Regulatory Considerations in the 5G Era: The 5GCity Neutral Host Case

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Abstract. The need for densification in 5G networks will necessitate the installation of large amounts of small cells in dense urban environments in order to meet future demands for capacity. The Neutral Host model has been proposed as a potential solution to this problem. This paper discusses the general regulatory considerations of 5G networks and specific considerations that relate to the Neutral Host model as this has been examined as part of the H2020 Project 5GCity.

Keywords: 5G Networks, Network Densification, Neutral Host, Regulation, Spectrum Sharing.

1 5G and the need for densification

5G is the latest generation of mobile networks which will enable faster and more reliable mobile networks as compared to the existing ones. Initial deployments of 5G networks will depend on existing infrastructure and will be based on Non-Standalone (NSA) 5G new radio standards. NSA new radio refers to a 5G network which uses a 4G core and radio anchor with a 5G small cell mobile broadband (MBB) capacity boost, while Standalone (SA) new radio refers to a 5G network which only depends on 5G technology both for its core and radio anchor. NSA standards will enable the enhanced mobile broadband (eMBB) use case family. This type of network is expected to be very popular in the early years of 5G as mobile network operators demand backward network compatibility. Subsequently, the industry will start launching SA 5G networks to support the strictest criteria regarding the technical specifications, such as latency, data rate, capacity, spectrum efficiency and mobility, to support massive machine-type communications (mMTC) and ultra-reliable low-latency communication (URLLC) [1].

5G will not be a revolutionary technology, but rather a fine orchestration of existing technologies, such as Software Defined Networking (SDN) [2], Network Functions Virtualisation (NFV) [3], Mobile Edge Computing (MEC) and Cloud Computing [4]. 5G is also going to use two new frequency bands, namely, 3.6 GHz and 26 GHz [5], which will be essential to achieve the advanced specifications it promises. Achieving

the specifications in these bands will only be possible with network densification by deploying a large number of small cells. This is due to the shorter transmission range that higher frequencies can achieve. Network densification will be particularly necessary in dense urban environments where the demand for capacity will be higher. Demand for more small cell antennas, however, outpaces the supply of available sites in many cities. This creates an imbalance in the market, which could potentially drive up rental fees for those sites to the benefit of their owners. In such cases, the development of parallel small cells networks by operators will be prohibitively expensive and potentially not feasible.

An alternative to building parallel networks will be the Neutral Host (NH) model [5], whereby a single entity, the NH, deploys and operates the network (through self-operation or outsourcing) and then provides wholesale access to those interested in providing their services. The hosting aspect refers to an entity that provides a certain set of resources that are made available to clients, such as Mobile Network Operators (MNO)s, allowing them to provide uninterrupted services to their clients at the expense of reduced flexibility and complex billing relationships. The "neutrality" aspect refers to the host acting as a shared platform to multiple hosted clients. Neutrality in this context does not imply strict equality between hosted clients, as the resources offered to each client are subject to the commercial agreement between the NH and the client, and policy-based management may be applied. From a hosted client's point of view, the system behaviour and services using the resources of a NH should be available without user intervention and, ideally, they should be seamless and identical to those provided by their hosted clients' dedicated resources.

Towards this direction, 5GCity [7] architecture employs distributed cloud technologies to build its combined edge and network infrastructure, providing a multi-tenant, cost-effective platform for deploying virtualized, heterogeneous services. The 5GCity architecture allows the exploitation of the NH model, employing features of the different layers:

- Application Layer: offers the tools and functions available for the infrastructure operators, customers, subcontractors, and third-party actors
- Orchestration and Control Layer: allows management of a non-homogeneous set of physical resources, abstraction of physical resources, operation of horizontal slicing to provide coherence cast end-to end services tailored to a multi-tenant framework
- Access Layer: the Neutral Host model requires network information on how to deal with the access layer (end-user devices - physical resources providing connectivity); in the Service Level Agreement (SLA) between the NH and the operator it is necessary to define how the network deals with the end-to-end chain from Radio elements and Fronthaul network to the end user devices in order to control for the availability and quality of the service.

5GCity will offer an infrastructure dashboard providing operators and verticals the ability to create slices according to their needs. 5GCity goes one step further by providing

a Software Development Kit (SDK) that allows developers to create network functions and services, and service providers to combine pre-existing functions in order to develop new services.

Moreover, both infrastructure and services dashboards will also provide advanced functionalities, such as billing, offering increased flexibility to mobile operators and other interested parties and motivating them to adopt the NH model.

2 Regulatory considerations in the 5G era

Past regulatory practice was generally based on the requirements of physically larger high-power macrocells. This approach will likely not be appropriate in the case of networks with smaller cells, such as the NH model. Enabling the deployment of small cell networks requires streamlined federal, state and local permitting, rights-of-way, application submission timelines, application fees, application review timelines and appeals processes to make it economically feasible for operators to deploy 5G across communities. Some of the issues that need to be addressed by regulatory authorities to facilitate the smooth transition to 5G networks are as follow.

2.1 Network equipment certification and permits

To enable the deployment of a large number of new antennas, a simplified and easily-replicable certification process could be considered. For instance, the height of the installed antenna and the Effective Isotropic Radiation Power (EIRP) metric are already being used in many countries as criteria for certification exemption or process simplification. The enforcement of the simplification should be done at a national level, though specific local considerations should be taken into account. This would allow for a flexible regulatory agenda which also respects local laws, given that the latter do not impede the development of new networks.

Indicative examples of metrics used as thresholds for the need for declaration or installation permission are:

• Antenna height: Canada (15m), Germany (10m), the Netherlands (5m), France (12m), United Kingdom (4m/15m)
• Power level: Chile (low power), France (up to 5W simple declaration is needed), Japan (low power type approved, 20mW), Malaysia (EIRP of 2W), Germany (10W)
• A combination of height and power: United States
• Regional-based simplified procedures: Spain

Before overhauling the certification and permitting procedures, considerations such as street furniture aesthetics should also be taken into account. In particular it could be

examined if the installation of multiple small cells can be facilitated at once, taking into account their relatively small size and visual impact.

Some additional recommendations made by the Small Cells Forum [8] and GSMA [9] in order to accelerate the deployment of small cell networks are as follow:
1. Use of generic permits or exemptions based on internationally standardized equipment classes (e.g. IEC 62232 Ed.2.0 installation classes).
2. Harmonization of the rules and administrative processes for planning permissions across different authority domains in accordance with the Digital Single Market (DSM) strategy [10] for Europe.
3. Simplified administrative processes for small cell deployments through use 'one stop shop' application procedures, reducing the decision-making time and paperwork.
4. Proving tacit approval if local authorities do not oppose an authorization request within a certain number of days or weeks.
5. Maintaining a database of qualified candidate site locations to speed-up site identification and further simplify processing of applications.
6. Incentivizing small cell deployments through revision or full exemptions of base station taxes and recurring fees originally devised for macro base stations.

In the United States (US), according to Federal Communications Commission (FCC) rules, small cells can be exempt from environmental assessment in case they meet certain size and visibility criteria. In addition, the FCC has set time limits for the authorities to decide on permit applications in case of collocation (90 days) and new installations (150 days). The United Kingdom (UK), in a radical move for European standards, has removed all restrictions for placing small cell antennas on commercial buildings/structures to support mobile network rollout. This has simplified network investment considerations for the MNOs which now can expand their 4G mobile networks and better prepare for 5G.

During the site identification phase, a site owner might be reluctant to provide access to all interested parties that want to install equipment and instead sign an exclusive agreement with only one of the operators. Such anticompetitive practices should also be taken care of by regulatory authorities to ensure a level playing field for all players.

The relevant public authorities should, therefore, work closely together with a view to simplify administrative procedures, reduce delays and lower the cost for operators, while protecting public interests.

2.2 Site availability

Regulating access to existing sites raises significant challenges for National Regulatory Authorities (NRAs), both in dense urban areas where the site availability is limited and some site owners might have significant negotiating power over the contract terms, as well as in rural areas where it is uneconomic to develop parallel networks. An alternative solution to alleviate some of the regulatory challenges is to increase the number of

available sites for network installation. To achieve that, the NRA must collaborate with local municipalities or the relevant state authority to reconsider planning rules which should accommodate the small size and radiation impact of small cell antennas in both indoor and outdoor environments. What is more, the public authorities should enable the cost-effective access to street furniture elements, such as lamp posts and masts, to ensure that the supply of sites suitable for antenna installations is enough to counter any market cornering or market power concentration incidents.

2.3 Electrical power

One of the biggest challenges that the industry is likely to face with 5G installations is the need for electrical power on each cell site. To tackle this problem, the authorities could facilitate the deployment of small cells near sites with electrical power like bus stops, street-lamps or ducts. To address this potential problem, operators are investigating off-grid network deployments including power over Ethernet, the construction of power generators or the use of renewable sources, suitable for installations in remote areas. In some countries, such as Luxembourg, on top of the above-mentioned problems, 5G stakeholders have highlighted that the necessity to deploy an electricity meter for each small cell antenna would increase both the complexity and deployment costs considering the number of small cells needed to be installed.

2.4 Access to public furniture and fiber networks

Depending on the use case that 5G networks need to support, this might include installing a large number of macrocells, small cells or line-of-sight connections. The need to deploy more antennas and new network equipment will be accompanied by issues associated with gaining access to sites, public and private infrastructure as well as with backhauling. These issues should be addressed from an early stage, during the network planning phase, to avoid impeding 5G network deployments.

Very high on the 5G ecosystem stakeholders' agenda are issues related to locating new available installation sites and agreeing on the contract terms with landlords, which apparently is a very lengthy and cumbersome process. Thus, easy access to public buildings, street furniture and street-lamps can significantly accelerate the deployment of 5G networks and especially small cells networks. Access to passive infrastructure, however, such as ducts and masts will also be required.

Addressing the need for backhauling will also be important. Although an alternative solution with microwaves has been suggested, this technology depends on weather conditions, as it can be impacted by heavy rainfall. Thus, access to fibre, depending on availability, will be necessary to address the need for backhauling. Hence, fibre sharing will need to be facilitated and regulated in order to accelerate 5G deployment.

2.5 Spectrum

Timely availability and price of spectrum will be critical factors for the deployment of 5G. Hence, it is essential to set up a roadmap for the grant of spectrum as early as possible and to investigate solutions beneficial for both the regulator and interested spectrum buyers. A 'spectrum fee holiday', that is to provide free access to spectrum for a predefined period provided that spectrum owners allocates pre-defined capital resources in 5G, could be among the potential regulatory considerations to lower the cost burden for operators. For instance, Italy auctioned 5G spectrum frequencies in October 2018, raising an astounding 6.5 billion euro, over a 14-days long bidding process, raising concerns regarding the operators' capacity to further invest in infrastructure over the coming years. Taking Italy as counter-example, the French regulator, ARCEP (Autorité de régulation des communications électroniques et des Postes), committed to working out a way to keep spectrum prices low, to encourage healthy competition and the much-needed investments in next generation infrastructure.

Another consideration related to spectrum, has to do with the active sharing of a future small cells network, whereby regulation permitting, or even obliging, spectrum sharing between the network operators and small cell operators, should be in place. This would allow the more efficient usage of spectrum, one of the main regulatory concerns as we move to 5G. Here, the use of a Licensed Shared Access (LSA) agreement could be in place, whereby the spectrum owner (mobile network operator) allows the small cell operator to use their spectrum in areas where it is unused by the MNO. Another alternative is for the small cell networks to use unlicensed spectrum though this solution runs the risk of causing interference with other equipment which could impair the small cell network's ability to deliver the specifications of a 5G network, such as low latency and high reliability.

Spectrum licensing for private indoor 5G networks that will be deployed in the future should also be considered. Regulators need to ensure that the spectrum bands used for private 5G networks should ideally be compatible across all European Union (EU) member states. Apart from the spectrum bands used, the way of licensing spectrum for private networks should also be considered. Spectrum sharing on an unprotected basis, raises concerns regarding the reliability of using such spectrum given the potential interference from existing users of unlicensed spectrum. Hence, there appears to be a need for private 5G networks to use spectrum bands that are distinct from existing uses of shared spectrum. However, given the potential limited interference that indoor private networks could have to outdoor spectrum users, there could be considerations to licence private networks as secondary spectrum users. This would ensure that the spectrum is shared on a non-interfering basis with network operators being the primary spectrum users. More specifically, the propagation characteristics of millimeter Wave (mmWave) bands limit any potential for interference while beamforming and massive MIMO techniques could also assist in reducing interference with other users.

2.6 Radiation

Organisations like the World Health Organisation (WHO) have issued recommendations and suggested limits for the allowed radio frequency exposure [11] that are also endorsed by the EU and other national governments. To meet the advanced specifications that 5G networks promise, a large number of small cell antennas and the use of intelligent beaming techniques, such as beamforming and massive Multiple Input Multiple Output (MIMO), might result in higher power levels when and where needed and lower levels once the needs are reduced. Hence, the 5G ecosystem stakeholders have raised concerns whether the existing radiation limit will still be relevant when 5G networks are introduced. Therefore, the new technology could trigger an adaptation of the existing regulatory framework, while respecting health-related laws and mandates.

3 Spectrum Auction in Italy and the NH Model

5G development can benefit from synergies among pioneer bands in frequencies:

1. Coverage-oriented band: 2x30 MHz Frequency Division Duplex (FDD) and up to 20 MHz SDL in the 694-790 MHz band
2. Intermediate band: 400 MHz Time Division Duplex (TDD) in the 3.6-3.8 GHz band
3. Capacity-oriented band: 1 GHz TDD in the 26.5-27.5 GHz band

Italy was the first country in Europe to auction spectrum in all three frequency bands concurrently, a process which took place in September 2018. All mobile operators participated in the 5G spectrum auction where a simultaneous multi-band award procedure was running. All spectrum assignments for all the bands were part of a single award procedure, which was divided in two phases. Firstly, the 700 MHz band was awarded and subsequently the remaining lots on the other bands were auctioned. The licence duration was set in a way that it offers enough time for the operators to recoup their investments in 5G networks within a reasonable timeframe. The expiry date of the allocated licenses is 31st December 2037 for all the assigned lots.

The financial exposure taken on in the Italian auction was huge, and all telcos will be impacted in the medium term as it happened in other countries after the 3G bands were auctioned in the early 2000s. This could affect the creation of a 5G ecosystem for the different actors because of the high price the operators had to pay, which squeezed their cash reserves. Operators have to explore new opportunities based on different use cases and business models in mission critical services, in massive IoT or in other verticals like Media and Energy. Possible synergies must be explored to cooperate with regulators and policymakers to deploy 5G in a more economically-efficient way.

A reliable 5G infrastructure is fundamental to offer the benefits enabled by the new technologies for different contexts.

Telcos have to follow not only the auction obligations but also to implement a new strategy for smart deployments, such as the one described in 5GCity by:

- sharing small cells networks
- prioritizing site construction according to the business models
- using more information coming from the business analysis of the customers
- creating smart partnerships to capture the economic benefits of the 5G technology.

4 Neutral Host-specific regulatory considerations

Regulating the NH model is a complex task given the various facets that need to be considered. Few considerations that NRAs should take into account are as follow:

4.1 Ensure neutrality

The NH should be obliged to provide wholesale access to all interested parties, e.g. network operators or other service providers, on a non-discriminatory basis. In other words, no operator or other party should be refused access to the NH's infrastructure, subject to regulatory approval. Neutrality doesn't necessarily mean providing the same level of service to everyone, since different bundles of services could be available to the hosted clients, but rather to provide the same level of service to those who have subscribed to the same service bundle.

4.2 No retail services

The NH should be prohibited from offering retail services that would put them in direct competition with existing MNOs, as this would defeat the purpose of the NH's very existence. Allowing a NH to exist in dense urban areas or rural areas where it is uneconomic to build individual networks ensures that MNOs have access to the NH's resources which complement their network to ensure improved coverage and service delivery. Direct competition between the two would turn operators away from trying to do business with the NH, making its existence not viable.

4.3 Price regulation

The wholesale access prices offered by the NH should be regulated to ensure transparency, reasonableness and equal treatment of all parties. The NH's significant market power in its niche market could give it the ability to charge extraordinary prices to provide wholesale access to other interested parties, squeezing their profit margins and creating distortions in the market. Hence, a transparent rate card with 'reasonable' prices for the different levels of service should be in place. Several pricing schemes could also be investigating, such as the 'pay as you grow', 'pay as you use' or one with a flat annual fee.

4.4 Spectrum ownership

Spectrum used by the NH should also be carefully regulated. Here, what needs to be clarified is who is going to be the spectrum owner in the case a NH exists. We have identified four alternative scenarios that vary in the form of the relationship between the operator and NH.

The operator owns the spectrum. The operator acquires a spectrum license from the NRA, while the NH has zero spectrum holdings. Should the operator decide to use the NH's network, the latter uses the frequency bands acquired by the former. In this scenario, the NH minimizes its expenses and avoids participating in the complex task of spectrum management.

The NH owns the spectrum. The NH acquires a local spectrum license on its own. This scenario gives the NH significant market power which needs to be regulated so that it offers competitive prices.

Both the operators and the NH own spectrum. In this case the operator will use its spectrum and NH's infrastructure. On the other hand, the NH can provide spectrum to verticals and other interesting parties that do not have their own license or complement operators' spectrum if needed.

A third entity owns the spectrum. In this case, the NH plays the role of the plays the role of the intermediary which increases the complexity since the NH undertakes the spectrum management task. A similar approach can be followed for the infrastructure.

4.5 Stakeholders opinion about NH regulatory considerations

In order to investigate stakeholders' opinion and confirm the initial NH regulatory considerations, 5GCity project conducted a survey through questionnaires during MWC19. Regarding the need for proper regulation of the Neutral Host, 73% of respondents believe that the NH services/products should be regulated. This likely relates to the potential exhaustive pricing and potential preferential treatment of the wholesale customers that the NH would have in case its products/services were not regulated. Should the NH products/services be regulated, this would enabled fair and equal treatment of all actors requesting access, stimulating healthy competition in the market. Concerning billing, the majority of respondents believe that the billing relationship between the NH and operators should be based on the resources used from the latter. Only 13% of respondents believe in a fixed fee relationship. This is likely due to the fact that operators/verticals prefer dynamic billing systems, which are tailored to their changing needs for access. Surprisingly, more respondents believe that the NH should be the spectrum owner, in contrast to the current model in which operators are the sole owners and are subject to strict regulation for its use. This is likely due to expectations that there would be less complexity in the process, should the NH own spectrum.

5 Conclusions

Although Europe, USA and Asia are competing about the leadership in the 5G era, there are still several challenges that should be addressed before the deployment and the commercialization of 5G networks. In this paper, the need for the NH model in this new environment was briefly discusses. The NH model supported by the H2020 5GCity project was then described. Regulatory considerations were investigated and several guidelines that will be useful for network operators to accelerate the deployment of 5G networks and adopt the NH model were provided.

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