



Carrier Aggregation with the Accelerated 6350-SR

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Carrier Aggregation

Spectrum availability is critical for delivering true 4G connectivity over Long-Term Evolution (LTE) networks. Many locations are reliant upon limited allocations of bandwidth, often as small as 10MHz, which restricts the maximum rate of data transfer available to users. This congestion is exacerbated by the exponential growth of mobile devices both in terms of subscriber quantity and the corresponding increase in traffic per subscribed device.

LTE Advanced (LTE-A) introduced Carrier Aggregation (CA) to optimize spectrum utilization. Mobile network operators typically broadcast over fragmented band segments that exist as isolated channels (also called carriers). Thanks to CA technology, these separate carriers can be combined to create additional usable bandwidth, facilitating higher data transmission rates as more spectrum is aggregated.

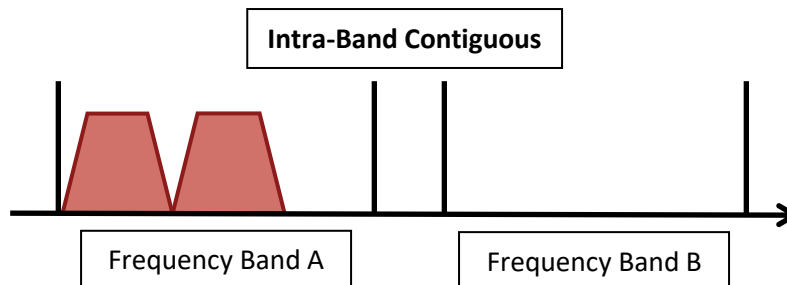
Leveraging CA ensures that mobile networks are operating at maximized efficiency. In addition to providing faster data speeds, lower latency, and broader coverage, operators can dynamically route traffic across an aggregated carrier's constituent channels to implement load balancing without requiring auxiliary service providers. Expanding this technology is a top priority as cellular networks transition from 4G to 5G.

Technical Overview

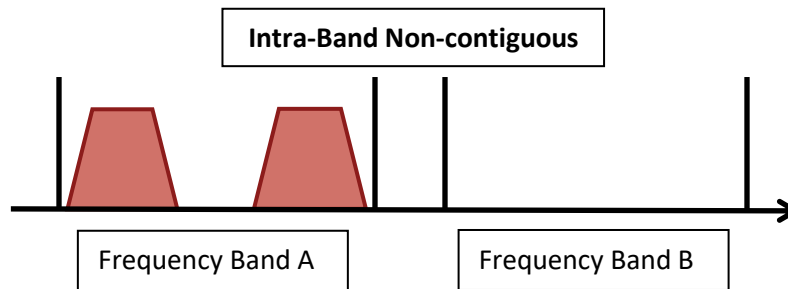
Component carriers (CCs) are the separate channels that band together to deliver CA. Each can have a bandwidth of 1.4, 3, 5, 10, or 20MHz, and LTE-A standards establish a theoretical maximum of 5 CCs, thus raising the upper limit of aggregated bandwidth to 100MHz. Since CA bandwidth is the sum of its combined carriers, this hypothetical threshold assumes all 5 CCs are 20MHz — carriers below 20MHz would detract from the pooled spectrum's peak performance. Furthermore, individual channels can be specifically dedicated to supplement either download (DL) or upload (UL) activity if necessary, though the number of UL carriers cannot exceed the number of DL carriers.

As is the case with LTE itself, CA specified under LTE-A standards supports both FDD and TDD bands over licensed and unlicensed carrier frequencies. CCs are classified based off of their relative location to each other within the wireless spectrum; they can either be intra-band, as in belonging to the same operating band, or they can be inter-band, indicating that the individual CCs come from separate bands. The intra-band delineation can be further divided into contiguous or non-contiguous CCs depending upon whether or not the aggregated carriers are directly adjacent within the same band.

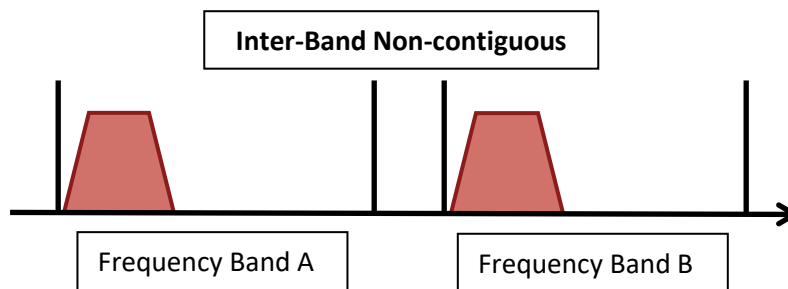
Intra-band contiguous is the simplest CA scenario from a deployment standpoint, needing only a single transceiver to interface with user equipment (UE), however the competitive state of operator frequency allocations (coupled with the inherently segmented nature of the LTE spectrum) minimizes the availability of adjacent carriers. When contiguous CCs are aggregated, network capacity is increased thanks to the availability of their combined bandwidth funneled through a single signal. Intra-band contiguous CA should become more feasible as new spectrum bands become available for cellular use.



Intra-band non-contiguous CA is prevalent in areas where LTE spectrum is distributed across multiple providers. It leverages channels that share a single band but, unlike contiguous approaches, they aren't situated next to each other on the spectrum. Non-contiguous aggregation necessitates additional transceivers for each CC. This method of aggregation currently serves as the most effective means of combining carriers given how commercial telecom markets are predominantly structured around fragmented spectrum holdings.



Inter-band non-contiguous CA incorporates more than a single operating band to aggregate CCs. It requires even more complex transceivers and algorithms sophisticated enough to process multi-carrier traffic while overcoming the associated increase in signal interference. Although accommodating these difficulties comes at a cost, the boost to spectrum utilization provides even more flexibility when implementing CA solutions.



User Impact

Of the potential 5 CCs outlined by 4G specifications, current cellular infrastructure supports 2 channels in the majority of locations. LTE Advanced 3xCarrier Aggregation (3CA) is in its early stages of global deployment, with many wireless service providers rolling out their first wave of 3CA-connected hardware. The list of devices that support 3CA is rather limited, making 2xCarrier Aggregation (2CA) the standard until UE catches up with network capabilities.

Category 6 (Cat 6) devices support 2 CCs allowing for a maximum theoretical data rate of 300Mbps with its 2 x 20MHz CCs. If the CCs are narrower, then the data rate is correspondingly lower. For example, if 10MHz and 20MHz carriers are aggregated, the maximum theoretical data rate is 225Mbps. Even higher bandwidths will be achieved as future generations of wireless UE utilize 3- and 4-band aggregations, which will reach peak data rates of 600Mbps (with 4 carriers).

Conclusion

CA introduces a scalable and more efficient use of spectrum to provide end users high-performance cellular data rates and network capacity in both upload and download speeds.

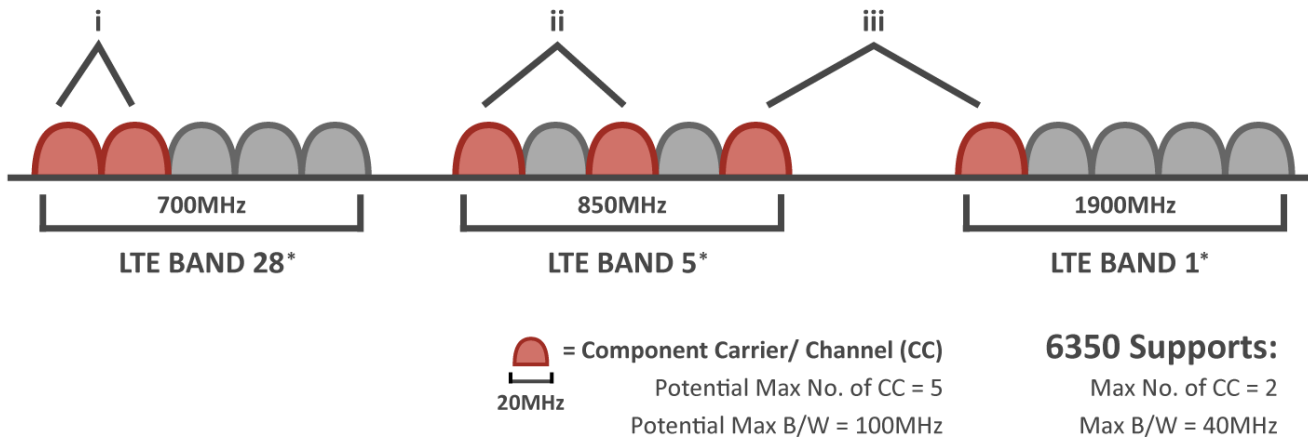
Carrier Aggregation in the Accelerated 6350-SR Family

The Accelerated 6350-SR Family of products is a high-performance router family that implements a Cat 6 module. 6350-SR supports:

- Intra-Band Contiguous CA
- Intra-Band Non-Contiguous CA
- Inter-Band Non-Contiguous CA

6350 Carrier Aggregation

- | | |
|-------------------------|------------------------------|
| 3GPP Release 10 (i) | Intra-Band Contiguous CA |
| 3GPP Release 10 (ii) | Intra-Band Non-Contiguous CA |
| 3GPP Release 11 (iii) | Inter-Band Non-Contiguous CA |

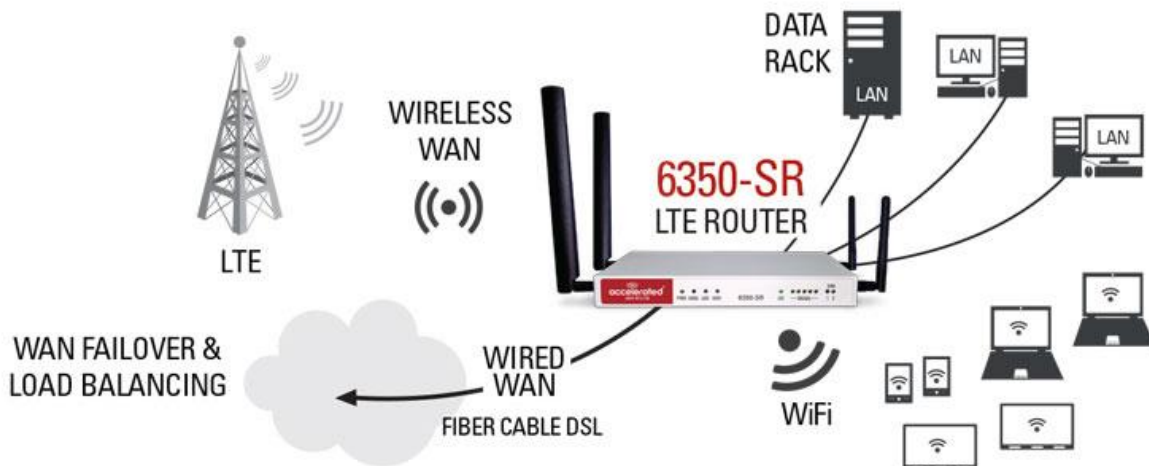


6350 Supports:
 Max No. of CC = 2
 Max B/W = 40MHz

* bands named only as examples; actual bands vary depending on the operator

6350-SR High Performance Cellular Solution

The 6350-SR provides improved business continuity with high-performance LTE and Carrier Aggregation. Accelerate your connectivity solutions and eliminate downtime with the Accelerated 6350-SR LTE Router featuring built-in primary or backup cellular connections. The 6350-SR LTE Router is a compact-yet-affordable, enterprise-grade device that supports multiple WAN connectivity options (Ethernet or cellular) as well as load balancing and failover. The 6350-SR LTE Router comes with a carrier-certified, Cat-6 embedded cellular modem for LTE connectivity and carrier aggregation. For large locations and data-intensive applications, a high-speed LTE Category 6 modem offers the best WWAN connection commercially available.



6350-SR (North America & Europe)

Band Support

Technology	Supported RF Bands														Data Rates/ Notes	
	1	2	3	4	5	7	8	12	13	20	25	26	29	30		41
LTE	F	F	F	F	F	F	F	F	F	F	F	F	F	F	T	Data rates: <ul style="list-style-type: none"> Downlink (Cat 6): FDD: 300 Mbps TDD: 222 Mbps Uplink (Cat 6): FDD: 50 Mbps TDD: 26 Mbps Notes: <ul style="list-style-type: none"> Downlink MIMO Support (2x2; 4x2) TDD: 26 Mbps F=FDD; T=TDD
DC-HSPA+ HSPA+ HSPA UMTS	Y	Y	Y	Y	Y		Y								N/A	Data rates: <ul style="list-style-type: none"> Downlink (Cat 24): Up to 42 Mbps Uplink (Cat 6): Up to 5.76 Mbps Notes: <ul style="list-style-type: none"> Diversity Support
GNSS	<ul style="list-style-type: none"> GPS: 1575.42 MHz GLONASS: 1602 MHz BeiDou: 1561.098 MHz Galileo: 1575.42 MHz 															

6350-SR Family Carrier Aggregation

Carrier Aggregation Combinations
1 + 8
2 + 2/5/12/13/29
3 + 7/20
4 + 4/5/12/13/29
5 + 2/4/30
7 + 3 /7/20
8 + 1
12 + 2 /4/30
13 + 2/4
20 + 3/7
30 + 5/12
41 + 41

USA Telcos' CA Combinations

AT&T Combos

AT&T's CA combinations are as follows. The 6350-SR provides full support.

Format is Band+Band (max spectrum).

- 4+12 (30) - Supported
- 2+12 (30) - Supported
- 4+29 (20/30) - Supported
- 2+29 (20/30) - Supported
- 2+5 (30) - Supported
- 4+5 (20/30) - Supported

Verizon CA Combos

2Band Combo supported today:

- B2+B13
- B2 + B5
- B4 + B5
- B4 + B2 (Not currently supported)

6350-SR for Asia Pacific (APAC)

Band Support

Technology	Supported RF Bands														Data Rates/ Notes	
	1	3	5	6	7	8	9	18	19	21	28	38	39	40		41
LTE	F	F	F		F	F		F	F	F	F	T	T	T	T	Data rates: <ul style="list-style-type: none"> Downlink (Cat 6): FDD: 300 Mbps TDD: 222 Mbps Uplink (Cat 6): FDD: 50 Mbps TDD: 26 Mbps Notes: <ul style="list-style-type: none"> Downlink MIMO Support (2x2; 4x2) TDD: 26 Mbps F=FDD; T=TDD
DC-HSPA+ HSPA+ HSPA UMTS	Y	Y	Y	Y		Y	Y		Y			N/A			Data rates: <ul style="list-style-type: none"> Downlink (Cat 24): Up to 42 Mbps Uplink (Cat 6): Up to 5.76 Mbps Notes: <ul style="list-style-type: none"> Diversity Support 	
TD-SCDMA													Y		Data rates: <ul style="list-style-type: none"> Downlink: Up to 2.8 Mbps Uplink: Up to 2.2 Mbps Spreading rate: <ul style="list-style-type: none"> Downlink: 1.28 Mbps Notes: <ul style="list-style-type: none"> Diversity support 	
GNSS	<ul style="list-style-type: none"> GPS: 1575.42 MHz GLONASS: 1602 MHz BeiDou: 1561.098 MHz Galileo: 1575.42 MHz 															

6350-SR Family Carrier Aggregation

Carrier Aggregation Combinations
1 + 8/18/19/21
3 + 5/7/19/28
5 + 3/7
7 + 3/5/7/28
8 + 1
18 + 1
19 + 1/3/21
21 + 1/19
28 + 3/7
38 + 38
39 + 39
40 + 40
41 + 41

Australia Band Support

Optus

6350-SR		Freq
Bands	UMTS	LTE
1	■	2100
3		1800
7		2600
8	■	900
28		700
40		2300

Telstra

6350-SR		Freq
Bands	UMTS	LTE
1	■	2100
3		1800
5	■	850
7		2600
8		900
28		700

Vodafone

6350-SR		Freq
Bands	UMTS	LTE
1	■	2100
3		1800
5		850
8	■	900