi require very high levels of QoS to deliver a superior experience to that of over-the-top alternatives, especially as customers become more dependent on mobile voice - many consumers and businesses no longer have landline telephone service and rely solely on mobile service for voice.

This is an example, then, of a service where good customer experience must be a starting point, not an afterthought, but where the cost must be well controlled.

The definition of good customer experience is changing. The more different types of services the mobile network supports - Internet of Things, critical communications and so on- the more different perceptions there will be of service quality. An operator will have to deliver high speed, unbroken connectivity for the video user at the same time as 100% availability and security for a critical communications agency.

On the user side, perception of QoE will be based on many factors, from customer care to the choice of devices, to pricing, to voice and data quality of service and predictability. The importance of each of those will be subjective. But in an environment where a user is close to a small cell wherever they go, there can be

significant improvements to their quality of experience in terms of higher bandwidth, reduced call drops or video glitches, lower latency – even in areas where large numbers of users are gathered together.

This can, in turn, have an impact on the customer's level of satisfaction, which can affect fundamental operator KPIs such as churn reduction and net promoter score, as well as overall measures like brand reputation. Particularly in developed markets, and among high value users such as businesspeople, QoE is the most important way to reduce churn and increase subscriber spend – 68% will churn if network QoE is poor, according to a study by Nokia.[1]

There will be many ways for the operator to support strong QoE, but a starting point will be a high quality network, with the levels of capacity, coverage and reliability to enable good experiences across a wide range of usage types; and also the flexibility for resources to be allocated where most required, and for the operator to maximize its use of those resources and keep costs under control.

The combination of high QoE and resource flexibility will be achieved through densification, bringing cells close to the user; creating a pool of capacity from a well-balanced combination of different spectrum, cell types and air interfaces; and automating the management of the experience via SON.

1.3 5G – the age of SON and plug & play networks

Automation is critical to the hyperdense small cell networks which will be integral to 5G. It is essential to scale cell numbers up significantly and affordably and keep operating costs low. Self-organizing or self-optimizing network (SON) and plug & play, multivendor interoperability will be central.

Densification will require the automation of many aspects of the delivery process using current and future SON techniques to streamline the configuration, management and optimization of small cells.

The current specifications built into 4G technology are an excellent starting point and SON is evolving rapidly, with unified interfaces to support multivendor systems, including Small Cell Forum's SON-API [SCF083] [3] and many new areas of functionality.

SON will be essential to enable cells to be set up, configured, and optimized with a minimal involvement of time, site disruption, and installation & maintenance personnel.

SON will go hand-in-hand with the emergence of plug & play base stations as enablers of low-cost deployment.

These will be key to achieving scalable, repeatable and cost-effective networks, as will a multivendor, multi-radio access technology (RAT) environment. That will allow operators to select network components from multiple vendors and multiple RATs such as Wi-Fi and LTE, to achieve the optimal balance of cost, capacity and capabilities. We are seeing the emergence of eNB products which are designed upfront to interwork with multiple RATs, and to accommodate drop-in plug & play network components from different vendors, to ensure seamless mobility.

[1] Nokia, 2016 Acquisition and Retention Study, https://pages.nokia.com/rs/677-JYK-041/images/Nokia-AR_Value-added_services_connected_devices_and_bundled_services.pdf

2. How do the new service requirements directly impact deployment issues?

It is clear that 5G deployments will be justified commercially if they support new services, and enhanced QoE for existing services. These new service requirements will drive hyperdensity in many cases, as outlined above, and so will also have a significant impact on how mobile networks are deployed.

Examples of new service requirements which require a new approach to network planning are:

- One of the important new service requirements for 5G small cell networks and HetNets will be enhanced location and context awareness. This can be enabled by cells which are very close to the user and can support a range of location-based services (LBS) such as finding the nearest ATM, connecting with friends, location-based commerce, and other similar services. LBS can be optimized by proper cell siting.
- The new 5G service requirements will also include heavily data-dependent services such as video conferencing, gaming, video streaming, etc. Proper siting close to where the consumption of data is taking place will be a key enabler to delivering maximum throughput to customers for these data-heavy scenarios as well as securing appropriate capacity.

In 5G, these concepts will evolve further, and require even more intelligence and connectivity very close to the network edge and the end user. ETSI's Mobile Edge Computing (MEC), the Cisco-driven Open Fog Alliance, and the UK 5GIC's Flat Distributed Cloud (FDC) are all examples of emerging architectures which are centered on hyperdensity and on distributing the services and cloud platform to the very edge of the network.

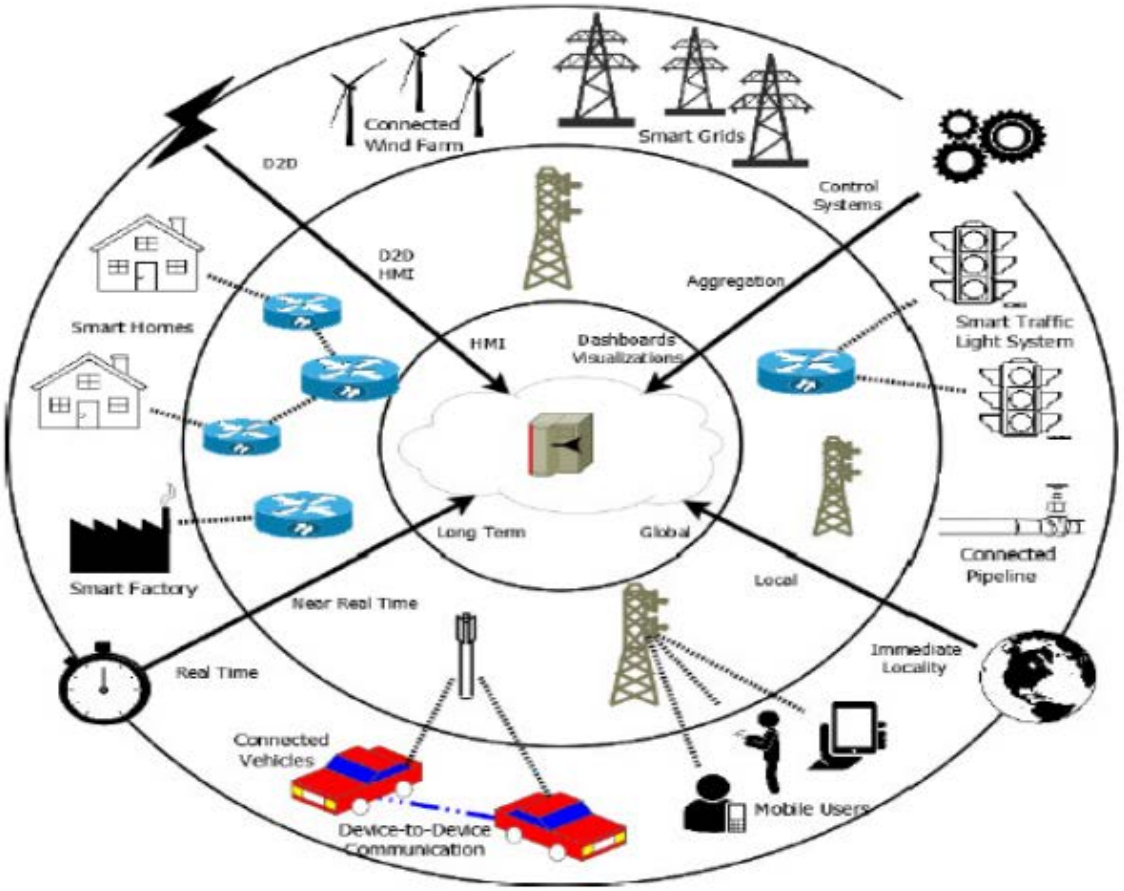

Figure 2–1 Examples of fog / MEC use cases enabled by small cells[2]

These new types of services will drive high capacity requirements and involve the use of all available spectrum, including higher frequencies.

[2] Fog Computing, MEC, cloudlets – which one? 2016 https://www.iaria.org/conferences2016/filesICSNC16/Softnet2016_Tutorial_Fog-MEC-Cloudlets-E.Borcoci-v1.1.pdf

3. Deployment and regulatory considerations and barriers for these dense HetNets

Some of the key objectives of a deployment framework optimized for large numbers of small cells will be:

- Reduced time-to-market for dense networks
- Seamless integration
- Self-healing
- Transport network efficiency
- Energy efficiency/Power requirements
- Aesthetics
- Public safety, to name some of the most important ones.

Barriers to those objectives include the following:

- Precise siting requirements may be required by the large scale of 5G HetNets– outdoor small cell use case. Cell density of the small-cell element drives reduced small cell coverage, which will call for greater precision in cell position near where the services are being consumed
- In some cases, it may be hard to make an attractive in-building business case for enterprise or large tenants.
- Large number of siting approvals will be needed for large-scale deployment of cells in a hyperdense HetNet environment
- Physical cell installation in large scale HetNet deployments can be a barrier due to permits needed, equipment transport and installation, and large numbers of cells requiring setup/ configuration.
- High volumes of individual equipment declarations can be a time-consuming process. Allowing declaration of batches of small cells vs. individual equipment declaration can lead to streamed and optimized processes.
- Lack of generic exemption-based compliance and/or simplified certification procedures for small cells based on specific criteria, applicable nation-wide.
- Existence of a number of local taxes and fees applicable to equipment, its installation and/or operation.
- Rights of way fees can be an important economic success parameter; these fees should be oriented to incentivize small cells deployment among all (existing) urban infrastructure owners.

Planning policies under the responsibility of local public entities can differ largely, depending of the local situations and peculiarities. A generic scope for planning with streamlined processes can assure the scalability required when deploying hyper-dense networks.

Key elements to scaling small cell deployment are streamlined requirements and supportive regulation and rules at national and local level. Given the number of entities that might be involved at the national and local level, the amount of paperwork likely to be required, along with the length a multitude of processes, enacting laws to streamline processes and development of common generic application forms can facilitate reducing the administrative processes and enable faster deployments.

Specific recommendations to enable densely-deployed small cells include:

- Small cell siting should be streamlined where possible to use local infrastructure policies and design guidelines, as small cells are similar to

access points and should not be considered large pieces of network equipment (such as macro cells), and thereby no specific planning permissions should be required to roll out such networks.
- To simplify and provide uniformity of networks, national rules should be established for rights-of-way for the deployment of small cells. This is for both the access to the property as well as the administrative paperwork – whereby the same policies should apply nationally.
- Scaled down administrative processes should be used for instances of small cells deployments; this will also speed up the administrative flow of documents through local planning.
- Standard deployment procedures for small cells should be developed and established.

Table 3–1 summarizes the key challenges for deploying a commercially viable dense network, and suggested solutions.

Challenge	Solution
TCO and cost of capacity	Advanced capacity planning, spectral efficiencies, shared or neutral host networks, automation/SON
Coverage and QoS	Flexible standards and regulations to cover non-traditional cell sites e.g. rural, street furniture, underground car parks
Backhaul and power	Standardized frameworks agreements with fiber or copper owners; mixed toolkit of backhaul and power options
Pre-deployment: site acquisition and equipment approval	Common rules on which equipment classes can be exempt or subject to fast track approval; a batch process for groups of cells; new base station design
Deployment and maintenance processes for large scale	Create simplified common frameworks for access to sites; simplify installation procedures; automate maintenance; site sharing

Table 3–1 Key challenges of dense deployment, and recommended solutions

With the collaboration/participation of industry groups, service providers, and manufacturers, the national and local authorities can work together to facilitate the deployment and adoption of small cells as part of the mobile networks that respond to the growing demand for wireless data connectivity.

4. Siting solutions and approaches

Small cells and HetNets must often be placed in challenging locations in order to extend coverage and capacity to areas such as urban canyons, gathering places such as shopping malls etc. This drives site access requirements for small cells in 5G deployments. Scalable low-cost siting techniques will be needed in order to enable deployment of HetNets, and these will be combined with simplified, scalable deployment and maintenance procedures.

Small cells will require to be sited in more precise locations than macro-cells, resulting in less flexibility in choosing sites and gaining access to them. New siting techniques such as mounting on existing structures (buildings, rooftops, street furniture, etc) will be needed. New base station design and deployment techniques will also be needed to make small cell installation and set-up relatively inexpensive, quickly deployed/installed, and unobtrusive.

Precise siting requirements for hyperdense deployments can be addressed by approaches such as shared sites, use of non-traditional sites (i.e., street furniture, alternative indoor locations), holistic siting approach that includes not only RF engineering, but also transport engineering, civil engineering, construction, utility relations, and municipal relations.

The holistic siting approach may include a well-defined rank of the possible alternatives and venue candidates as well as looking for synergies with the existing infrastructure.

The time and labor involved in gaining a large number of siting approvals may be partially mitigated by advocating regulatory changes towards uniformity in regulatory environment in order to move towards commonality in siting request/approvals. This can also help to overcome overly-burdensome local regulatory restrictions.

Physical cell installation may require establishment of streamlined processes that include advance base station setup/provisioning in order to avoid site disruption and minimize time to perform installation, as well as a lean cell site solution, targeting the right elements and simplicity.

5. Backhaul and fronthaul solutions and approaches

In 5G, the network bottleneck is likely to shift from the radio interface to backhaul/fronthaul.

The more small cells are located close to one another, the more challenging it becomes to backhaul them all cost-effectively, especially if the operator does not have its own dense fiber network.

The heavy backhaul requirements that will accompany hyperdense 5G networks will require network operators to work closely with fiber providers. Rather than deploying fiber backhaul on a site-by-site basis, network operators are likely to increase development of partnerships with fiber providers. Partnerships with other network operators to share the available fiber backhaul resources can result in cost-effective availability of backhaul resources. Also new methods of transport compression should be developed to allow operators to use existing copper based backhaul for 5G when fiber is unavailable or cost-prohibitive.

Cost and availability of fiber (to the cell or to an aggregation point), and the maturity or performance of wireless and copper alternatives, are all cited as concerns by operators, though some emerging solutions such as G.fast are seen as positives by many MNOs.

Licensed microwave and lightly-licensed mmWave line of sight (LOS) point-to-point (PTP) solutions can offer quality, high power, low latency with multi-Gbps to double digit Gbps of capacity. In conjunction with emerging licensed and unlicensed point-to-multipoint (PMP) solutions these will decrease installation times and economics for many small cell deployments.

Unpaired spectrum and TDD technology are also important in the HetNet backhaul toolkit. TDD is spectrum efficient and recently significant improvements have been made with key performance indicators. TDD-LTE could be used as backhaul alternative for small cells in some scenarios.

Other developments will make wireless solutions applicable in a widening range of scenarios. For instance, MIMO and beamforming solutions will help reach capacity targets while being effective in multipath conditions in the sub 6GHz range. Unlicensed spectrum solutions will evolve, though they will require a combination of enhanced interference mitigation and avoidance techniques to maintain and improve certain key performance indicators.

Multi-feature design tools with current high resolution clutter data are critical in overcoming the design challenges for dense small cell networks and the co-existence of access and backhaul technology.

Plug and play (PnP) solutions will reduce manual complicated configurations and lower the risk of misconfiguration. High capacity on the hub is required to support low latency multi-remote requirements. PnP solutions should evolve and scale to meshed and SON networks with improved availability.

In these distributed architectures, which behave more like IT networks, there is a need to extend standardization and define clear procedures for the nodes, and to ensure security functionality. This will ensure a more seamless plug & play solution with greater intelligence and ability to allocate resources flexibly.

The challenges are increased when operators deploy virtualized networks or Cloud-RANs, which may require very high speed, low latency fronthaul connections between the central controller and the sites. In a location like a stadium or enterprise building, a fiber/Ethernet based fronthaul would enable the benefit of cloud RAN (C-RAN) for small cell deployment, leading to better performance achieved by higher coordination among small cells and lower cost of utilizing a shared baseband processing pool.

6. Cost-of-deployment solutions and approaches

The number of small cell base stations in a hyperdense network environment will be cost-prohibitive, in capex and opex terms, if traditional cost structures are not changed dramatically. Key areas where new cost assumptions are essential are summarized in Table 6–1:

Cost challenge	Solution
Upfront base station cost, if thousands are to be deployed	Commoditized WiFi-like designs, multivendor interoperability
Individual approval and deployment	Standardized and streamlined regulatory processes (see section 3)
Site and backhaul costs	New site types e.g. smart lamp posts; bulk site deals; infrastructure sharing between MNOs
Operations and maintenance	Automation including SON

Table 6–1 Cost challenges

Sharing of infrastructure ownership, along with making installation & provisioning both streamlined and standardized should allow for efficient use of available deployment sites as well as fiber backhaul resources.

New approaches will be required to shift the economics and build business model confidence. Some are already emerging into the commercial world, including neutral host and PaaS/NWaaS (platform/network-as-a-service) services. Others are on the horizon, including highly flexible virtualized architectures, which could be the catalyst to mass deployment of multi-operator small cell networks.

Small Cell Forum makes the following recommendations to ease the path to shared small cell networks and so transform the cost base for hyperdense deployments:[3]

- Support development or implementation of technologies which improve the cost:risk equation for MNOs. In particular, radio resource management approaches which allow the host operator to organize capacity to suit its own business model – e.g., to reserve some capacity for itself, to retain first mover advantage; or to enable a large number of tenants in order to maximize revenues especially from non-competitive specialists.
- Refine multi-operator load balancing techniques across large clusters of cells. Contribute actively to the development of virtualization technologies and standards, which will further improve the business case by providing the host operator with high levels of control and multi-tenancy, looking ahead to 5G network slicing. Accelerate trials and deployments of existing solutions to virtualize radio resources, or – where these have been developed for the macro environment – to adapt them for MOCN/MORAN small cell clusters [1].
- Lobby regulators and contribute to trials and debates around new spectrum approaches such as licensed shared access. Spectrum which is dedicated to shared networks may reduce the MNO's conflicts of interest over using its

[3] Small Cell Forum 'Multi-operator Market Drivers' 2016 www.scf.io

own expensive spectrum to host others; and enables new neutral host start-ups.

- Work to improve regulatory environment for neutral host and XaaS specialists, which may create fewer conflicts of interest for MNOs than hosting rivals (or being their tenants).
- Develop templates or blueprints to address complex process and legal aspects of multi-operator deployment and sharing e.g. for identifying optimum sites, legal contracts, service level agreements, integrator or management contracts etc.

7. The importance of SON in small cell deployment

As outlined in Section 1.2, the siting and deployment of hyperdense 5G small cells can be greatly enhanced by leveraging the automation and PnP setup enabled by self-organizing/optimizing networks (SON).

In a recent study (see Figure 7–1), MNOs concluded that automation and SON become entirely critical to the HetNet business case at a density level of about 10 cells per macro/50 cells per square km point, though SON was considered highly desirable beyond three cells per macro/15 per square km.

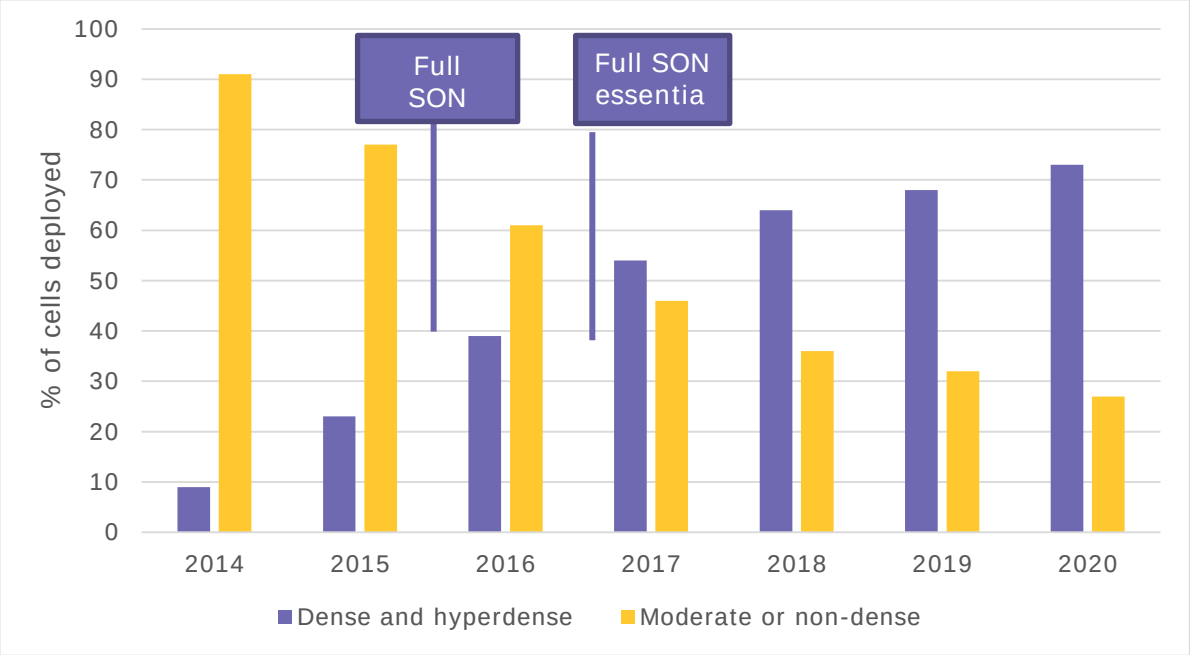

Figure 7–1 When SON becomes essential to HetNet business case

Source: Rethink

For this survey, the following assumptions were made:

Low density small cells	<20 per square km
Medium density	20-75 per square km
Dense	75-200 per square km
Hyperdense	>200 per square km

Use of SON can enable network management automation, network performance automation, improve network robustness and self-healing, as well as enhancing overall network agility. These enhancements can lead to significant reductions in implementation and deployment costs, as well as enabling more efficient siting and installation/setup/configuration. The efficient installation and PnP setup/configuration can significantly reduce capex and the automated management, optimization, and self-healing can significantly reduce operational expenses (opex).

In addition to reduced capex and opex, the self-configuration, optimization, and self-healing offered by SON can lead to a greatly improved customer experience. SON networks can automatically download software updates, manage network traffic, manage interference, and other similar dynamic configuration aspects leading to an improved customer experience as well as lower costs to the operator.

The benefits of SON's self-organizing, self-optimizing, and robust self-healing operations can give network operators the confidence to deploy cells at the massive scale required by 5G hyperdense networks.

More information can be found in the SCF paper 'Role of SON in HetNet Deployment' [SCF173] [4].

8. Specific indoor solutions

Most operators think about hyperdensity in terms of networks or zones which span both outdoor and indoor environments. Increasingly, these will interwork, with indoor small cells providing 'inside-out' coverage extensions for passers-by; and seamless mobility between indoor and outdoor will be important.

In-building coverage is a particularly important business goal of small cells and densification, because it remains poor in many areas, and that has an increasingly significant impact on users and business owners, especially as they move towards mobile-first usage patterns. Although 90% of our time is spent indoors, and about 80% of mobile data is consumed there, indoor connectivity remains the poor relation of mobile networks in many areas.

If operators succeed in delivering a strong quality of experience indoors, especially in high value areas like enterprise premises, they can secure differentiation which can clearly be monetized by increased usage and business value-added services. On the other hand, if they do not take on the challenges of deploying and optimizing an in-building network, they risk being excluded from large parts of the enterprise market because of their inability to guarantee coverage and QoS in the places where most business takes place

To extend densification indoors effectively will require some specialized solutions. Various specific in-building wireless solutions exist, allowing traffic to be offloaded from the macro network once users are inside the building, greatly improving the user experience.

A combination of technologies may be used, including cellular small cells, Wi-Fi access points and distributed antenna system (DAS), and a larger enterprise may even implement a localized mobile core to carry out some activities, like mobile data offload or PBX integration, on-premise. In some high capacity venues (e.g. stadium), the rising demand will drive alternative options beyond the traditional DAS, such as a distributed small cell radio solution, which can leverage resource pooling and coordination.

Siting and deployment issues will often be very different from those outdoors. Some important recommendations will improve the economics and deployability of dense indoor HetNets:

- The indoor solution should follow an IT-type approach to infrastructure where it is possible to take advantage of lower cost of deployment and the broader spectrum of siting alternatives.
- It should expand on future capabilities such as LTE in unlicensed spectrum (LTE-LAA, MulteFire etc) to support new applications and boost capacity at affordable cost.
- The indoor solution should complement nearby outdoor areas so it allows for centralization, pooling and coordination of resources as well as leverage transport.

9. Emerging and 5G options with an impact on deployment and siting

There is still great uncertainty about exactly how 5G technologies and standards will look, and which use cases will prove most important to the mobile business model. Some elements are almost certain however, and these will have further impact on the siting and deployment processes for HetNets.

There are elements of 5G which are already starting to emerge, and which regulators and operators - and industry bodies like Small Cell Forum – need to start considering now, if deployment is to be viable in the early 2020s.

These include:

- Rising use of 5G spectrum above 6 GHz (e.g. 28 GHz, 37 GHz, 60 GHz, 70/80 GHz) for microwave and millimeter wave small cells. This has the potential to deliver anywhere from multi-Gbps to double digit Gbps throughput by utilizing the wide bandwidth of unlicensed/lightly licensed spectrum. However, it will require hyperdense deployment to ensure coverage as the coverage area of a >6GHz cell is small.
- Multi-Gbps backhaul will be needed for some 5G applications of density, but this remains challenging and will need to be addressed by novel wireless or fiber backhaul technologies and topologies.
- Increased use of virtualized and software-defined networking (SDN) technologies in RANs will require new approaches to siting and deployment. When fully centralized and virtualized, small cell siting will be much simpler since a small low-power radio can cover hundreds of meters.
- New operational platforms such as extreme multi-tenancy and network slicing. These will support large numbers of service providers but will rely on large numbers of sites so that resources can be allocated flexibly wherever they are required at a given time. They will also require that many barriers to network sharing and neutral host – technical, commercial and regulatory - are removed.
- Emerging 5G use cases may require unprecedented numbers of cells to assure high capacity, ubiquitous coverage and low latency e.g. for connected car and virtual reality applications.

10. Summary

The introduction of 5G brings exciting new service opportunities to consumers, and brings new challenges to network operators. The rapidly-rising demand for increased data traffic and ubiquitous coverage, along with new functions and services for 5G, are likely to require the deployment of small cells in hyper-dense HetNet environments. New designs (including virtual elements), additional spectrum resources, new regulatory processes, and new & innovative business methods will be needed, as well as innovative new methods to install, setup, and maintain cell sites. This paper summarizes the issues and challenges that will accompany 5G hyper-dense deployments and offers mitigation techniques to enable the challenge to be met.

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