The Network *Inside* the Network—Part 2

Here's what to consider when choosing whether to use repeater DAS, hybrid DAS or lossless DAS for in-building systems to work as part of a larger wireless communications network.

by Jerry Black

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Subscribers expect reliable and continuous wireless communications anywhere they may choose to receive or place a voice or data call. Those with jobs outside the home spend more active hours at the workplace than at any other single location. Fierce competitors, wireless service providers expand, optimize and tweak their macro networks. They also recognize that for ubiquitous in-building coverage, a more localized approach is necessary.

Developing the most appropriate in-building network involves understanding platform choices, the coverage objectives and what differentiates vendors. Five important factors include:

- specific characteristics of the facility.
- effects on the macro network.
- system performance.
- system flexibility and expansion.
- ROI.

In-building network platforms, components and vendor capabilities have advanced to the point where cookie-cutter solutions simply don't—"cut it." For comparison, when a new base-transceiver station (BTS) facility is deployed, antenna C/L, gain and pattern are selected to meet the facility's coverage objectives. The same applies for an in-building deployment with respect to the five important factors listed above.

Technology enhancements

Outdoor repeaters were forerunners to the compact, in-building repeaters that are a critical element in most current in-building network deployments. Even though outdoor repeaters produce higher-power output than repeaters used for in-building networks, their specifications are essentially the same. They must have linear amplification as described by the spurious-free dynamic range to maintain macro-network quality and performance, especially in the presence of multiple tones, or carriers. Cost reductions and design refinements that led to compact repeaters resulted in a wide variety of product choices.

Reduced output power and gain allow further reduction of component cost with the use of gain-block cascades and packaged amplifiers. Reduced power simplifies the filtering. Inter-stage surface acoustic wave (SAW) filters provide variable bandwidth windows with reasonable shape-factored responses. Cumulatively, these changes reduce size and cost. Most, if not all, compact repeaters are made offshore, and the lower labor cost is reflected in lower prices.

Compact repeaters for in-building networks morphed from single- to dual- and even triple-band devices. They are the most widely used active-network "connection probe" for in-building deployments, serving as the primary network-element interface.

Platform overview

As a basic platform, a distributed antenna system (DAS) is the most common in-building system. It's not the best choice for all deployments, but it remains the most popular and often the least expensive. It is generally suited for smaller applications less than 100,000 square feet and is so widely used because so many deployments are in that category.

In its simplest form, a DAS consists of a compact repeater or BTS connected to a passive network of distribution components comprising power dividers, directional couplers, interconnection transmission lines and antennas. This lossy network closely resembles a CATV distribution system commonly found in the home, but without the amplifiers or antennas. The distribution strategy is essentially the same.

The simple DAS platform most often uses a compact repeater for its only active element. As a bi-directional amplifier and the only active element, the repeater is critical to the in-building system *and* to the macro-network node to which it is connected. The simple configuration usually makes it necessary to operate the repeater close to its maximum limits to overcome DAS-distribution losses.

The spurious free dynamic range, specifically inherent in each compact-repeater model's design, determines the repeater's overall performance when operated at these levels. It controls the degree to which the repeater could become a source of interference to the macro network. In a hybrid-platform deployment, the repeater is operated well below its

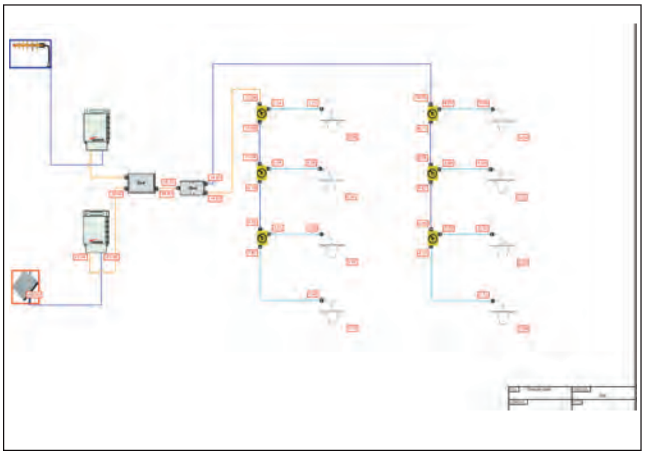

Figure 1. A classic, repeater-connected DAS offers nearly identical performance compared with a DAS connected to a base-transceiver station (BTS), yet at a much lower cost if it avoids the need to deploy a BTS.

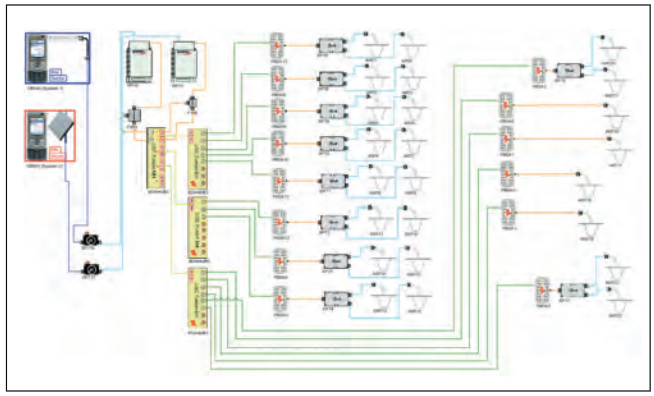

Figure 3. A virtually lossless DAS differs from the hybrid DAS in Figure 2 in its elimination of the simplified DAS components typically located at each remote node. Without them, each remote node then connects directly to a dedicated antenna, making complete contour control possible for each node.

maximum limits, significantly reducing its potential negative effect on the network.

A hybrid DAS platform offers more capability and enhancements. It consist of a “virtually lossless” distribution system using fiber-optic cable or another active approach to eliminate high losses associated with a repeater DAS used in the 800 MHz to 2000 MHz range, especially in a large complex. Larger deployments with longer distribution paths use it because, with fiber, loss is virtually independent of length. Each fiber path connects to remote nodes or hubs that convert the fiber signals back to the original RF spectrum. At the remote node or hub, simplified conventional DAS elements connect each node or hub to multiple antennas located within the immediate coverage area.

When a particular deployment allows only “home run” points of connection to each antenna or when solution-specific coverage requirements dictate the use of dedicated hub/antenna assignment, lossless DAS is the platform of choice. Many benefits such as scalability, optimization and performance offset the incremental increase in cost compared to a simple DAS. Although it depends on the specific deployment, fiber often costs less to install than transmission line.

Repeater-connected DAS

Passive DAS installations are connected to the network by either a BTS or a compact repeater. A classic repeater-connected DAS is shown in Figure 1 above. System performance is essentially identical whether the network connection uses a BTS or a repeater. Given the cost comparison between compact repeaters and constructing new cellsites (even a microcell), it is hard to justify deploying a BTS unless the in-building deployment is collocated with an existing BTS facility.

A repeater is by far the most common choice. The repeater amplifies both the forward path (from the BTS to the user) and the reverse path (from users inside the building back to the network). At one port of the repeater, a donor antenna, mounted on the roof of the building, is typically aligned to the closest BTS facility. The other port of the repeater connects to the DAS network, consisting of antennas located throughout the indoor target-coverage area.

As mentioned previously, the repeater specification with the most effect on system performance is the spurious-free dynamic range (SFDR). This important parameter varies widely among repeater products. Simply defined, the specification represents both the minimum useable input-signal level and the maximum signal that can be amplified while maintaining the incoming signal’s spectral purity. Therefore, SFDR largely determines the linear operation, spectral purity and interference potential for any manufacturer’s product. (More about this in a future article.)

The repeater-connected DAS platform reaches its maximum practical limits as the DAS network becomes increasingly complex, resulting in higher losses that then become the limiting factor. Most deployments in the workplace involve office space. Office space

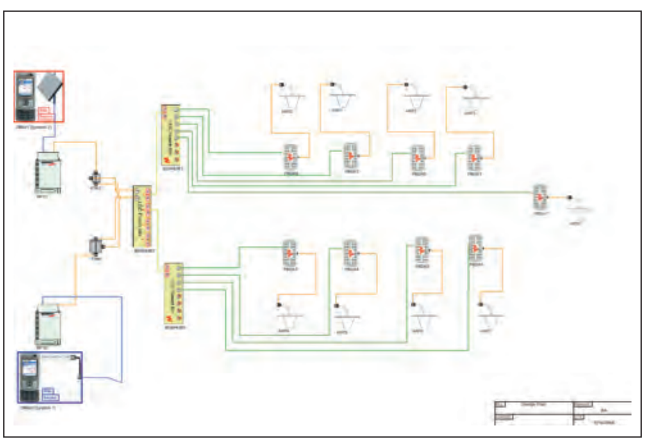

Figure 2. A hybrid DAS platform offers better performance and more flexibility than the simple repeater DAS shown in Figure 1. Its most significant advantages, compared to the repeater-connected DAS platform, are scalability and the ‘virtually lossless’ distribution characteristic.

DAS Forum news

There is in an-ever expanding constellation of distributed-antenna system (DAS) deployments by both carriers and DAS providers. The DAS Forum's first DAS in Action event in Hilton Head, SC, was discussed in the April issue of AGL. Other notable installations are in service in Detroit, San Diego, Seattle, and on Nantucket Island, MA..

National Grid Wireless's Andover, MA, DAS is another good example of a wireless solution that benefits wireless carriers and the local community. The Andover network was designed in conjunction with leading wireless carriers to complement their current macro networks in Andover, filling an important gap in cellular/PCS availability for customers along two key roadways where previously they had poor or no reception at all.

Launched with multiple carriers from day one, the Andover DAS provided these tenants with a targeted solution, deployed quickly, with a unanimous decision by the local zoning board.

"This is just another example of our collaboration with customers and the communities they serve," said Doug Wiest, CEO of National Grid Wireless US. "Our targeted DAS network is an ideal solution in neighborhoods, like Andover, to solve specific coverage problems in a cost-effective, unobtrusive way."

DAS doesn't solve every problem. It is an exciting new tool for network providers, creating new design options for extending coverage and capacity. Still, while the smaller cells are less expensive than building a new tower, the equipment-cost savings can be offset by construction costs. This guarantees that collocation on existing cellsites remains the most economical method for extending capacity and coverage in most cases.

Meanwhile, the increasing number of DAS deployments ensures network providers become more experienced and efficient, extending the opportunities to showcase the advantages of DAS in a world increasingly reliant on wireless technologies.

—Allen Dixon, president, DAS Forum

characteristically has moderate-to-dense clutter losses. The deployment often is divided among several levels, which adds to the DAS losses. When the deployment must support PSC spectrum, the maximum deployment size is generally limited to about 80,000 square feet.

It generally is a good idea to de-rate the vendor-supplied maximum composite signal because the maximum level usually applies to a single analog carrier. First, de-rate it to a safe zone well below the 1 dB compression point, and second, de-rate it further for multi-carrier operation. The amount of de-rating depends specifically on the amplifier design. Nevertheless, in general, a properly established safe zone for multi-carrier deployment may require the maximum composite rating described above to shrink by 10 dB. This is the primary reason the repeater-connected DAS platform is well suited for smaller, more open deployments.

Hybrid DAS systems

Figure 2 on page 47 shows a hybrid DAS platform solution with better performance and more flexibility than a simple repeater DAS. Its most significant advantage, compared to the repeater-connected DAS platform, is *scalability* and the "virtually lossless" distribution characteristic. DAS loss in the repeater-connected DAS platform is that system's limiting factor. With a hybrid system, DAS losses do not significantly limit the deployment scope.

Because the repeater connects directly to the "virtually lossless" distribution medium (generally fiber, but other technologies accomplish the same objective to a similar degree), the repeater is no longer the primary active-distribution element. This relaxes the compact repeater's drive-level requirements and significantly reduces the SFDR problem because only a fraction of the compact-repeater output is needed to properly drive the fiber node.

As seen in Figure 2, fiber distributes the signal from the main node or hub to the remote nodes or hubs. Because the fiber-distribution losses are not distance dependent (as far as 1.5 km for single-mode fiber), the only DAS losses in the deployment stem from the more simplified DAS network elements connected to each remote node or hub. Placing centrally located remote nodes at distant coverage areas within the deployment reduces DAS losses significantly. Further simplifications, if possible, will reduce the overall losses even more and allow greater contour intervals for each antenna placement. Moreover, the reduction in antenna- and transmission-line count reduces installation and material costs.

Even though the hybrid platform offers the optimum *cost-weighted scalability*, some solution-specific deployments do not lend themselves to any DAS or remote-node antenna sharing. Some deployments may not allow the use of transmission line because of installation problems or perhaps because the coverage contour from each remote node must be maximized.

Virtually lossless DAS

Compared to the hybrid DAS platform, the virtually lossless DAS differs only in the elimination of the simplified DAS components that typically are located at each remote node. Without them, each remote node then connects directly to a dedicated antenna, making complete contour control possible for each node. Most vendors support this configuration.

Figure 3 on page 47 shows a DAS network-platform design incorporating this approach. Because the compact repeater connects directly to the fiber hub, composite output requirements are significantly reduced, diminishing concerns over linearity.

Even though there are no incremental distribution losses with virtually lossless DAS, it is important to emphasize that this solution is not *actually* lossless. Inherent noise associated with any amplification, and conversion losses associated with the RF-to-fiber medium, certainly add some effect, compared to a truly lossless connection. Although the losses are in essence virtually invisible to the network, they do exist.

In terms of overall system

performance, scalability, optimization enhancements and overall control, much is gained from the incremental cost increase of this platform relative to the hybrid DAS. Installation effort is also reduced and, depending on the deployment, that could represent substantial savings. In a deployment where multi-mode fiber may already exist, installation costs could be slashed significantly even if some extension of the multi-mode fiber plant were required.

Nearly 90 percent of all workplace deployments use multi-mode fiber, and most have enough spare capacity to support the limited fiber backbone needed for the vast majority of all in-building deployments.

Advances in fusion splicing have placed this expanded capability of virtually lossless DAS within everyone's reach. No longer is it necessary to spend extra amounts to add or to expand fiber connections. For much less than the cost of a popular hand-held spectrum analyzer/transmission line sweep test set, one can own this technology and be up to speed in less than three hours. (More on this in a future article as well.)

The right system for the right venue

The choice of vendor platform largely determines what enhancements, features and capabilities are integral to the system. The need to deploy high-power repeaters to cover large venues isn't necessary. Seldom is it the best solution when reduced costs associated with in fiber or other elegant distribution mediums are taken into account. Compact-repeater specifications and ratings vary widely, so it pays to read them carefully. Capabilities among the larger platform solutions also vary widely.

Only a few vendors offer fiber-based solutions, and among them, *capabilities actually vary more than price*. For example, fewer than half of these vendors provide a solution that operates with both multi-mode and single-mode fiber. In a deployment where ample multi-mode fiber is available, using it could significantly reduce the deployment cost.

Fortunately, there are many in-building solution platforms from which to choose, including repeater DAS, hybrid DAS and lossless DAS. Specific hardware choices within each platform drive additional performance and optimization enhancements and affect the overall solution. Assessing each deployment design with an understanding of each type (and the specific capabilities of each vendor) allows these important differentiators to be exploited in developing the best application-specific solution. agl

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