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Online, October 10th – 19th, 2022

Agenda item: 6.3.1

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Title: Fallbacks in 38.101 specs

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# 1 Introduction

There was a long discussion about fallback combinations in RAN4#104. It seems it was unclear, which are fallbacks that are needed and if there are some fallbacks that are not needed. This Tdoc describes how to derive fallbacks from higher order combinations and which of them are needed to be specified in the 38.101 specs. It also contains a text proposal for the TR.

# Discussion

## 2.1 General definition of fallbacks

In the 36.101 and 38.101 specs thousands of band combinations for LTE, EN-DC, NR-DC… are specified having at least two carriers, but in most cases many more than two carriers. There are already many rules and definitions for these configurations

Definitions:

* A fallback DC,CA or SUL configuration is a configuration, where one of the carriers of the higher order configuration is removed.
* A mandatory fallback is a fallback that is mandatory to be specified in the UE specification and supported by the UE
* A Fallback Group is specified for contiguous CA, only fallback configurations within the same fallback group need to be supported

Explanations and rules:

* A higher order configuration has generally the same number of fallbacks as it has carriers, i.e. a configuration with 4 carriers has 4 next level fallbacks.
  + Example: CA\_n1A-n2A-n3A-n4A has the 4 next level fallbacks CA\_n2A-n3A-n4A, CA\_n1A-n3A-n4A, CA\_n1A-n2A-n4A, CA\_n1A-n2A-n3A, where the first, the second, the third and the fourth carrier have been removed
* For intra-band CA some of the fallbacks are identical, so that the number of unique fallbacks can be lower than the number of carriers. For contiguous intra-band CA there is only one unique fallback, for non-contiguous intra-band CA as well. For contiguous intra-band configurations removing one of the middle carriers would not result in a valid fallback, since this would transform the contiguous configuration to a non-contiguous configuration. But for the combination of contiguous and non-contiguous intra-band CA there will usually be more than one unique fallback left.
  + Example: CA\_n1(3A) would have three fallbacks, where the first, the second or the third carrier would be removed, but in all three cases the resulting fallback is the same: CA\_n1(2A), so we only have one unique fallback configuration left out of the three
  + Example: CA\_n1D would have three fallbacks, where the first, the second or the third carrier would be removed, but in all three cases the resulting fallback is the same: CA\_n1C, so we only have one unique fallback configuration left out of the three. Additionally removing the middle carrier doesn’t result in a valid fallback, since it would change the contiguous configuration to a non-contiguous one.
  + Example: CA\_n265R12 would have twelve fallbacks, where the first, the second … twelfth carrier would be removed, but in all twelve cases the resulting fallback is the same: CA\_n265R11, so we only have one unique fallback configuration left out of the twelve. Also here removing one of the middle carrier doesn’t result in a valid fallback, since it would change the contiguous configuration to a non-contiguous one.
  + Example: CA\_n1(A-C) would have three fallbacks, where the first, the second or the third carrier would be removed, this would result in CA\_n1C, CA\_n1(2A), CA\_n1(2A) as fallbacks, where the last two are duplicates, so in this case we have two unique fallback configurations left out of the three: CA\_n1C and CA\_n1(2A)
* For intra-band contiguous CA we have to follow the fallback groups. Only fallbacks within this group can be used, BW classes outside the fallback group are no legal fallbacks.
  + Example: CA\_n1D falls back to CA\_n1C
  + Example: CA\_n1C falls back to CA\_n1A, BUT NOT to CA\_n1B, since this is in a different fallback group
  + Example: CA\_n265I (FR2) falls back to CA\_n265H, this falls back to CA\_n265G, this falls back to CA\_n265A, NOT to CA\_n265F
* For combined contiguous and non-contiguous intra-band CA, which is mainly used for FR2, there will be many fallbacks, especially when there is a large number of carriers, but also there some fallbacks after removing a carrier may be duplicates.
  + Example: CA\_n265(A-G-H), removing the “A” carrier results in CA\_n265(G-H), removing one of the “G” carriers results in CA\_n265(A-A-H), which will be correctly written as CA\_n265(2A-H), removing one of the “H” carrier will result in CA\_n265(A-G-G), which will be correctly written as CA\_n265(A-2G), so we get three unique configurations out of these six carriers

## 2.2 Mandatory Fallbacks

In general all fallbacks need to be specified and supported until we end up at a single carrier. So it is necessary to generate a fallback tree starting at the configuration with the highest number of carriers down to a single carrier.

* A configuration has as many fallback levels as the highest order combination has carriers. For example a four carrier combination will have four three carrier fallbacks, each of these has three two carrier fallbacks, each of these would end up in single carriers. However, in this chain there will again be some duplicates.
  + Example: CA\_n1A-n2A-n3A-n4An has these fallbacks:
  + CA\_n2A-n3A-n4A, CA\_n1A-n3A-n4A, CA\_n1A-n2A-n4A, CA\_n1A-n2A-n3A
  + These four combinations have these two carrier fallbacks (colors as above):
  + CA\_n3A-n4A, CA\_n2A-n4A, CA\_n2A-n3A, CA\_n3A-n4A, CA\_n1A-n4A, CA\_n1A-n3A, CA\_n2A-n4A, CA\_n1A-n4A, CA\_n1A-n2A, CA\_n2A-n3A, CA\_n1A-n3A, CA\_n1A-n2A
  + As we see there are several duplicates, removing these we end up with these second level fallbacks:
  + CA\_n3A-n4A, CA\_n2A-n4A, CA\_n2A-n3A, CA\_n1A-n4A, CA\_n1A-n3A, CA\_n1A-n2A
  + All of these end up in 4 single carriers of n1A, n2A, n3A and n4A
* This is a recursive action, we first have to check the next lower level fallbacks, then take these as the basis for the next lower level and so on, until we end up with single carriers.
* All fallbacks for these DC, CA or SUL combinations are mandatory to be supported, as long as the corresponding UL is supported as well.

One relatively simple example of such a combination is DC\_2A\_n261(H-I). But already this simple example generates a fallback tree with 12 fallbacks when going from 8 carriers to a single dual carrier DC combination. This is shown in figure 1:



* Figure 1: Fallback tree for DC\_2A\_n261(H-I)

There are much more complicated CA combinations that will create many more combinations like CA\_n260(2A-2O-Q) and there are many of these combinations. For CA\_n260(2A-2O-Q) figure 2 shows the fallback tree with 46 unique fallback combinations (all duplicates already removed). This combination is already in 38.101, however, most of these fallbacks were initially missing and added later. Figure 3 shows a visualization of what CA\_n260(2A-2O-Q) means.



Figure 2: Fallback tree for CA\_n260(2A-2O-Q)



Figure 3: Visualization of CA combination CA\_n260(2A-2O-Q)

All of these fallbacks have to be specified in 38.101 specs and need to be supported by the UE.

## 2.3 Fallbacks of EN-DC Configurations

In 38.101-3 we find this general rule on fallbacks for EN-DC combinations:

*“A terminal which supports an inter-band EN-DC configuration with a certain UL configuration shall support the all lower order DL configurations of the lower order EN-DC combinations, which have this certain UL configuration and the fallbacks of this UL configuration. ”*

Of course this means that we have to support all fallbacks for which this rule is fulfilled.

This rule is a restriction of the general rule that all fallbacks need to be supported. The reason is that there can be combinations, for which the UL is not supported, of course when there is no UL, also the DL combination doesn’t make sense anymore.

* Assumption: DC\_1A-2A\_n3A is the DL configuration and DC\_1A\_n3A is supported as the UL
  + DC\_1A-2A\_n3A as DL configuration has DC\_1A\_n3A, DC\_2A\_n3A as next level fallbacks
  + The fallback DC\_1A\_n3A has the same UL DC\_1A\_n3A as the higher order combination, therefore this fallback is mandatory to be supported.
  + The fallback DC\_2A\_n3A would need DC\_2A\_n3A as the UL, but only DC\_1A\_n3A is supported for the UL of the higher order combination, therefore this fallback is not mandatory to be supported.

Fallbacks from EN-DC to E-UTRA only or NR only configurations need to be supported as well. For example if we have a configuration DC\_1A-2A-3A\_n4A-n5A of course the constituent LTE combination CA\_1A-2A-3A as well as NR CA\_n4A-n5A need to be specified in 36.101 and 38.101 respectively and it is mandatory to support them, since the EN-DC combination is based on them.

## 2.4 Fallbacks of UL Configurations

Of course fallbacks of UL configurations need to be specified and supported as well.

* All fallbacks of UL configurations with higher order need to be supported down to a single carrier
  + Example: UL CA\_n265M needs these UL fallbacks: CA\_n265L, CA\_n265K, CA\_n265J, CA\_n265I, CA\_n265H, CA\_n265G, n265A
  + Example: UL EN-DC DC\_1A\_n265M needs these UL fallbacks: DC\_1A\_n265L, DC\_1A\_n265K, DC\_1A\_n265J, DC\_1A\_n265I, DC\_1A\_n265H, DC\_1A\_n265G, DC\_1A\_n265A

Generally there is the rule that UL configurations can only have the same, or less carriers that are part of the DL configuration, as an example it is not allowed to have an UL configuration DC\_1A\_n265M for a DL configuration DC\_1A\_n265H.

# 3 Conclusion

In this contribution we describe the rules for fallbacks that are already specified and applied in 3GPP specs 36.101 and 38.101. To share this information we also have the attached text proposal for the TR for the FS\_SimBC study item.

Start of Text proposal for TR 38.846:

# 6 Guidelines of specifying band combinations

## 6.1 General

< Editor's note: This section will collect the new agreements on the rules and guidelines of specifying band combinations. The possible optimization to the band combination will also be discussed in this section.>

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