Comba

Tech Study

Radio Solution Comparison

Radios: 2T4R or 4T4R?

This topic easily becomes divisive. There are many times very fixed opinions about what one must have in the network. This partly stems from spectrum availability, regional preferences, and sometimes practical aspects such as avoidance of intermodulation. This paper takes on to evaluate two configurations that are common in many product portfolios.

We will be studying **2T4R 2 x 60W** vs **4T4R 4 x 40W** in a rural setting using a channel model based on the Rician channel and TDLC300-100 low. The carrier will be 20MHz FDD in B28(700MHz). On the UE side, we will look at both 1T2R and 1T4R devices as it represents the present and the future.

What this simulation answer is under what conditions one should consider the 2T4R and 4T4R when deployed as a single layer in a **rural environment**. What this does not address is multi-layer deployments with the low and mid-band.

METHODOLOGY

SIMULATION OF THROUGHPUT AND RANK INDICATOR OVER THE RSRP RANGE

_ Radio, 2T4R 2x60W vs 4T4R 4x40W
_ UE, 1T2R and 1T4R
_ System: LTE using TM3 (open loop)
_ Carrier BW: 20MHz
_ Band: B28
_ Antenna gain: 15dBi
_ Channel model: Rician channel and TDLC300-100 low

DATA CONSUMPTION MODEL

_ Fully loaded cell
_ Resource model: UEs have time proportional access to RBs
_ No interference
_ User positions-based profiles collected real network cells

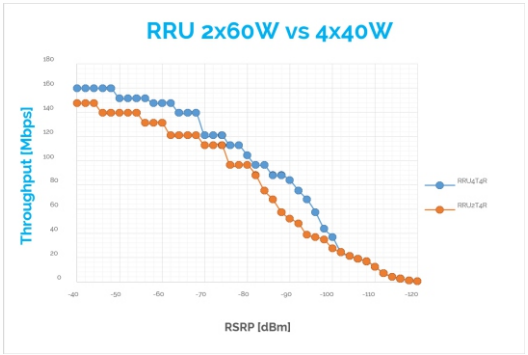
This will give us an idea of how the different combinations perform relative to each other. The results should not be interpreted as absolute cell capacity as network items such as interference are not included. There is one inequality selected in this model. There is a 1.25dBm power difference between the 2x60W 2T4R and the 4x40W 4T4R. This was selected as 2x60W is more readily available in fanless RRU than 2x80W.

SIMULATION RESULTS FROM INDIVIDUAL 1T2R UEs

In this simulation, we look at three metrics to understand the difference.

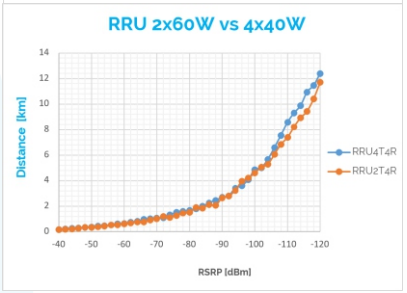
The first is the **maximum throughput** of a UE located at a given RSRP level. As we can see here the 4T4R system has a small edge over the 2T2R system. This comes from two factors:

1) The additional power 160W vs 120W
2) Diversity gains



The second metric we look at is the **rank indicator** which tells the story of when you drop from rank 2 to rank 1 in this case as we are limited to 1T2R UEs in this first set of scenarios. As seen from the graph there is, about 8dB, difference between the two. 1.25dB comes from the power difference and the remaining <7dB is from diversity gains.

The third metric we look at is the propagation model expressed as the maximum distance at which a specific RSRP level can be found outdoors. To convert this to indoors a 15-20dB margin can be taken off.

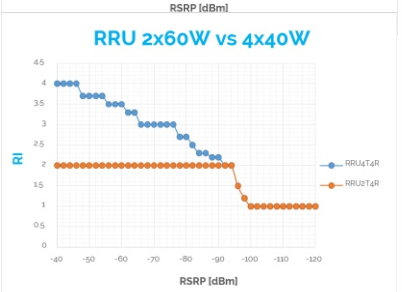


SIMULATION RESULTS FROM INDIVIDUAL 1T4R UEs

In this simulation, we look at three metrics to understand the difference.

Not surprisingly the picture changes dramatically. The MIMO exploration of additional multipath is quite present down to -80dB. This will result in a significant improvement in end-user experience if one is situated in this space between -40dBm and -80dBm RSRP.

The rank indicator share shows this clearly. The 2T4R radio cannot utilize that multipath space effectively as it is limited by only having two TX paths.

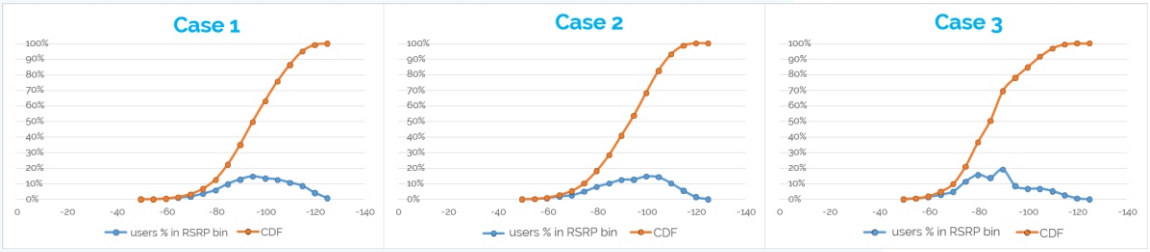


As for the RSRP coverage, nothing changed the RSRP still covers the same.

At this point, it is easy to be led astray with such a visible gain under -80dBm. The issue with graphs like this is that they give a false view of how much is covered rank 2+. The graphs easily exaggerate the area/users covered.

PUTTING SIMULATIONS INTO A REAL CELL CONTEXT

The composition and location of users in a cell vary from place to place. We will take a look at three scenarios based on three cases from real networks.



Each of these plots (blue line) give the likelihood that users are located at a place where RSRP is at a certain level. The orange line is the corresponding cumulative distribution functions for those user distributions. As one can see from real life, as most users are indoors and not outdoors we end up with very few users >-80dBm, ie the area with the 4T4R system with 1T4R had its best gains.

With these distributions, we can go back to throughput vs RSRP and "virtually" load up the network with these users and then get the compound cell throughput at 100% load and an equal split for resources between the fictive users.

First the cumulative throughput for each combination. These numbers are not realistic to achieve on average in a real field. Real field values will be 30-35% less than these as the simulation does not take any inter-cell interference into account and is also able to keep RB load at 100%.
With this in mind, the numbers are still valid as relative numbers to each other.

	2T4R 2x60W			4T4R 4x40W		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
1T2R	44mbps	50mbps	69mbps	56mbps	63mbps	85mbps
1T4R	80mbps	88mbps	112 mbps	89mbps	100mbps	133 mbps

Table 1: cumulative throughput

	2T4R 2x60W			4T4R 4x40W		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
1T2R	x1.0	x1.0	x1.0	x1.3	x1.3	x1.2
1T4R	x1.0	x1.0	x1.0	x1.1	x1.1	x1.2

Table 2: Relative throughput 2T4R vs 4T4R baselines on 2T4R per case and UE tyme

	2T4R 2x60W			4T4R 4x40W		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
1T2R	x1.0	x1.0	x1.0	x1.0	x1.0	x1.0
1T4R	x1.8	x1.8	x1.6	x1.6	x1.6	x1.6

Table 3: Relative throughput 1T2R UE vs 1T4R UE baselined on 1T2R per case and per RU configuration

ENERGY CONSUMPTION

The two systems have different output power and different DFE processing, hence they will also have different energy consumption. The additional energy consumption is about **30-40%** and needs to be added to the increased TCO of the 4T4R system.

	ENERGY CONSUMPTION	
	2T4R 2x60W	4T4R 4x40W
50%	x1.0	x1.3
100%	x1.0	x1.4

The friend of like-for-like comparisons may ask how would a 2x80W compare to a 4x40W. The answer is very similar. There would be a slight advantage for the 2T4R system. Depending on where you think you operate in terms of load the energy consumption could be 10% up over the 2T4R system at the same power level.

	ENERGY CONSUMPTION	
	2T4R 2x80W	4T4R 4x40W
50%	x1.0	x1.1
100%	x1.0	x1.0

CONCLUSION

Should one go 2T4R or 4T4R for low band rural?
Recommendation: (normal coverage deployment)

Short of capacity on site and no other spectrum available:	4T4R@ 4x40W is a better option, uplift with 10% to 30%
Other cases:	2T4R@ 2x60W is less costly to buy and is likely to reduce the energy bill by 30-40%.
Need more capacity?	10-30% uplift is not much compared to the annual traffic growth so one is likely to get more by adding another frequency layer

What if I had a 2x80W 2T4R. How close does it get?

	2T4R 2x60W			4T4R 4x40W			2T4R 2x80W		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
1T2R	x1.0	x1.0	x1.0	x1.3	x1.3	x1.2	x1.07	x1.06	x1.05
1T4R	x1.0	x1.0	x1.0	x1.1	x1.1	x1.2	x1.05	x1.05	x1.03

We can estimate this by shifting the RSRP 1.25dB to reflect 2x80W. As one can see below there would be a 5% gain over 2x60W but energy consumption would go up 20%.

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