TECHNICAL BRIEF

Broadband Backhaul
Asymmetric Wireless Transmission

Abstract

Ceragon Networks offers its customers an innovative way to increase mobile backhauling capacity over microwave networks. Based on a unique asymmetric transmission technique developed by Ceragon, operators and their subscribers can benefit from enhanced downstream capacity, enabling the use of bandwidth-hungry broadband mobile applications.

This technical brief describes Ceragon's patent-pending asymmetric transmission capabilities, and how they can help increase capacity without requiring new investment in networking infrastructure.

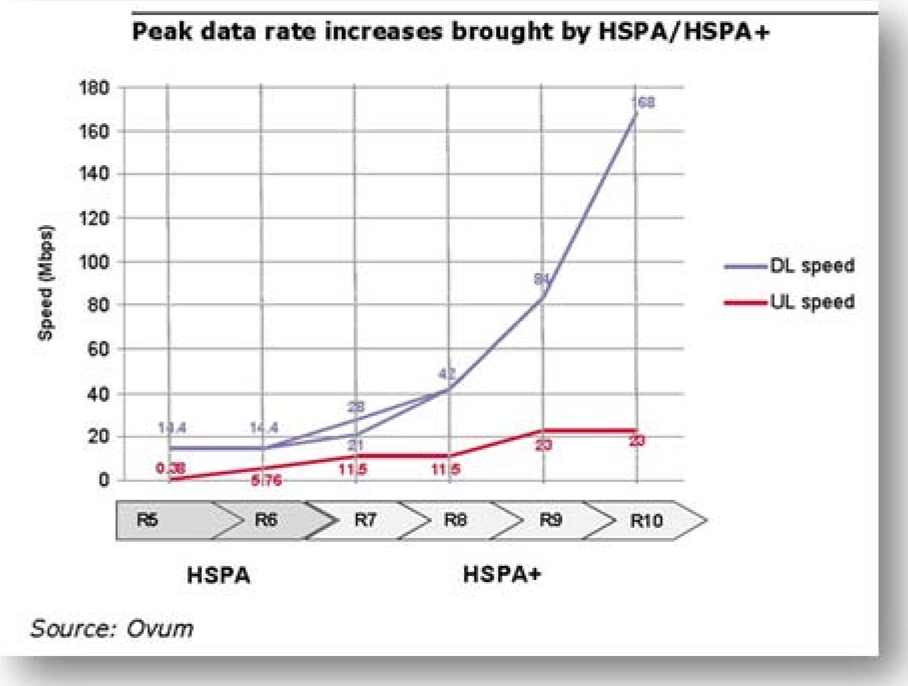
The Need for Expanded Data Capacity

Mobile operators offering data services to their customers are constantly searching for backhauling transport solutions that will allow them to quickly and effectively expand capacity as the use of these services increases. Projected 4G/LTE requirements will accelerate the need for higher capacities. While new fiber-optic deployments may provide the ultimate solution, they involve heavy CAPEX investment, as well as lengthy deployment schedules that may delay the introduction of mobile broadband and internet services to the marketplace.

Mobile Data Traffic Characteristics

Traditional wireline networks, originally designed to support telephony services, employed symmetrical transmission capabilities only. The introduction of asymmetric broadband access technologies – such as ADSL, DOCSIS, and GPON – enhanced downstream capacities, thus enabling web browsing, massive file downloading, and video streaming. Today, the ratio of downstream (DL) to upstream (UL) traffic in fixed-line networks is estimated at between 3:1 and 10:1, depending on the application and access technology used.

As the growth in mobile data use accelerates, cellular networks – which were originally built to support voice communications – are rapidly adopting wireline broadband traffic characteristics (as illustrated in Figure 1), and can be expected to approach the same DL/UL ratio levels. This change has forced operators to re-think and re-adapt their networks from access to core.


Peak data rate increases brought by HSPA/HSPA+

Source: Ovum

Figure 1: Wireless DL/UL Traffic Comparison in HSPA

In contrast with the access infrastructure mentioned previously, transport systems in general and microwave-based transmission systems in particular are symmetrical – as dictated by the needs of traditional telephony networks. Nevertheless, symmetrical configurations are not well suited for broadband and mobile internet backhauling, as they reserve precious network resources, including underutilized upstream transmission frequencies.

Meeting Mobile Internet and Wireless Broadband Requirements

In order to adapt cellular backhaul networks to emerging data traffic patterns, Ceragon has devised a novel (patent pending) approach, in which microwave resources are optimized for broadband service using **asymmetrical transmission.** Ceragon's innovative approach allows operators to better utilize their existing backhaul Frequency Division Duplex (FDD) spectrum plan to meet the growing demand for downstream bandwidth, while actually reducing overall spectrum requirements. In order to achieve non-symmetric transmission between upstream and downstream flows, Ceragon's FibeAir microwave platform enables the reallocation of FDD frequencies in order to adapt to traffic conditions – either statically or dynamically.

As an example, let's discuss a cellular network that provides both voice and data services to its subscribers. While bread-and-butter voice services generate symmetric traffic loads – that is, with a 1:1 downstream-to-upstream ratio – the broadband service ratio is closer to 10:1. In aggregate, we will assume a combined downstream-to-upstream ratio of 3:1.

Ceragon products allow the dynamic redistribution of radio channels into sub-channels of a finer granularity. In our example, let's assume a 28 MHz channel that can be divided into sub-channels of 7, 14, or 21 MHz. For 40 MHz channels, we can create sub-channels of 10, 20, and 30 MHz. We then provision our network to allocate channel pairs of 21/7 MHz, or 30/10 MHz thus satisfying the 3:1 ratio requirement. The increased spectrum availability for the highly-congested downstream direction is achieved by allocating bandwidth from the underutilized upstream spectrum. It is important to note that this spectrum re-allocation technique is interference-free and safe to use in most existing FDD networks.

Topological Considerations

Now, let's re-examine our asymmetric paradigm in the framework of a variety of topologies.

Asymmetric Transmission over Microwave Chains

Figure 2 below illustrates a chain of radio hops, each hop using adjacent 14 MHz channels, providing an overall capacity of 28 MHz. (or, similarly, adjacent 20 MHz channels, providing an overall capacity of 40 MHz).

Figure 2 describes a symmetric radio plan that uses some notation changes to simplify the explanation of the asymmetrical paradigm.

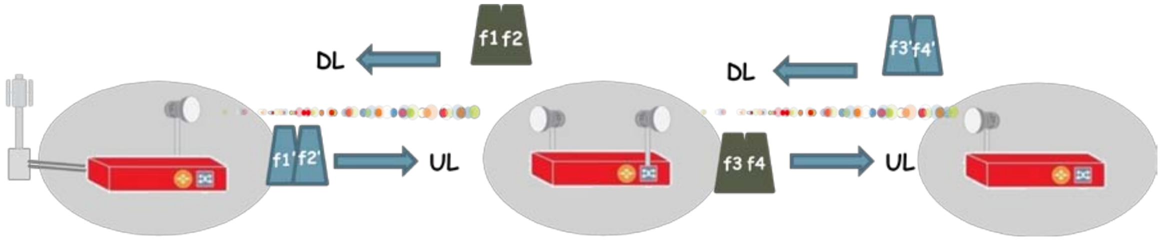


Figure 2: Symmetric Transmission over a Microwave Chain

In order to support asymmetric transmission, we divide each 14 MHz channel into two 7 MHz segments – labeled f1 and f2 for the downlink (DL), and f1' and f2' for the uplink (UL). In this example, all tagged channels denote a high channel while the untagged channels denote a low channel. In the adjacent hop, the downlink is represented by f3’ and f4’, and the uplink by f3 and f4. Interference is avoided by making sure that a node always transmits in one direction using a high channel, while it transmits in the opposite direction using a low channel.

Now, we re-assign the segments in order to attain the 3:1 downstream-to-upstream ratio mentioned previously. As shown in Figure 3, we can allocate three segments for downstream traffic, and one segment for upstream traffic, enabling us to achieve downstream and upstream channel bandwidths of 21 MHz and 7 MHz, respectively – a 50% downstream capacity gain. Note that for ease of implementation, the reallocated segments are the segments whose frequencies are adjacent to the existing downstream frequencies. In the diagram in Figure 3 below, f3 is appended to the downstream channel containing f1 and f2, while f2’ is appended to the downstream channel containing f3’ and f4’. (Note that the radio transmits the 21/30 MHz channel as a continuum and *not* as 3 separate 7/10 MHz channels).

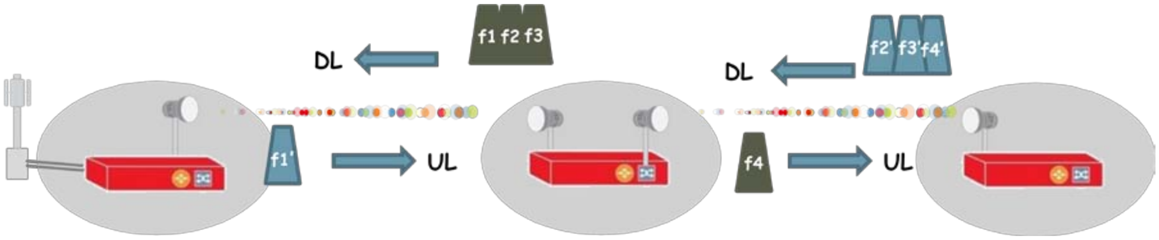


Figure 3: Asymmetric Transmission over a Microwave Chain

Asymmetric Transmission over Aggregated Microwave Links

In the symmetric aggregation example below, two adjacent 28 MHz channels are used to aggregate traffic from a small radio access network. Traditionally, we would split the 28 MHz channel into two 14 MHz channels for the 2 access links, and then employ a single 28 MHz channel for the aggregation feed, as presented in Figure 4 below. This results in a subnetwork with a capacity of about 100 Mbps per each 14 MHz tail segment, and around 200 Mbps for the 28 MHz aggregation feed. For the sake of simplicity, we will assume neither compression nor statistical multiplexing, even though both methods are highly recommended for implementation in broadband networks.

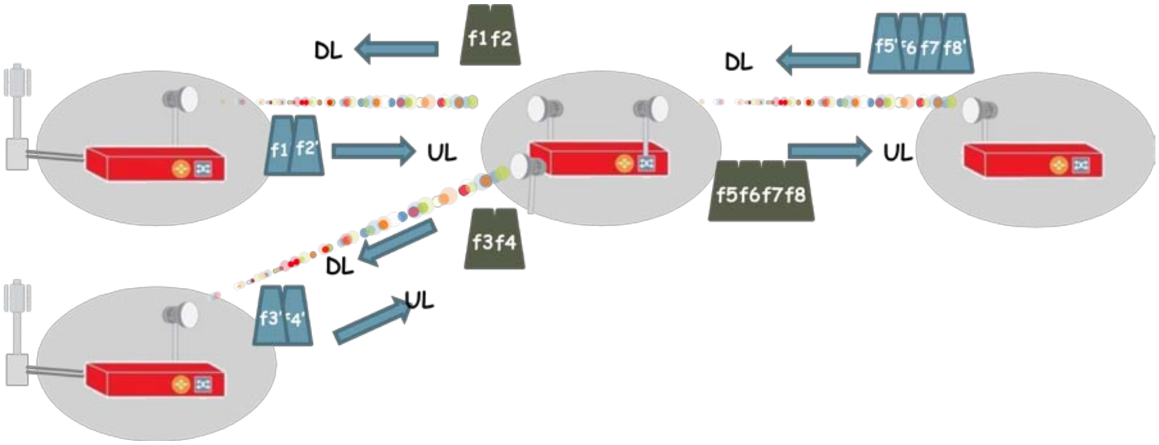


Figure 4: Symmetric Transmission over Aggregated Links

In order to reach the desired 3:1 DL/UL ratio, we again divide the channels into 7 MHz segments, and re-assign the segments to optimize the transport of broadband traffic, as shown in Figure 5 below. The aggregation feed now supports six downstream segments (6x7 = 42 MHz) and two upstream segments (2x7 = 14 MHz), while each tail supports three downstream segments (21 MHz) and one upstream segment (7 MHz). In this way, we increase the downstream capacity of the tails to 150 Mbps, and the downstream capacity of the aggregation feed to 300 Mbps, a 50% improvement in each case.

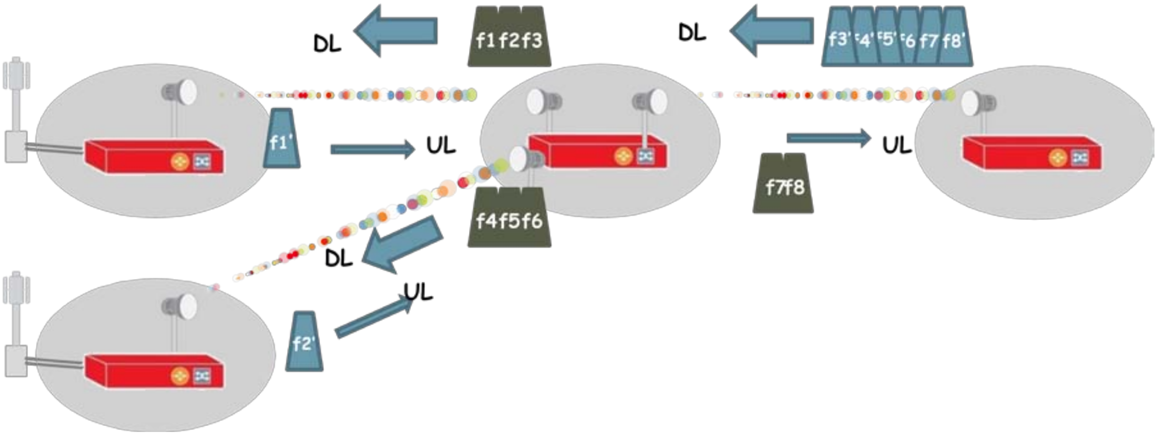


Figure 5: Asymmetric Transmission over Aggregated Links

Ring Support for Asymmetric Transmission

Traditional transport rings, with their inherent symmetric traffic flow and built-in protection facilities, were not designed to handle massive broadband traffic loads. As mobile services shift from voice-centric to data-centric, network planners may be called upon to rethink their ring architectures to account for the following:

- The 3:1 aggregate DL/UL ratio, as mentioned earlier, is not commonly supported in transport networks, resulting in capacity shortages and wasted bandwidth resources.
- Most data traffic flows to and from an RNC or 4G service gateway, thus enabling the identification of all flows as “upstream” or “downstream.” Furthermore, the ring’s upstream and downstream directions may change suddenly as links fail and recover.

Ring-based asymmetric transport solutions are not within the scope of this paper. Ceragon’s patent-pending asymmetric transmission technologies offer load balancing and protection capabilities in the mobile operator’s access and aggregation rings.

Summary

Ceragon’s asymmetric transmission is an excellent way to increase the capacity available for data services without requiring further investment in networking infrastructure or spectrum assets. Asymmetric transmission optimizes the backhaul network for smartphones, tablets and data-heavy applications, and helps to pave the way to a profitable 3G or 4G/LTE introduction.

The flexibility of Ceragon’s FibeAir® IP-10 family allows carriers to implement a wide range of backhauling architectures and topologies. Designed to help carriers reach their IP migration goals, Ceragon’s FibeAir® IP-10 is an excellent platform for LTE capacity optimizations

About Ceragon Networks

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 under any given deployment scenario. Ceragon's solutions are deployed by more than 230 service providers of all sizes, and hundreds of private networks in more than 130 countries. Visit Ceragon at www.ceragon.com.