Multi-Carrier ABC vs. Ethernet LAG

In Wireless Backhaul Networks

Abstract

Ethernet Link Aggregation is a widely-implemented method for building high-capacity, highly resilient networks. Ceragon's Multi-Carrier ABC (*Adaptive Bandwidth Control*) is an innovative technology that creates logical bundles of multiple links and optimizes them for wireless backhaul applications. This paper looks at both technologies and compares their support for high-bandwidth applications and service differentiation.

NOTE

Ethernet-over-SDH technologies, such as GFP, VCAT, and LCAS, are out of the scope of this paper. This is due to the reduced efficiency of these solutions (25-30% less capacity than native Ethernet), and because of the rapid, industry-wide migration to all-IP backhaul networks.

The Need for Logical Link Bundling

Logical link bundling technologies, such as Link Aggregation (LAG) and Ceragon's Multi-Carrier ABC, address two major drawbacks of Ethernet networks – weak granularity and lack of resilience.

Weak Granularity. Bandwidth capacity does not scale linearly. Historically, Ethernet bandwidths have increased by an order of magnitude with each new generation: 10 Mbps, 100 Mbps, 1 Gbps, etc. As traffic levels approach bandwidth ceilings, the only option was to upgrade to the next bandwidth step, a potentially cost-prohibitive action. An alternative solution, offered by both Multi-Carrier ABC and LAG, is to combine multiple physical Ethernet links into one logical link via channel bonding, thus widening the pipe at lower cost.

Lack of Resilience. Wireless, point-to-point Ethernet connections, with their multiple points of failure, are potentially unstable. In order to provide protection against network down time, operators employed multiple redundant physical connections – an inefficient solution, due to the lack of awareness between physical links. In addition, higher level protocols, such as TCP/IP, were not designed for seamless failover. Multi-Carrier ABC and LAG, which offer physical-link awareness as well as smooth failover transitions, provide sufficient resilience support.

In addition to meeting the requirements described above, link bundling solutions must also support bandwidth-intensive services by reducing latency and by maintaining QoS standards. This technical brief focuses on these latency and QoS requirements, following an introduction to Multi-Carrier ABC and LAG technologies.

Distributing Traffic across Multiple Wireless Links

In this section, we introduce Link Aggregation and Multi-Carrier ABC, and how they distribute traffic across multiple wireless links, supporting load-balancing and improving network reliability.

Link Aggregation

Link Aggregation (LAG), based on IEEE standard 802.1AX-2008 (formerly known as IEEE 802.3-2005 Clause 43, or as the IEEE 802.3ad Working Group), describes the bundling (or trunking) of multiple Ethernet links into a single logical link, in order to increase capacity and enhance availability.

Link Aggregation allows a MAC client to interact with a bundle (or Link Aggregation Group) as a single, enlarged pipe. When one of the links in the bundle fails, the traffic from the MAC client can be automatically forwarded to another link in the group.

While LAG has proven to be highly efficient in the case of link failovers, it is less effective when responding to congestion states. LAG assumes the *same capacity* on all links, and cannot shift flows dynamically from one link to another.

In addition, LAG's efficiency is reduced when the switching and the transmission mechanisms are housed in separate systems. The switch and its LAG module must be kept aware of the state and the bandwidth availability of each link. If the status information is not constantly synchronized, the switch could continue sending traffic over a degraded or malfunctioning link.

LAG distributes traffic over the bundle on a **Packet-by-Packet** basis (see Figure 1), selecting a link in the Link Aggregation group via a hashing algorithm based on the packet's source or destination MAC address. Some LAG implementations, such as *EtherChannel*, support packet distribution based on IP addresses or on TCP/UDP port numbers.

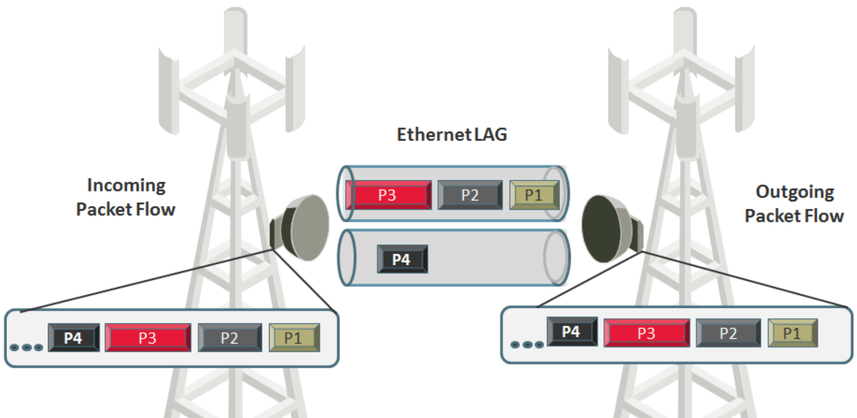

Figure 1: LAG traffic distribution across multiple wireless links

LAG implementations that distribute traffic based on MAC addresses may neutralize the load sharing benefits described above. For example, when connecting two routers (see Figure 2) over a wireless LAG, the LAG distribution function uses the MAC address of the router. In many cases, all the traffic traversing the link may share a common MAC source/destination address.

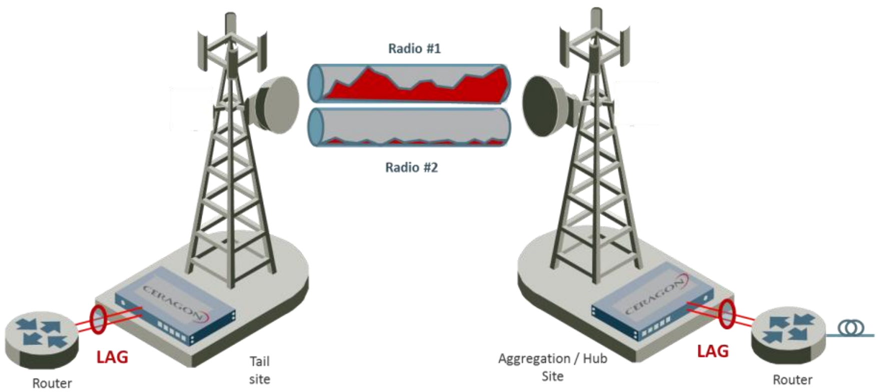

Figure 2: LAG-based wireless link aggregation with common MAC addresses

As illustrated in Figure 2, the result is that radio link #1 is overloaded with traffic, while radio link #2 is almost unused. The LAG function cannot distribute the traffic equally between the links. Use of adaptive modulation further aggravates this problem.

In summary: *While LAG can be deployed over microwave links, it was clearly neither designed nor optimized for wireless transport.*

Ceragon's Multi-Carrier ABC System

Ceragon's Multi-Carrier ABC system is designed to achieve 100% utilization of available radio resources by optimizing the way traffic is distributed between the multiple wireless links. Traffic is forwarded over available radio carriers, ***Byte-by-Byte***, as shown in Figure 3 below, thus reducing link latency. The tight integration between the wireless links and the bundling component increases availability awareness, and enhances load balancing.

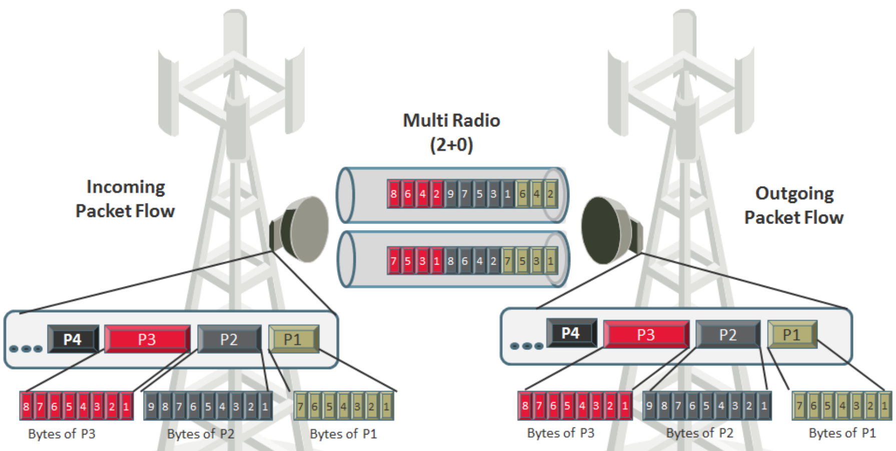

Figure 3: Multi-Carrier ABC traffic distribution across multiple wireless links

Ceragon's Multi-Carrier ABC system offers independent behavior for each radio carrier, thus maximizing spectrum efficiency even when using adaptive modulation. As shown in Figure 4 below, Ceragon's integrated solution allows for a graceful degradation in the event of failure of one or more links.

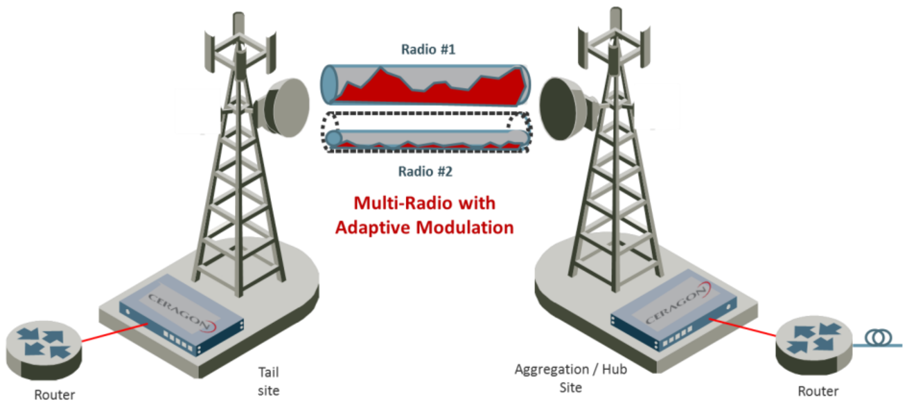

Figure 4: Multi-Carrier ABC's independent carriers using adaptive modulation

Traditionally, radio bonding was based on N+1 (SONET/SDH) protection schemes in which N carriers provided actual throughput, while the additional carrier remained on standby. New implementations based on LCAS (Link Capacity Adjustment Scheme) enabled a smoother transition to packet networking, and also utilized the standby carrier for best effort traffic.

Despite the improvements in throughput, the surge in the demand for capacity calls for higher spectral efficiency, which may be obtained in the migration to native Ethernet transmission. Native Ethernet improves spectral efficiency by at least 20% due to improved granularity, and may yield even greater gains when applying optimization techniques. N+0 native Ethernet radio bonding offers the capacity benefits of Ethernet radios, without the need for standby carriers.

Comparing Multi-Carrier ABC vs. Ethernet LAG in Wireless Backhaul

Backhaul network planners are focused on enhancing revenues, based on efficient support for high-bandwidth services, and service-differentiation capabilities that guarantee subscriber quality-of-experience. In order to achieve this, link bundling features must ensure low latency and preserve QoS consistency.

Latency. LAG-based systems divide traffic *packet-by-packet.* At the receiving node, the arriving packet is buffered until it is completely delivered ("store and forward") before being forwarded to the next hop. In this case, the total transmission latency depends on the rate of the wireless physical link used. On the other hand, Multi-Carrier ABC divides traffic *byte-by-byte* between all available parallel links, so that the receiving node receives packet fragments from *multiple* physical links. Therefore, Multi-Carrier ABC's latency depends on the aggregate capacity of the entire bundle, significantly reducing network delay. In networks supporting large frames, Multi-Carrier ABC's per-byte approach offers major latency reductions.

Table 1 below contains sample latency comparisons between Multi-Carrier ABC and Ethernet LAG, using two different modulation profiles.

Configuration	Profile	Latency	
		Ceragon Multi-Carrier ABC	Ethernet LAG
2+0 [28 MHz]	256 QAM	175 µsec	207 µsec
2+0 [28 MHz]	128 QAM	185 µsec	220 µsec

Table 1: Sample Multi-Carrier ABC vs. Ethernet LAG Latency Comparison

QoS. While LAG operates each microwave carrier as an independent link, Multi-Carrier ABC coordinates the physical links, and supports adaptive modulation. When a link deteriorates, Multi-Carrier ABC is immediately notified, and adjusts by sending less information over that link.

Let's look at a two-link bundle in which two classes of service are supported – high and low. Address-based LAG mechanisms may cause traffic to drop by sending high-priority traffic over a deteriorated link, while sending low-priority traffic over the fully-functional link. On the other hand, Multi-Carrier ABC constantly monitors the physical links and their available capacity, and transmits high-priority traffic over the optimal carrier.

The table below summarizes the benefits offered by Ceragon's Multi-Carrier ABC when bundling radio links:

Feature	Ceragon Multi-Carrier ABC	Ethernet LAG
Degree of integration	Tight integration between components handling the logical bundling and the multiple physical wireless links	Loose integration
Traffic distribution mode	Byte-by-byte	Packet-by-packet
Load balancing methodology	Based on instantaneous monitoring of radio capacity per carrier	Depends on the number of discrete MAC/IP addresses
Latency	Low, using byte-by-byte approach	High, due to store & forward mechanism
QoS aware	Coordinated parallel links	Independent parallel links
Adaptive modulation aware	Yes	No

Table 2: Multi-Carrier ABC vs. Ethernet LAG

Summary

Ceragon's innovative Multi-Carrier ABC technology is optimized for microwave point-to-point links. Its reduced delay and efficient QoS mechanisms enhance backaul network performance. Multi-Carrier ABC's integrated design ensures quick system response to link degradation and outages, improving network availability and responsiveness.

ABOUT CERAGON

Ceragon Networks Ltd. (NASDAQ: CRNT) is the premier wireless backhaul specialist.

Ceragon's high capacity wireless backhaul solutions enable cellular operators and other wireless service providers to deliver 2G/3G and LTE/4G voice and data services that enable smart-phone applications such as Internet browsing, music and video. With unmatched technology and cost innovation, Ceragon's advanced point-to-point microwave systems allow wireless service providers to evolve their networks from circuit-switched and hybrid concepts to all IP networks. Ceragon solutions are designed to support all wireless access technologies, delivering more capacity over longer distances in any given deployment scenario.

Ceragon's solutions are deployed by more than 230 service providers of all sizes, and in hundreds of private networks in more than 130 countries.

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