Wi-Fi: Designing for Performance

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Wi-Fi is a standards-based technology, and most designers assume that their finished products will work out of the box on any Wi-Fi infrastructure with which they’re used. By and large they’re right. However, there is a world of difference between simply working and working optimally.

Wi-Fi Alliance certification will help ensure a high degree of interoperability and security, but it’s no guarantee that your products will always deliver the best possible performance. For that you need to be aware some of the ins and outs of Wi-Fi networks so you can squeeze the best performance from your design. You may even get a competitive leg-up in the process.

Operating Band

Wi-Fi design today invariably involves a trade-off between speed, cost, and power consumption. The hottest new Wi-Fi technology, 802.11n, has the potential to operate faster than Fast Ethernet when used with multiple antennas and multiple in/out streams (referred to as MIMO). As chip volumes ramp and prices fall due to the widespread use of 802.11n in PCs and smart phones, 802.11n is superseding 802.11g as the preferred wireless physical layer.

Achieving the full benefits of 802.11n comes at a physical and monetary price: to squeeze the maximum throughout out of 802.11n you need multiple sets of antennas and multiple spatial streams. However, the resulting space and power demands are impractical for manufacturers of many portable and/or battery-operated devices.

Typical 802.11n Access Point
(Courtesy Aruba Networks)

That’s why many device vendors have elected to ride the downward price curve by using 802.11n RF chips, but conserve space and battery life by compromising the number of antennas and streams. To get the best performance under these circumstances, it’s important to ensure that your device can be configured by the user for operation on the 5 GHz band, even if it defaults to the 2.4 GHz band.

Why? Because the crowded 2.4 GHz band has only three usable channels, and is shared with Bluetooth devices, cordless phones, and microwave ovens. The 5 GHz band is far quieter because it’s less used, and it has more available operating channels.

Some wireless networks, including those from Aruba Networks, automatically probe Wi-Fi devices to determine if they’re capable of operating at 5 GHz, even if the driver defaults to the 2.4 GHz band. They then entice the device to switch to the 5GHz band by probing at 5 GHz and denying access at 2.4 GHz. This ensures that the device can operate at the highest possible speed. It is therefore important that you test your device to ensure that the chip set drivers permit such a band change or else you’ll be leaving potential performance gains on the table.

Power Conservation
For portable device manufacturers, battery operating life is a key competitive differentiator. The battery life of Wi-Fi capable mobile devices can be extended by enabling the Wi-Fi radio to enter a low-power “sleep” mode when no data need to be transmitted or received. The longer the sleep time, the lower the battery drain. The difficulty is ensuring that the device can wake-up in a timely manner and without impacting network performance.

Mobile device drivers and radio firmware employ a variety of pre-set timers and trigger events to optimize entry into, and termination of, sleep time. The techniques employed typically vary by device and applications. For example, scanners typically have longer pre-set sleep times than laptops because the latter are assumed to have greater access to a recharger. Using timers to limit application duty cycles – such as the rate at which I/O are scanned or data are collected – can make a significant difference in active power consumption and hence battery life.

A variety of Wi-Fi power-saving standards and options are available, but beware that the implementation can be tricky for state machines. If a device gets out of synch with infrastructure wake-up features, then data will be lost. It’s therefore essential that you test your device to ensure proper synchronization with all leading wireless LANs.

Broadcast and multicast Wi-Fi traffic chatter can prevent a device from entering sleep mode, keeping it awake to check in case any of the chatter includes packets intended for the device. The most current Wi-Fi networks can identify and block network chatter (multicast traffic) that would negatively affect mobile devices. Protocol conversion from multicast/broadcast to unicast frames can also increase adjustable wake-up times (DTIM interval) without negatively affecting network performance.

Power-save polling, proxy ARP, protocol conversion, and the DTIM interval should all be tested to ensure that battery-saving mechanisms work in practice. It’s also helpful to note in product documentation and partner training that any Wi-Fi network with which the devices will be used should employ these solutions for best results.

Some Wi-Fi vendors promote an alternate approach to power conservation by recommending that their proprietary software clients or firmware hooks be integrated into end devices. These approaches lock vendors and end users alike into using only devices embedded with the proprietary technology.

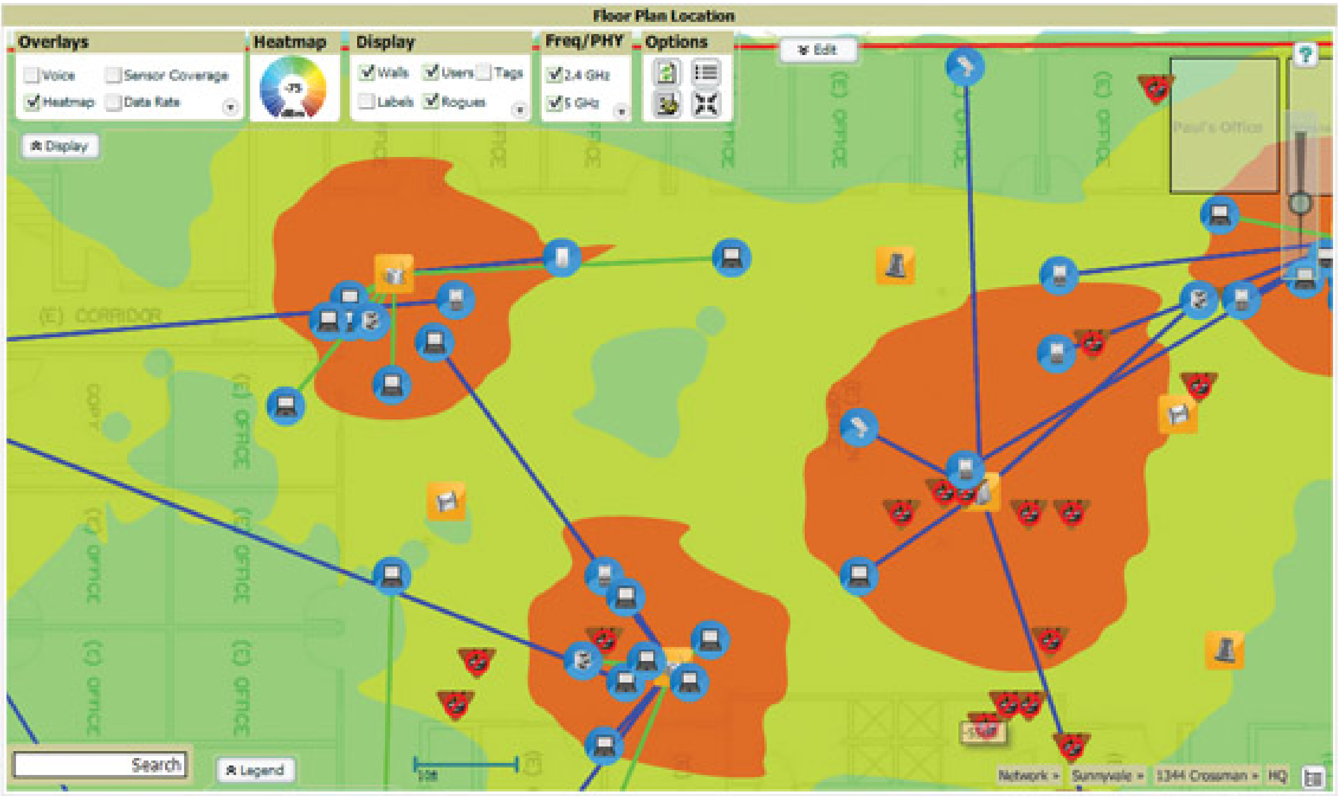
They also require the manufacturer to implement strict revision control over the client software and firmware to avoid incompatibilities or performance differences that exist between revisions. As a rule, proprietary power-saving clients and hooks are always best avoided.

Real-Time Messaging
Despite IP being a non-deterministic protocol, some vendors attempt to use Wi-Fi in a deterministic manner. They define precise guard bands within which data must be transferred, and assume that they have exclusive use of the channel when they need network access.

Bad assumption. Even if theirs is the only device using the network, there are many factors that can impact the delivery of their payload in a timely manner. Nearby Wi-Fi networks, sources of interference, and even wireless intrusion detection scans can require that packets be retransmitted - sometimes more than once - until they can be successfully received. And that can push packet reception outside the allowable limits.

So plan for failure. If you have to deliver data in real time, ensure that you’ve built in adequate safeguards to handle delays that are outside of your control. Test your devices in a range of networks to ensure proper operation across a wide variety of operating conditions.

Handover and Location Data
Most Wi-Fi enabled devices are mobile, and network data will be handed over from access point to access point while the device is in motion. Correctly timing when a handover occurs is important for the proper operation and stability of the device and its related applications. Consider incorporating neighbor report and channel report (802.11k) as well as BSS transition management (802.11v) into your device to improve the handover process.



Location Information Can Help Improve Operational Efficiency and Productivity (Courtesy Aruba Networks)

Also consider offering location information to applications running on the device. 802.11k and 11v allow the device to query the Wi-Fi infrastructure for location in GPS, street address and URI formats. As users increasingly look to IT infrastructure to improve operational efficiency and productivity, location information will play a key role in these endeavors. So get a leg up on your competition and differentiate your product now.

Conclusion
Wi-Fi standards and even Wi-Fi Alliance certification address interoperability, but are not sufficient to ensure that a device will operate at peak performance. There are a number of measures designers can take to boost the utility, battery-life, and reliability of Wi-Fi based devices. Doing so will ensure best performance across the widest range of operating conditions.

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