Achieve High-Performance Simulcast

Advantages & Optimization Options

BY CARL B. "BERNIE" OLSON

Historically, simulcasting has been the solution to scarcity of spectrum for multiple-site, wide-area systems. In the process of improving capability, other advantages have been achieved with simulcasting. *The obvious:* By using less spectrum, simulcasting greatly improves the probability of obtaining licenses. In addition, the overlapping of desired signals improves coverage reliability. Portable in-building coverage is improved due to strong signals arriving from multiple directions. Because the same talk-in frequencies are used at every site, receiver voting (i.e., macro diversity) improves talk-in performance, particularly from portable transceivers. And users' radios are simpler because complex scanning options are not required, reducing potential operator confusion.

By definition, multicasting requires more frequencies and more complex scanning capabilities in user radios to identify alternate sites and associate with them. Because only one site is selected at a time, simulcasting's multiple signal advantage is not provided. Implementing voting in a multicast system requires additional hardware at the adjacent sites or voting-only sites.

An early challenge of simulcast was that additional and unique engineering skills were required to properly design and set up the simulcast system. This challenge has been met with advanced computer simulcast simulations and GPS time-delay control.

COMPUTER SIMULATIONS

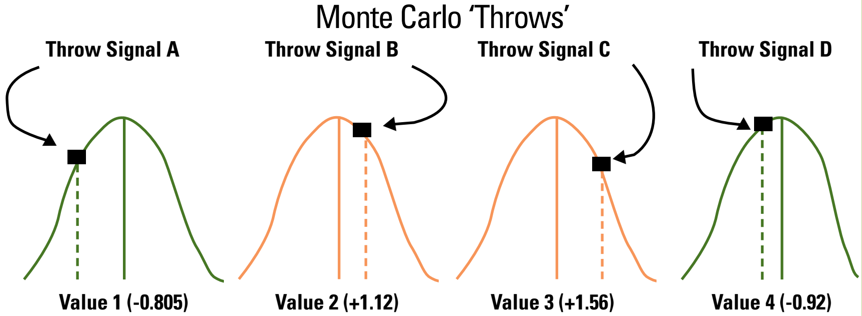
Monte Carlo simulations are used to determine the probability of achieving the desired performance criteria for the delay spread[1] at a given location. Margins are required to account for the location standard deviation and are incorporated in the Monte Carlo simulations. For each throw (simulation), the faded C/N and delay spread are calculated and compared with the Delivered Audio Quality (DAQ) criteria. If the results of a throw meet or exceed the desired DAQ, that throw is considered a success. If not, the throw is a failure. The dominant signal is also evaluated to determine if it can provide the criterion performance by itself. Large numbers of draws are required to determine the statistical probability for a given location with high confidence.

The process is repeated for all locations so that the probability of achieving the desired DAQ over the defined user's service area can be calculated. This is usually stated as *XX% probability of achieving a DAQ value to meet or exceed Y over the specified service area.* Simulcast system designs with DAQ values of 4.0 can be very costly because of the increased site count and might be prohibited by FCC restrictions of maximum RF signal power at the edge of the service area.

Simulcast system design requires an iterative process to select optimal sites from candidate sites, as well as optimization of signal levels by changing transmitter-radiated power, antenna configurations and height at specific sites. Absolute delays are changed in the infrastructure distribution to optimize the overall design by running different simulations. In the past, determining absolute delay was a complex process; the potential for alternative, redundant distribution paths made setting conditional optimal delays difficult. With the advent of GPS-timing signals, the worst case delay can be determined so that each site knows how long to buffer and delay launching the digital signal. This eliminates the distribution path variable. A GPS atomic reference can also be used to discipline the frequency reference to keep all transmitters precisely on the same frequency.

Many people use the delay spread cri-

Monte Carlo 'Throws'



- Throws are from a zero mean Log Normal Distribution
- Throw value x σ + Mean Signal level equals Value for that throw
  - e.g., Value 1 = -0.805 x 5.6 dB + (-90 dBm) = -94.51 dBm
- Calculate the relative delays of each signal
  - Launch delay plus propagation time
- Calculate the delay spread from the variables of the throw
- Sufficient throws to achieve desired probability accuracy for that location
- Continue to next location for evaluation

Glossary

- **Multicast:** In a land mobile radio system, a technique in which identical audio information is transmitted from multiple sites operating on different frequencies.
- **Simulcast:** In a land mobile radio system, a technique in which identical audio information is transmitted from multiple sites operating on the same assigned frequency. It requires careful control and engineering of the system parameters to effectively deliver high-quality audio or data. The alternate technology is multicasting.

teria as a rule of thumb to estimate a site-to-site separation. *Example:* For a 60-microsecond (µs) criterion, the distance, 11.2 miles, is found by dividing by the speed of light (5.35 µs/mi). This is *not* a valid estimation. As additional sites are used, the signal level and delay interactions become more complex, in addition to the variable environmental effects, creating localized areas where the criterion isn't met. The local environment is not uniformly lossy (i.e., causing attenuation or dissipation of electrical energy) due to terrain variations and land usage, resulting in nonmonotonic[2] losses with increased distance from a site.

GENERAL RECOMMENDATIONS

To achieve high performance in a simulcast system, the following parameters need to be considered and controlled:

- Frequency stability should be controlled to minimize any frequency differences at the different sites. Atomic frequency standards are recommended. Multipath minimizes the effects of carrier nulling.
- Amplitude and phase equalization of the modulation at each site is critical. The use of digital multiplex for the infrastructure and precise control over any differences in the modulating signal at each site are essential.
- Signal delay equalization to optimize the delay spread over the desired service area is required. Use computer modeling and iterative adjustments of ERP, HAAT and antenna patterns at various sites to optimize the user's service area's probability of achieving a specified DAQ.
- Monte Carlo simulation is the proven methodology for optimizing a simulcast system for the desired probability of achieving a given DAQ. ||PSC||

END NOTES

1. Signals arrive at slightly different times based on the time of launch and length of the propagation path to the point being evaluated. This is delay spread.
2. Losses only increase with distance in a monotonic condition.

CARL B. "BERNIE" OLSON has more than 45 years of experience in telecommunications. He is currently semi-retired and working on Telecommunications Industry Association (TIA) standards development.