maximising the potential of advanced wireless communications

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Brains beat brawn in radio linking

A common misconception among radio professionals is that a large bandwidth is needed when linking analogue and digital PMR base-station sites. However, as Paul Daigneault concludes, this isn't necessarily the case.

With the development and adoption of new higher spectrally efficient radio technologies, it can be argued that there's no overall shortage of radio spectrum. However, the set of unique propagation properties particularly associated with radio waves in the UHF bands, make this the most sought after and crowded band in the usable spectrum. As a consequence, the spectrum in these "golden" bands has been regularly divided up into smaller chunks or channels to accommodate more users and make the best utility out of this finite and valuable resource.

In the past, linking of radio infrastructure had typically been implemented utilising UHF linking frequencies where possible, which not only provided propagation advantages, but also predictability in terms of latency, jitter, availability and reliability. More recently, however, it has become common to assume that microwave links are required to accommodate the growing bandwidth requirements of digital PMR networks.

The fact is that "megahertz bandwidths" are not needed to provide an optimised low-latency PMR network-linking solution. Instead, there is a growing recognition of the value that ultra-spectrally efficient narrowband systems that have been cleverly designed to achieve the desired QoS (quality of service) — are a good fit for linking PMR sites. In fact, if the QoS issues are overlooked, then the systems selected on the basis of "megahertz bandwidths" alone may still lead to excess delays and data loss.

At the same time, the increasing popularity of IP has shifted the paradigm from "IP over everything" to "everything over IP, including linking of PMR sites". Behind all this success is the underlying fabric of the internet: the Internet Protocol. IP was designed to provide best-effort service for delivery of data packets and to run across virtually any network transmission media and system platform. As a consequence, issues such as delay (latency), variation in delay (jitter), packet loss, late packet arrival, availability and bandwidth requirements all become very significant.

By being aware of these issues and using a combination of intelligent radio design and smart software features, it's possible to support a large number of PMR channels in narrow bandwidth with minimal packet loss and late packet arrival, while still maintaining very low latency and jitter, even across challenging terrains.

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What can seriously smart technology do?

25 kHz	P25		DMR	
	Min. Number of Trunked Channels	Residual Ethernet BW	Min. Number of Trunked Channels	Residual Ethernet BW
QAM256	10 Channels	123 kbps	13 Channels	126 kbps
QAM64	8 Channels	79 kbps	11 Channels	79 kbps
QAM16	5 Channels	47 kbps	7 Channels	49 kbps
QPSK	2 Channels	13 kbps	3 Channels	18 kbps

12.5 kHz	P25		DMR	
	Min. Number of Trunked Channels	Residual Ethernet BW	Min. Number of Trunked Channels	Residual Ethernet BW
QAM256	5 Channels	46 kbps	7 Channels	53 kbps
QAM64	4 Channels	24 kbps	5 Channels	38 kbps
QAM16	2 Channels	13 kbps	3 Channels	23 kbps
QPSK	N/A	N/A	1 Channel	8 kbps

How is this achievable?

MiMOMax uses multiple-input, multiple-output technology and space–time diversity, in combination with high orders of modulation and M-DAP (data acceleration protocol), to provide very high capacity in narrow bandwidths.

A high performance narrowband radio with optimised compression algorithm, combined with QoS management and forward error correction-processing architecture, are used to enhance the reliability. Finally, fast training algorithms for the equalising in fading channel conditions ensure high availability. The M-DAP assigns high priority to critical data packets.

M-CAM (Cognizant Adaptive Modulation) is another optional adaptive modulation feature that can further enhance system reliability by enabling the constellation to be varied from higher order quadrature amplitude modulation to a lower order modulation, based on the equaliser’s error performance.

The total system bandwidth available to transport the required number of channels is dictated by the modulation rates available for a particular application. The tables above give the absolute minimum number of P25 trunked or conventional channels that can be carried when using a particular modulation rate in a typical 2x2 MIMO link. The residual bandwidth in the table is available for PMR link management, and it’s possible to either carry more channels (depending on the Ethernet’s non-VoIP data rate requirements) or additional traffic.

As a result of bandwidth misconceptions and despite the RF propagation, implementation and cost advantages, narrow-band radio may be unjustifiably discounted as a backhaul solution for PMR and other higher bandwidth applications, when in fact it may be the best solution.

In conclusion, PMR linking solutions need to be robust and have the ability to rapidly re-train in the presence of destructive interference so that the overall availability is as high as possible in any given environment. Optimum linking solutions are those that support comprehensive FEC schemes but not at the cost of excessive latency. By using a combination of intelligent radio design and smart software features, it is possible to reliably support a large number of PMR channels in narrow bandwidth while still maintaining very low latency and jitter, to provide users with an efficient, economical and reliable customized communications solution.