The Difference Between Trunked and Conventional Radio Systems

Summary

Public-safety executives have more choices when selecting radio communications systems than ever before and the decisions are often marred in politics and high finance. A huge amount of money is in play over these choices. Equipment manufacturers, sales organizations, some consultants, and some government agencies are motivated to create the illusion of need for highly complex and proprietary technologies, even though simple systems would fulfill the business requirements and are often a better choice. Beware of politicians, bureaucrats and sales people specifying systems that use unnecessarily complex technology for first responder communication.

Nowhere is this more prevalent than when selling trunked radio systems to government entities. Trunked radio technology addresses some specific business problems, however it has major drawbacks. Sales tactics are aggressive and countless systems are sold to clients that would be better off without them. Many systems are deemed failures, often because the buyers didn't understand the shortcomings before implementation. A cursory examination of these issues is presented herein.

Benefit of Trunked Radio Technology

Trunked radio systems take advantage of the probability that with any given number of users, not everyone will need channel access at the same time. Therefore with a given number of users, fewer discrete radio channels are required. From another perspective, with a given number of radio channels, a greater quantity of users can be accommodated.

The quantity of simultaneous conversations is limited by the number of discrete channels, minus one. Trunking does not increase the number of possible concurrent radio conversations beyond the quantity of discrete radio channels. Rather, trunking permits the discrete channels to be dynamically assigned in a manner that is more efficient than non-trunked systems.

Should a channel fail in a trunked system, the affected radios can possibly be automatically moved to another channel with only a slight degradation of service.

Trunked systems offer some limited security features, as radios have to be registered before they can be used. This benefit is generally negated by the fact that trunked radio systems are highly vulnerable to sophisticated denial of service attacks that could render a radio system useless for a very large number of first responders.

Incidental features include the ability to individually disable a radio if it's lost or stolen, and to silently transmit an identifying number with all broadcasts made from a mobile or potable radio.

By Daryl Jones (http://blog.tcomeng.com) December 2007

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How Trunked Radio Systems Work

Trunked radio systems work by sending computer data between a mobile radio and a central controller. When a mobile radio user presses the push-to-talk button, the radio sends a digital message to the system controller requesting a channel assignment. If a channel is available, the system controller sends a message back to the mobile radio with the channel assignment information, and also broadcasts a similar message to other radios in the fleet so that they can tune to the designated channel if necessary. A voice conversation can occur after the channel assignment process is completed.

Trunked radio systems can be designed to use analog or digital modulation for voice, even though the control channel is used for data.

A good analogy is to think of a trunked radio system working like the waiting line in a bank. Customers typically wait in one line for the next available teller. Conventional (non-trunked) radio systems work more like a supermarket, where customers queue up behind a checker that they choose. Rules of queuing theory prove that more customers per hour can usually be handled with a single line such as in a bank, but practicality often dictates that the supermarket model sometimes works better.

The Downside of Trunked Radio Systems

Radio systems take on an added dimension of complexity when coupled with computer software that controls channel assignment. This complexity offers some benefit, but it also has a significant downside. The benefit should be carefully compared to its problems and risks. Generally speaking, the best radio systems are those that are sufficiently complex only to meet the business requirements. Complexity beyond that point is detrimental to overall effectiveness.

Technical Issues

- Trunked radio systems rely on a centralized computer controller to make channel assignments. Trunked systems will fail or be severely impaired when malfunctions of the controller occur. Problems with the controller could affect thousands of radio users in large systems.

- Most trunked radio systems are dependent on the building facilities where the controller is located. For example, trunked systems will fail or be severely impaired if electrical power problems occur, or there are temperature or humidity problems, or structural problems with the building itself. Non-trunked systems can be made diverse by locating comparators and other common equipment at multiple locations, so as not to be dependent on a single building.

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- Trunked radio operation will be unavailable or severely compromised if the central controller becomes isolated from its remote radio sites. This can affect thousands of users. Equipment at remote radio sites is typically connected to the controller (and related equipment at the controller location) via microwave radio facilities and/or telephone circuits. Well-designed conventional radio systems are typically built using a compartmentalized approach so as not to be dependent on a single building or facility.

- Trunked systems typically serve a large number of users over a wide geographic area. Small problems can have a major impact on thousands of radio system users.

- It's rarely talked about, but well-known by public-safety radio engineers. It is possible for a sophisticated hacker to maliciously craft digital messages to confuse or disable trunked radio systems. This is much more damaging than mere jamming of the control channel(s). This vulnerability can be partially mitigated by encrypting the control channel messages; however this is expensive and can make regional interoperability impossible or much more complex.

- Trunked radio systems have a significant delay from the time a radio push-to-talk button is pressed until the user can start talking. This delay occurs while the trunked radio system is finding and assigning an appropriate channel.

- Trunked radio systems can handle a finite number of simultaneous conversations. The number is usually limited by the quantity of discrete radio channels, minus one. Users will hear a busy signal if all channels are in use.

- The audio latency through a digital trunked radio system can be quite high. To put this in perspective, consider a law enforcement tactical operation where the operatives rely on hand signals as well as radio communication. A team member could raise his arm to touch his PTT button, speak a message, then put his arm down - all before the other team members hear the message. The audio and visual communication is incongruent, resulting in potentially critical error.

Business Issues

- Most trunked radio systems rely on proprietary software. Unlike conventional (non-trunked) radios that allow various brands of radios to seamlessly communicate, most trunked radios contain software that is licensed exclusively by the manufacturer. Most trunking software is viewed as a trade secret by radio manufacturers.

- For the most part, trunking-capable radios cannot be competitively procured. Radio pricing is established without the benefit of competition. Once an agency commits to a

particular product, the manufacturer can set any price it desires for add-on products, software upgrades and services.

- Interoperability with radio systems that use different trunking technology (different brand of equipment and/or different software versions) is usually not possible.

- Trunked radios cost between three and five times more than non-trunked radios over the life of the equipment.

- System operators often view the radio system as a source of revenue that will exceed the cost of operating the system. Sometimes trunked radio systems become profit centers for government entities at the expense of others. Cost sharing is not always equitable.

- Trunked radio systems are similar in many ways to managing complex computer networks. Change management policies must be developed and enforced. Software upgrades will need to be purchased and installed. Upgrades will have to be carefully managed to avoid disruption to critical services. The highly skilled team of engineers and technicians that will be required to manage a complex trunked system is quite expensive.

- Incremental replacement of infrastructure equipment is often impossible because of the need to use compatible software and firmware versions in all equipment. Current software often won't work in older hardware, even though the older hardware may be in excellent condition. Hardware that is in good condition must be replaced at considerable expense, just like we have to do with computers.

- It is technically and politically complex, and very expensive to expand coverage or make changes to trunked radio systems. Since trunked radio systems are intended to serve large groups of users, consensus must be developed for even simple changes. Cost sharing for enhancement and change is usually an issue that results in long delays.

- Trunked radio equipment has a comparatively short life cycle due to planned obsolescence. Equipment will need to be replaced due to software obsolescence rather than traditional “wear and tear” factors.

Trunked System Software Reliability

There is also a lesser, but still considerable, issue of software and firmware reliability. The greater simplicity of fixed circuit-based logic means conventional systems can generally be perfected to a very high standard of reliability before leaving the design lab. Short of physical hardware deterioration, nothing typically alters the state at a later time. In the vastly more

sophisticated world of software and firmware, not all bugs can be identified in the time manufacturers are willing to spend on pre-release testing. This places the onus of beta-testing on the users. In critical systems like public-safety communication, the result of bugs rearing their heads at inopportune moments can be life-threatening. While it's certainly possible to eliminate all bugs from a software or firmware environment given adequate time, this possibility tends to be thwarted by the irresistibility of constantly changing (upgrading) software and firmware code after manufacturing. Every new feature brings more bugs. Even bug fixes can introduce new bugs.

More than half of the trunked system failures that we have investigated stemmed from software defects, or incompatible versions of software being used in the same system.

Well-designed conventional (non-trunked) systems offer greater reliability through simplicity of design.

Conclusion

Given the public's perception of anything "digital" being cutting-edge and inherently superior to analog, I think the move by some agencies to trunking is being driven less by technical considerations than by politics and bureaucracy trying to make itself appear proactive to voters and/or superiors according to the popular simplified perception of the analog vs/ digital issue. In the end, the disadvantages are borne by our first responders, and by the public itself.

Trunking is a compromise that may be warranted when a certain set of business issues exist. If those issues don't exist, then trunking is an unnecessarily expensive and complex technology that should be avoided.

I recommend that every agency executive who may be considering a trunked radio system seriously consider the consequences. Be forewarned of politicians, bureaucrats and salesman who recommend communications technology that they may not fully understand, and may be motivated to promote for nefarious reasons.

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