Mobile Radio Protocols Used in Two Way Radio Communications

What comes to mind when asked about radios? There are two types of radios: broadcast and two way radios. Broadcast radios are used for listening, while two way radios are used for two or more people to talk to each other. In broadcasting radio, music or radio shows are transmitted so that people can listen to them on the receiver. Two way radios are used by the police, the fire department, hospitals, and transportation. Each organization uses two way radios to communicate with each other quickly and efficiently. Two way radios use trunked radio. Trunked radio got its name from the world of telephony. Once there were two cities that would bundle their connections together. That bundle looked like a trunk of a tree, also known as a trunked line. The local household loop lines operated like branches of a tree, one for each household (“Basic Radio Awareness” online). In trunked radio, which is computer-controlled radio, calls are set up between radios, using the messages that are exchanged through the air. The message exchange process is achieved through radio signal transmission methods (FM and AM). To make a call, one must first register the radio, and then establish the call on a trunk channel. After both registration and call setup are complete, there are many different types of calls available for radios to utilize. There are also conventional radios, and those radios are different than trunked radios and have different advantages and disadvantages than trunked radio. Radio signal transmission methods are fundamental to how calls between radios work.

FM (frequency modulation) and AM (amplitude modulation) are two methods for how radios transmit information. “A radio broadcast normally consists of only one information signal” (“Radio Technology" online). The signal’s intensity, like light intensity, decreases as the distance from the radio increases ("Radio Technology"” online). The radio signal intensity is important to account for when setting up radio communications. Modulation of the frequencies of signals is needed in order to carry information via a carrier wave. Modulation changes one aspect of the carrier frequency (the frequency that is sent over the air) such as its amplitude, frequency, or duration ("Radio Technology" online). FM modulation changes the frequency, not the amplitude of a radio wave (“FM Radio” online). AM modulation changes the signal strength of the wave, not the frequency (“AM Radio” online). FM radios are in the 100MHz range, while AM radios are in the 1MHz range (“Radio Wave” online). FM radios thus have a larger range of frequencies than AM. There are disadvantages to both AM and FM. AM is susceptible to atmospheric noise. For example, lightning causes crackling to be heard on AM radios, and switching high-voltage power lines can create crackling noise as well ("Radio Technology" online). These “interferences occur when an undesired signal overlaps the channel reserved for the desired signal” ("Radio Technology" online). FM requires more space for the frequency because in order to modulate the frequency, the transmitted signal must be made wider or narrower (O’Byrne Personal Interview). Bandwidth is also important for FM and AM. “The radio-frequency bandwidth is the range of frequencies covered by the modulated radio-frequency signal” (“Radio Technology"” online). The more bandwidth that is given and the smaller each call’s bandwidth is, the greater number of calls could be possible (O'Byrne Personal Interview). While signals, FM, AM, and bandwidth are all crucial to send information, registration of radios is needed before calls can commence.

In order for a call setup to occur, the radio must be registered to the controller. “A controller is a device containing a computer processor that makes decisions about which users can access a system and makes decisions about how resources are used within the system” (O’Byrne Personal Interview). Registration is a process that, for the purpose of simplifying, the Connect Plus handles. Connect Plus is a trunked radio system made by Motorola (O’Byrne Personal Interview). The registration process has two main purposes: “ (1) It limits system access to authorized users, and (2) It provides the controller with the important information it needs to properly route calls and efficiently utilize RF and IP bandwidth” (MOTOTRBO ™ Connect online). RF stands for radio frequency. IP bandwidth is the measurement of the amount of data that can be conveyed between two points (O’Byrne Personal Interview). Registration occurs on the Control Channel time slot (MOTOTRBO ™ Connect online). A time slot is a type of digital signaling that uses time division in order to get multiple conversations on the same frequency at the same time (O’Byrne Personal Interview). When the user’s radio sends the registration request to the controller, the controller receives that request and checks three IDs. One ID is the Unit ID, another is the radio’s Serial Number Authentication or Physical Serial Number (PSN) authentication, and the last one is a Group ID (MOTOTRBO ™ Connect online). The unit’s serial number is in the controller’s database, while the physical serial number is embedded in a chip (O’Byrne Personal Interview). Once all of the IDs are valid, “the controller sends an affirmative response to accept the registration” (MOTOTRBO ™ Connect online). If any of the users are not in the controller’s database or if the user is marked as “disabled”, the controller rejects the registration. As well as registration, radios are also de-registered. “The process of de-registration is also important because it tells the controller which SUs and Talk Groups no longer require system resources” (MOTOTRBO ™ Connect online). SUs are individual radios (O’Byrne Personal Interview). So AM, FM, and registration are all required for calls, but there is another aspect that needs to occur before radios can begin to talk to each other.

Call Setup is something that is integral for radios to communicate with each other. “The SU sends all Call Requests on the Control Channel time slot” (MOTOTRBO ™ Connect online). Based on those call requests, the controller has to perform multiple checks. In a private call, there are two different radios: the Source ID radio and the Destination ID radio. The source radio is the radio that is initiating the call, while the destination radio is the radio that is receiving the call from the source radio. Both radios have to be “enabled” in the controller's database and the radios have to be registered. If the source radio is “disabled” or not present in the database, the controller denies the call request and disables the unit. If all of the checks are okay, the controller then looks at the calls currently in-progress. The purpose of these checks is to determine whether the Destination ID is already active and to see whether there is a channel resource available to utilize. If the destination radio is busy, the source radio is sent a message to try again later. If a trunk-to-time slot is needed, but none is available, the controller tells the source radio that it is put into a Busy Queue (MOTOTRBO ™ Connect online). A Busy Queue is a list of radios that are waiting for a channel (O’Byrne Personal Interview). Call setup is the second part to how radios prepare to talk to each other, but trunking capability controls how these calls occur.

Conventional radios were used before trunking radio, and were fixed to one frequency. Trunking radios changed the conventional radio methodology so that there could be multiple frequencies, and trunking allocates the users among those frequencies (O’Byrne Personal Interview). Conventional systems have dedicated channels for different users (“Basic Radio Awareness” online). Some also scan more than one channel to achieve correct transmission (“Two Way Radio Technology" online). Users manually control how the channels are dispersed through the use of a knob in conventional radio use. Users could also manually select a drop-down menu on the radio. In trunking, a computer processor is the one that controls channel selection. Conventional radios make the user have to wait for a call to end on a channel before he can use that channel. Users are thus limited to how many channels they have access to. If a user wants to have a channel available, he has to program the channel into the radios (“Basic Radio Awareness” online). Trunking radio uses multi-channel systems for separate purposes, and if all physical channels are busy, “some systems include a protocol to queue or stack pending requests until channel is available” (“Two Way Radio Technology” online). Trunking radio is based on the theory that not everybody will want to use a channel at the same time, and there are more users than there are channels. Because of that, trunking radios automatically assign calls to a channel when there is one available, otherwise the trunking controller puts the call in the busy queue (“Basic Radio Awareness” online). Trunking is better in some cases because users do not have to wait as long to be able to talk to other users. However; the controller is expensive, and if there is a small company wanting to utilize radio communication, it would use conventional radio, because the cost is lower than trunked radios and there is not a huge demand for channels to use for talking. While trunking allows for less waiting, one communication path has to be dedicated for signaling, leaving it unusable for other users. The trunking radio and conventional radio methodologies, as well as registration and call setup, are all important. To utilize these aspects efficiently, there are different types of calls that users can choose from based on what they want to accomplish.

There are many different types of calls that users can utilize in order to talk to other radios. There are two types of voice calls, ones with no Control Channel acknowledgment and others with Control Channel acknowledgment. The calls with no Control Channel acknowledgement includes group calls, multigroup calls, site all calls, and network wide all calls. The calls with Control Channel acknowledgment includes private calls, and remote monitor calls. Group calls consists of one or more radio transmissions that can be heard by all radios with the same Talk Group ID. Multigroup calls have one radio talking and that radio can be heard by other radios that are programmed with the same MultiGroup ID. Site All calls also have one radio talking heard by all radios that have the same site where the transmission occurs. Network Wide All calls is a one way voice transmission that is begun by some device (that may not be a radio) that connects the Connect Plus network with something other than a radio (MOTOTRBO ™ Connect online). No Control Channel acknowledgment is good for group calls and getting in contact with multiple users at once. There are also Channel Grants that assign the Source and Destination ID to the trunk-to-time slot in no control acknowledgment calls, which is useful for “late-joiners and radios that return to the Control Channel time slot before the call ends due to fade” (MOTOTRBO ™ Connect online). In the Control Channel acknowledgment call types, there are private calls as well as remote monitor calls. Private Calls consist of one or more voice transmissions between the Source ID radio and the Destination ID radio. The remote monitor call type allows a user outside of the controller’s database to activate a target radio’s microphone and transmitter for a period of time (MOTOTRBO ™ Connect online). Control Channel acknowledgment calls are useful because they make sure that the destination radio is available before the call is setup. Having different types of calls is important because there is a system that prioritizes calls and there are different options for users to choose from.

Two way radios have multiple components that come together to make them sophisticated yet efficient. Some components include the radio signal transmission methods, which establish how information is transferred between the radios. Two other components include the fact that radios have to be registered and that call setup has to be made before a call begins. The call itself is connected through trunking, and there are many different types of calls that can be initialized. Two way radios are not just used in Motorola, but in many other organizations and companies, such as hotels, the fire department, the police department, hospitals, and transportation agencies. These companies and organizations need to communicate with each other in order to convey and spread information efficiently. Without that communication, those companies or organizations would not be able to function, as long distance contact would not be possible. Given these considerations, two way radios should be acknowledged for their usefulness and intricacies.