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802.11n: Complicated and about to become even messier

In January 2007, I bemoaned the blizzard of “draft” 802.11n gear at that year’s Consumer Electronics Show, whose presence constrained the continued evolution of the then-under-development next-generation Wi-Fi standard. More than two years later, the IEEE is still slaving away on the specification, although tentative indications suggest that the approval work—albeit perhaps not the pending lawsuits—may wrap up by year-end. In a mid-2008 interview

with Stephen Palm, the technical director of Broadcom’s broadband-communication group, I grumbled about the fact that the draft standard allowed for access points and access-point-containing routers to optionally support either 2.4- or 5.8-GHz—but not necessarily both—ISM (industrial/scientific/medical) bands, pointing out the market confusion that might result but acknowledging the cost-driven motivations for the decision.

Unfortunately, the situation is about to get even more muddled. First, keep in mind that LAN clients also do not need to support both the 2.4- and 5.8-GHz bands. Even more bewildering is the relationship or—perhaps more accurately—lack of relationship between 802.11n-cognizant equipment’s MIMO (multiple-input/multiple-output)-antenna arrays and the number of simultaneous-stream transfers they support along with the dearth of product documentation regarding these specifications. The minimum number of antennas on both sides of the link limits the number of possible simultaneous data streams. However, the radios often further limit the number of spatial streams that can carry unique data.

To help identify a radio’s performance, the IEEE uses the $a \times b : c$ notation, where a is the maximum number of transmitting antennas or RF chains the radio can use, b is the maximum number of receiver antennas or RF chains the radio can use, and c is the maximum number of data-spatial streams the radio can use. For example, a $2 \times 3 : 2$ radio can transmit on two antennas and receive on three but can send or receive only two data streams. The 802.11n specification working draft allows for configurations that can transmit and receive on as many as four antennas and can send or receive as many as four data streams. Common retail configurations of 11n devices are $2 \times 2 : 2$, $2 \times 3 : 2$, and $3 \times 3 : 2$. All three configurations have the same maximum throughputs and features and differ only in the amount of diversity the antenna systems provide.


The current 802.11n specification working draft, according to knowledgeable sources, requires that access points and routers containing them deliver $2 \times 2 : 2$ or better transfer-rate capabilities, although it allows LAN clients to drop down to $1 \times 1 : 1$ levels. Its aspirations differ, however, from the certification requirements of the Wi-Fi

Alliance, an organization that ramped up its activities in the absence of formal specification approval, as a means of jump-starting the market transition to 802.11n. Like the IEEE, the Wi-Fi Alliance requires that 802.11n access points and routers be $2 \times 2 : 2$ or better. However, with respect to LAN clients, the Wi-Fi Alliance differentiates between PCs, which must receive at least two simultaneous streams but must minimally support only single-stream transmissions, and mobile devices, for which single-stream support for both basic transmitting and basic receiving operations is acceptable.

I acknowledge the cost-versus-performance background of this differentiation, but the split between the two categories is imprecise. Consider the laptop, especially the cost-sensitive netbook. Is it a PC or a mobile device? And what about the “low-power 802.11n” mode supposedly coming in the next-generation iPhone and iPod touch? Does this feature simply mean “single-stream capable,” or will these devices also artificially limit the maximum per-stream bit rate as some suppliers have done in the past with 802.11b and 802.11g? Will anyone ever know the answer to this question, save for Apple and its rumored silicon supplier, Broadcom?

As 802.11n matures, and as suppliers strive to differentiate themselves, two- and three-stream-capable clients and three-stream-capable access points and routers will inevitably become more common. However, unless vendors clearly document the gear’s capabilities and limitations and unless end users intuitively understand these limitations, the end result will inevitably be a combination of implementation frustration and purchase paralysis. **EDN**

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