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SMALL CELL COST SHARING

(SHORT REPORT)

Ideas for Small Cell Cost Sharing

by NGMN Alliance

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Abstract

There is a long held vision of very high capacity networks using small cells in areas of high demand. With the expected availability of large quantities of mmWave spectrum for 5G, this opportunity in principle becomes even greater. But the economics of small cell deployment have proved very challenging in practice – and this challenge will only increase at mmWave frequencies, where coverage of an individual cell is typically even smaller. Unless the industry can find ways to reduce the per cell building, operation and maintenance costs, the opportunity to build out small cell networks using mmWave spectrum will be severely constrained.

NGMN carried out a study to identify and assess different approaches to improving the economics of small cells through some form of cost sharing between operators (with 5G small cells typically anchored to a 5G or LTE coverage layer). This short public report presents the most important and interesting ideas arising from that study. A fuller report from the NGMN study is also available [1].

Document History

Date	Version	Author	Changes
13/09/2019	V 0.1	Steve Babbage, Vodafone	Initial draft
18/09/2019	V0.2	Steve Babbage, Vodafone	Added text based on suggestions from TELUS to clarify expectations on regulators
21/10/2019	V0.3	Jean-Yves Bernard, Rogers; Steve Babbage, Vodafone	Changes based on comments from Rogers; slight change to some diagrams, and one new reference added
14/11/2019	V1.0	Steve Babbage, Vodafone	Sent for board approval
20/12/2019	V1.1	Steve Babbage, Vodafone	One sentence added in section 2.1 to clarify which architectures are in scope. Also added a relevant reference.

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GLOSSARY

Abbreviation	Meaning
5GC	5G Core
BBU	Baseband Unit
CU	Central Unit (in a split gNodeB architecture)
DU	Distributed Unit (in a split gNodeB architecture)
eNB	Evolved NodeB (which could be a Next Generation eNB, or ng-eNB)
EPC	Enhanced Packet Core
gNB	Next Generation NodeB
MNO	Mobile Network Operator
MOCN	Multi-Operator Core Network
MORAN	Multi-Operator Radio Access Network
NG	Next Generation
NR	New Radio
RRH	Remote Radio Head

Contents

1 INTRODUCTION AND MOTIVATION

1.1 Background

There is a long held vision of very high capacity networks using small cells in areas of high demand. With the expected availability of large quantities of mmWave spectrum for 5G, this opportunity in principle becomes even greater. But the economics of small cell deployment have proved very challenging in practice – and this challenge will only increase at mmWave frequencies, where coverage of an individual cell is typically even smaller. Unless the industry can find ways to reduce the per cell building, operation and maintenance costs, the opportunity to build out small cell networks using mmWave spectrum will be severely constrained.

NGMN carried out a study to identify and assess different approaches to improving the economics of small cells through some form of cost sharing between operators (with 5G small cells typically anchored to a 5G or LTE coverage layer). This short public report presents the most important and interesting ideas arising from that study.

A fuller report from the NGMN study is also available [1].

1.2 Target audience, and the role of the regulator

Many factors will influence the potential and nature of small cell deployment in a particular market. We expect that different cost reduction solutions will work best in different markets, so we do not try to identify a “one size fits all” approach.

We believe that the entities best placed to determine what cost reduction arrangements will work best in a market are the operators in that market. All of the ideas presented in this report are for operators to consider; if two or more operators in a market favour a particular idea, then they may agree to pursue it. Given the economic challenges to small cell deployment that motivate this report (see section 1.1), we encourage regulators to support any initiatives that the operators favour, unless they see something in them that would be significantly damaging to the market. “Support” here will sometimes just mean “approve”, and sometimes mean “facilitate”, depending on the cost reduction arrangement in question.

For the avoidance of doubt: we do not believe that a regulator should impose a particular cost reduction or sharing arrangement against the best advice of the operators.

We note that the European Union is working to reduce other barriers to small cell deployment, in the form of planning permission and permits [2]. Although this is outside the scope of the present report, we applaud this initiative and encourage regulators in other regions to take similar steps.

2 USE CASES

2.1 Deployment architectures

The small cell deployment use cases that we consider in this document are illustrated in Figure 1. Note that the dual connectivity architectures we focus on are those in which the secondary cell is a gNodeB, operating in high frequency 5G spectrum; architectures in which the secondary cell is an LTE eNodeB, such as Option 4 or LTE-only dual connectivity, are out of scope [8].

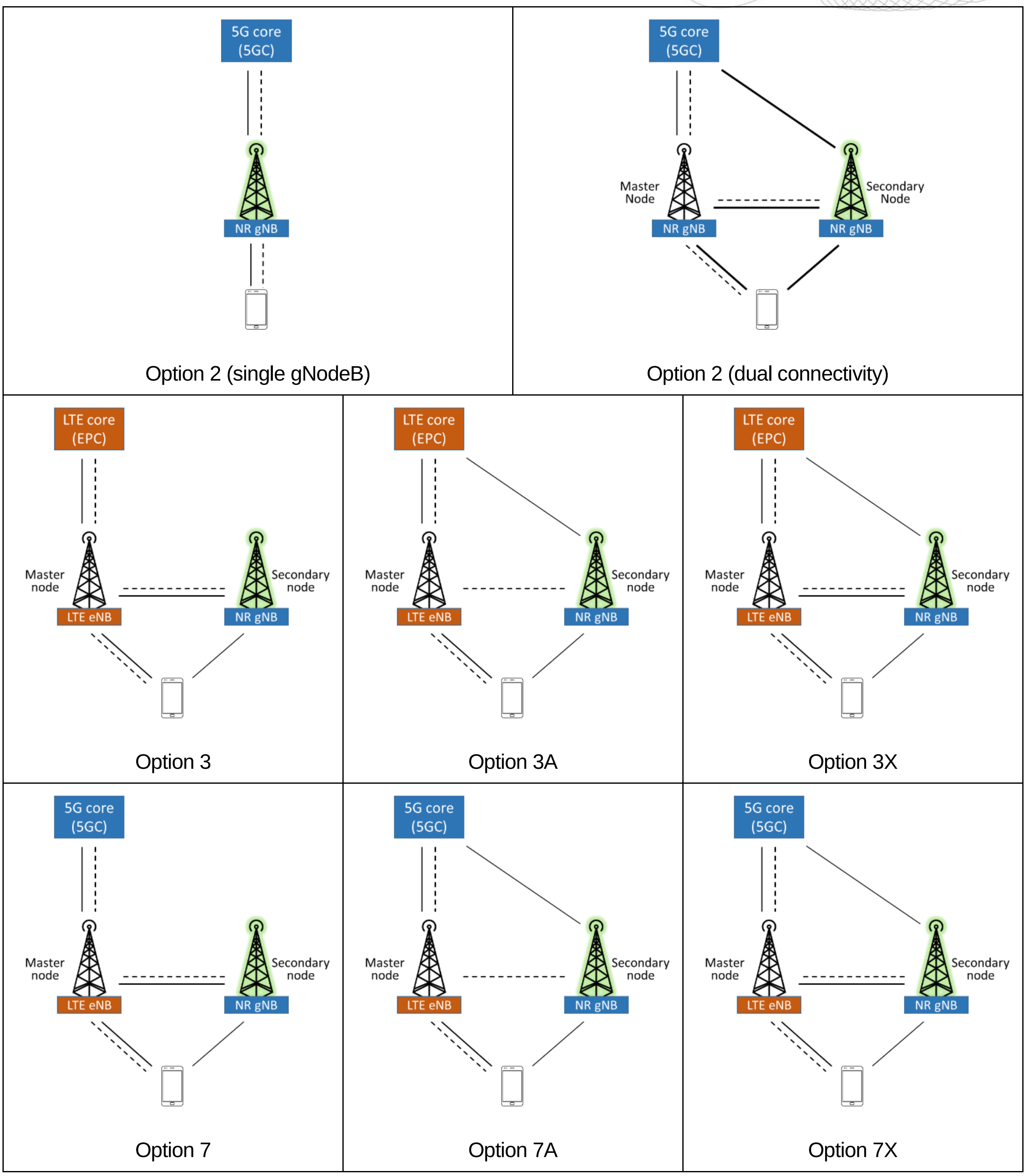


Figure 1: Small cell deployment architectures. (The high frequency small cell is coloured green. User plane traffic is shown by a solid line, and control plane traffic by a dashed line.)

The picture in the top left shows a small cell deployed on its own. This will only work well in a limited set of circumstances, e.g. where mobility is not expected.

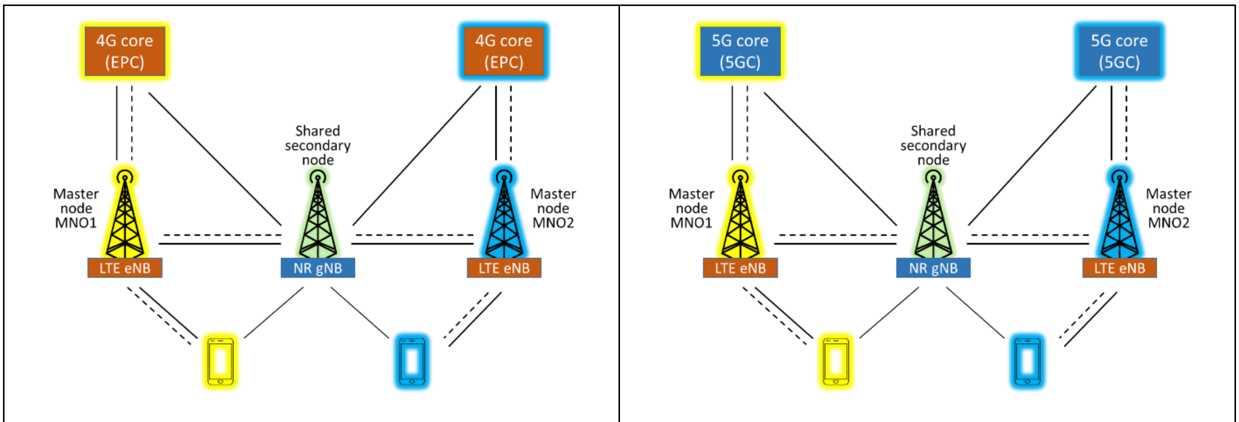
All other pictures show a high frequency (e.g. mmWave) small cell used as a secondary cell in conjunction with a lower frequency "anchor layer" master cell. Typically, most of the user traffic volume will be carried by the small cell, while the master cell will provide coordination and mobility, and fill in the gaps between small cells.

It will be seen that in some architectures the traffic from the small cell is backhauled entirely via the master cell (over the X2 or Xn interface between the two cells), while in others the small cell has its own direct backhaul link. Option 2 (dual connectivity) is shown as a single picture, but in principle the same backhauling options are possible: exclusively via the master cell (like options 3 and 7), or exclusively via a direct connection to the core (like options 3A and 7A), or a combination of both (like options 3X and 7X).

Where there is a master cell and a secondary cell, we would usually expect them to belong to the same mobile operator. But later in this document we will consider approaches where they belong to different operators. A typical (non-roaming) example of this would be as follows:

- the core network and the master cell belong to the customer's home MNO;
- the secondary small cell is run by a different company;
- user plane traffic is backhauled entirely via the master cell, as in options 3 or 7 (so there is no direct interface between secondary cell and core).

Examples of such an approach are illustrated in Figure 2.



Option 3X, secondary node sharing | Option 7X, secondary node sharing

Figure 2: Secondary node shared between two MNOs

Finally, we should note that the split gNodeB architecture may be used, as illustrated in Figure 3.

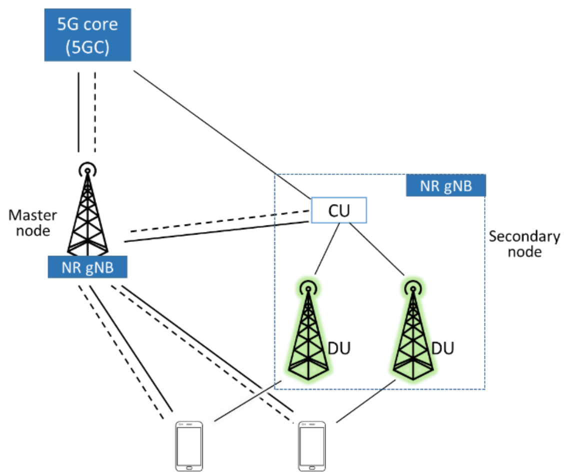


Figure 3: Split gNodeB architecture (CU = Central Unit, DU = Distributed Unit)

3 IDEA #1: A FLEXIBLE AND RESPONSIVE MECHANISM TO AGREE NEW SITE ROLLOUT AND ALLOCATE COSTS

3.1 Background: the "Hong Kong model"

In Hong Kong, indoor small cells carry more than 80% of the overall data traffic in the mobile network due to an extremely high population density living in an ultra-dense city. The four (non-virtual) mobile network operators in Hong Kong have therefore established a sophisticated sharing arrangement to address the high demand of indoor mobile data traffic, with the benefit of cost saving. This includes a flexible mechanism to determine who should build and operate each new site, and how costs should be allocated for that site.

In Hong Kong itself, this is associated with a particular small cell technology solution. While these technical aspects are also important, it is the decision-making and cost allocation mechanism that we focus on here. This decision-making and cost allocation mechanism could be applied to almost any technical flavour of network sharing (indoor or outdoor; whether the shared elements include site facilities only, or also radio components; whether or not spectrum is shared; etc etc).

More details on the Hong Kong arrangement – including technical aspects – can be found in [1].

3.2 The decision-making and cost allocation mechanism

For illustrative purposes, suppose that (as in Hong Kong) four mobile operators take part in this arrangement. Then, in brief:

- Two or more MNOs agree that a new site should be built in a particular location.
- Each MNO submits a bid, and the lowest bid wins; the winner becomes the "lead operator", responsible for building up the shared cell with the subsequent right of operation and maintenance.
- Any other MNOs can then obtain the right-to-use of the shared cell. To do so, they pay the lead operator a proportion of the winning bid. If all four MNOs offer the same access connectivity, then each other MNO pays the lead operator ¼ of the winning bid; the share may be different if some MNOs only use a subset of available technologies (e.g. only 4G, not 5G) or demand a different amount of bandwidth. All of the rules for determining shares are fixed in advance.
- Tenant MNOs also pay the lead operator a monthly maintenance fee (again, pre-determined).

We may illustrate this by an example. Suppose that all four MNOs (A, B, C and D) want to share a cell. MNO A believes that they can build the shared cell for €80K, but bids slightly higher than that – say €90K – to give a margin of error and to make sure that they will be happy if they end up winning. MNOs B, C and D each estimate their build costs to be €100K, so each bid at least €100K; thus MNO A's bid of €90K wins.

If all MNOs share the cell and offer the same service, then each of MNOs B, C and D pays ¼ of €90K, i.e. €22.5K, to MNO A. MNOs B, C and D are all happy to be tenants, because they're now paying €22.5K for a ¼ share of a site that would have cost them at least €100K to build. MNO A is happy to be the lead operator, because they receive €67.5K from the three tenants, and end up with a net cost of only €12.5K. Thus the incentives work for all MNOs.

In the Hong Kong model as described above, the lowest bid becomes the "winning price" in the auction, and determines what other MNOs have to pay to the lead operator. Different auction formats could alternatively be used here – possible alternatives are examined in [1].

Deciding where to build new sites is relatively straightforward. If any MNO would like to see a new site built in a particular location, they can invite the others to join a site share there as described above; if at least one other MNO agrees to share there, then the process described above can go ahead. If no other MNO is interested, the originating MNO can still go ahead and build an unshared cell if they consider it worthwhile.

Network sharing arrangements in operation today often involve some kind of geographical split ("you take the north, we'll take the south"). This is not always economically efficient or responsive to need (e.g. the "north" operator may not build sites where the "south" operator most wants them.) The mechanism described here has the potential to work better in both respects.

4 IDEA #2: MORAN SHARING

Multi-Operator Radio Access Network (MORAN) is a 3GPP-recognised arrangement in which, put simply, operators share the physical radio mast but with each operator in its own distinct set of frequencies. Vendors produce equipment specifically designed to support MORAN sharing. Typically, the baseband unit (BBU), remote radio head (RRH) and antenna(s) are all shared, with the ability to transmit and receive signals for multiple operators simultaneously.

MORAN sharing is already a relatively common arrangement, and including it for consideration in this report is not novel. However, we believe it to be a simple, natural and generally uncontroversial approach, and we recommend that operators consider it.

Backhaul from the shared small cell would typically be a shared connection to an existing, high quality, national or regional fibre network, on which all operators concerned have breakout points to their individual core networks. The connection from the small cell to the fibre network may be fibre all the way, or may include a wireless leg; the considerations for this decision are not significantly different from those affecting an unshared cell, except that the total capacity requirement may be greater.

Regarding the responsibilities, decision making, and financial arrangements, we recommend that operators consider adopting the "Hong Kong model" outlined in the previous section.

5 IDEA #3: SECONDARY NODE MOCN SHARING

5.1 MOCN sharing

Multi-Operator Core Network (MOCN) sharing is another 3GPP-recognised network sharing arrangement. A single cell broadcasts multiple PLMN IDs for the same frequency band, and thus allows customers of multiple operators to use the cell, each thinking that they are using their own network as usual (i.e. each sees their own network's PLMN ID displayed). Traffic for the different operators is separated only in the respective core networks.

Regulators sometimes consider MOCN as providing reduced differentiation between operators, and do not always respond positively to requests for it (see e.g. [3]); some may also be concerned that the sharing of spectrum reduces spectrum auction revenue. Nevertheless, there are several examples of MOCN in operation around the world (see [4] and [5]).

5.2 Secondary node sharing

The particular approach that we recommend operators to consider is based on MOCN sharing, but specifically tailored to the small cell use case. It aims to achieve the greater cost savings of MOCN sharing, while addressing regulator concerns about the reduction in competition that MOCN sharing may bring.

The key element of this approach is to embrace MOCN sharing, but only for high frequency (particularly mmWave) small cells. We noted in section 2 that these small cells will primarily be used in a dual connectivity architecture, as secondary nodes in combination with a low frequency (anchor layer) master node. We therefore recommend **secondary node sharing**: a single small cell, shared between multiple MNOs, working as a secondary node in conjunction with the master nodes of multiple MNOs simultaneously.

This concept is illustrated in Figure 4, Figure 5 and Figure 6. These figures all show a common fibre ring being used for backhaul and inter-node signalling, but of course other bearers may be used. Also, all of these figures show only two operators sharing, but the concept can clearly extend to three or more. Each operator, independently, could be using an Option 2 architecture with dual connectivity, or an Option 3 architecture, or an Option 7 architecture; Figure 4, Figure 5 and Figure 6 show some of the possible combinations, but clearly there are others.

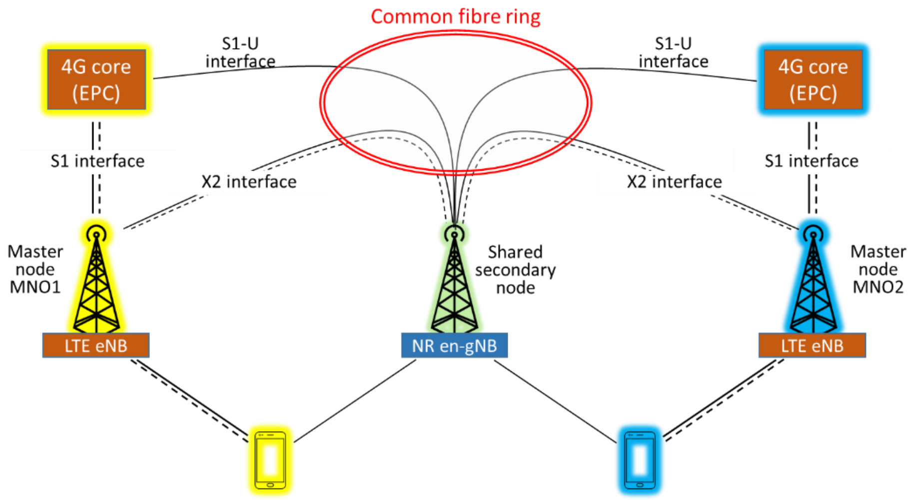


Figure 4: Secondary node sharing (Option 3 for both MNOs)

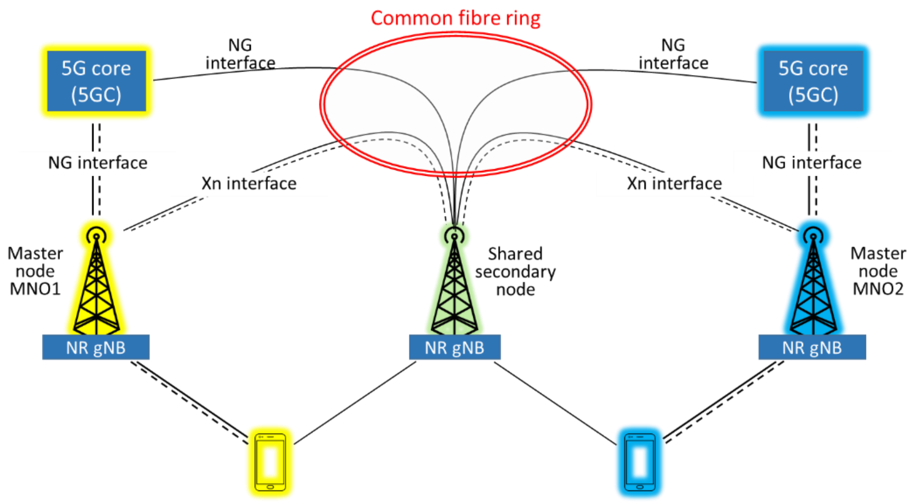


Figure 5: Secondary node sharing (Option 2 with dual connectivity for both MNOs)

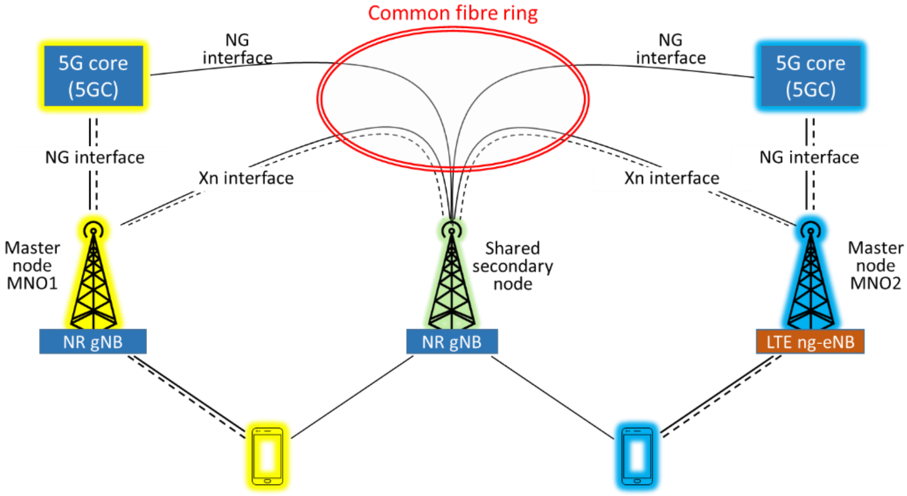


Figure 6: Secondary node sharing (Option 2 with dual connectivity for one MNO, option 7 for another)

Secondary node sharing goes a long way towards addressing the small cell business case challenge that motivates this whole report. It will enable more high capacity small cells to be built, alleviating congestion and improving customer experience. It still allows MNOs to compete on coverage and mobility (and depending on how much spectrum is shared, could also allow MNOs to compete on capacity in particular areas, as explained later in this section).

In terms of how sites are selected, who builds the sites and who brings the spectrum, our recommendation is flexible:

- If individual participating MNOs have licensed spectrum, then the considerations are the same as for regular MOCN sharing (see e.g. [6], section 3.3). We encourage operators to consider the auction-based approach that we outlined in section 3 as a flexible and efficient way to decide who builds which site and how costs are allocated.
- An alternative is for spectrum to be allocated to a neutral host (TowerCo) that builds the sites. This is a more radical approach, and may not be palatable to some operators or regulators. But in a country where the small cell business case looks particularly challenging, it may be the best way to ensure that investment goes towards the small cells themselves rather than, say, to spectrum licence fees. It may therefore be in the best interests of customers.
    - If sites are built by a neutral host, it is still up to individual MNOs to decide which of these sites they want to use. Connecting the MNO's network (its master nodes) to the neutral host's small cell (as secondary node) requires some integration. The MNO may be required to pay a fee to access each small cell site.

It could be that all of the spectrum used in this band to serve participating operators is shared; or it could be that some is shared, while other spectrum is retained by operators for their sole use. We are open to either possibility. In mmWave bands, where very large amounts of spectrum are available, having some spectrum retained for sole use has little disadvantage, and allows some benefits:

- Any MNO whose specific needs are not met by the shared cells can build its own unshared cell with no difficulty and no risk of interference. In particular, an MNO wanting to provide service to an enterprise customer's factory or workplace could do this (whereas other MNOs, who do not have this company as a customer, may have no interest in sharing a cell there).
- This creates greater potential for differentiation between MNOs, which may further help to allay regulator concerns about MOCN sharing.

6 CONCLUDING REMARKS

In this paper we have outlined three ideas:

- one procedural and commercial approach (the auction based mechanism for site decision-making and cost allocation – section 3) based on existing practice in Hong Kong;
- one architectural approach (MORAN sharing – section 4) already in fairly widespread use in sub-6GHz spectrum;
- another architectural approach (secondary node MOCN sharing – section 5) that we believe to be novel.

The auction-based mechanism can be used in conjunction with either of the two architectural approaches.

We would like to reiterate that the entities best placed to determine what cost reduction arrangements will work best in a market are the operators in that market. We encourage regulators to support any initiatives that the operators favour, unless they see something in them that would be significantly damaging to the market; we do not believe that a regulator should impose a particular cost reduction or network sharing arrangement against the best advice of the operators, which could make the telecoms services marketplace less competitive.