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Network Design for Emergency Communications

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Emergency Communications organizations are implementing TCP/IP networks to support a variety of functions, with a key long term goal of supporting IP based calls that meet the Next Generation 9-1-1 standards. In evaluating needs for new or expanded networks, key areas of consideration are as follows:

- **Bandwidth required to satisfy operational needs at a given time**
- **Quality of service to support voice emergency calls**
- **Network reliability and redundancy**
- **Network management tools or managed services support**
- **Initial costs and ongoing monthly costs**

This paper provides a review of factors contributing to each of these areas above to allow you to make better decisions regarding your Emergency Communications networks.

Bandwidth:

The bandwidth in each segment of your network, in bits per second, will be the primary driver of the ongoing network costs, so careful analysis of current and future needs is important to your operations. Examples of typical functional requirements and related bandwidth are as follows:

- *Remote management* is a valuable function when networks are in place, so changes in systems can be made without driving to the remote site. Very little bandwidth is required for this, as little as 56,000 bits per second (56 kbps). With proper security, this can be provision via an Internet connection without a dedicated network.
- *Voice connections* for PSAP calls and radio interoperability can vary according to the voice quality required. A typical high quality compressed voice channel will require about 20kbps (20,000 bits per second). Thus, if 10 voice channels are required to and from a particular site, at least 200kbps in bandwidth would be required. Also note Quality of Service in the next section.
- *File transfers* between sites for mapping updates, data backups or other functions will require bandwidth according to the file size and the time allowed for the transfer. If a 1MB file (1 million bytes or 8 million bits) must be transferred in 1 second to assure very fast updates, then a link with about 10mbps of bandwidth will be required. If there are no time constraints, then a much smaller bandwidth can be installed. A 100kbps (100,000 bps) link could transfer the same file in about 100 seconds.
- *Real-time remote applications* access requires calculations similar to files transfers. If a remote terminal is accessing mapping and applications data, the amount of data and the required response time will dictate the bandwidth required. If a map screen update requires 100kBytes (800,000 bits) and the desired update time is 1 second, then at least 1Mbps will be required on the remote link. This link could support multiple terminals with the same requirement, as they do not require simultaneous or continuous updates.

Combining the various bandwidth requirements will allow you to develop total bandwidth needs for each part of your new network.

Quality of Service:
Packet based voice streams (Voice over IP or VoIP) require priority in the data stream to assure timely delivery of packets and to minimize loss of packets. In a network, this function is known as *Quality of Service*. Network routers and switches are programmed give first priority to voice packets and lower priority to data packets in the network, assuring high quality VoIP calls at all times.

Network Reliability and Redundancy:
Emergency Communications networks must be available to the maximum extent possible. If a PSAP network connection is out and calls can be rerouted to another PSAP, it might be possible to allow lower reliability than for a PSAP with limited alternative answering arrangements.

For reference, the often mentioned "Five 9s" is an uptime of 99.999%, or about 5.3 minutes of downtime per year. Uptime of 99.99% is a little less than an hour per year and 99.9% is about 9 hours per year.

Networks that support remote maintenance and mapping updates can tolerate worse uptime that networks that support actual emergency communications or real-time mapping, location or remote recording connections. A review of your current PSAP uptime related to the network connections is a useful means to evaluate the desired reliability of new network configurations.

The redundancy built into the network will help determine the reliability, where the following are examples of redundancy:

- Two separate, physically diverse network access lines to each PSAP into the core network
- Core network structure with a ring topology, such that a break in the ring (such as a backhoe digging a ditch) will not interrupt communications, as the traffic can be carried in either direction on the ring
- Two different core networks, such as a carrier based network in parallel with existing radio systems microwave network

If a location has two network access lines, each with 99% uptime, the total uptime will be 99.99% - the probability that at least one of the lines will be up.

Network Management:
Ongoing measurement of bandwidth utilization in your network is the simplest means to understand when expansion of the capacity is required. If you have network services provided by a communications carrier, they should provide you with access to both real-time performance information and historical performance data to allow trending of network utilization for planning purposes.

If you develop and deploy a mixed network with multiple network providers (carrier, fiber, wireless, microwave, etc.), relatively inexpensive software tools can provide network utilization data and historical network data from each network router and switch, including uptime on each of these network components. A support services vendor can also provide these same management and monitoring capabilities if your internal technical resources are limited.

Costs:

Ultimately, your financial resources must be a critical factor in the network design. The network costs are influenced, in order of importance, as follows:

- Bandwidth required for each PSAP and total bandwidth required in the core network. Higher bandwidth results in higher monthly costs, particularly when each location requires more that a single digital T-1 connection (1.544 Mbps) from that communications carrier.
- Reliability and redundancy required in the network. More reliability (higher uptime for each location) results in higher monthly costs.
- Network management and monitoring will be a very small cost in the overall annual costs for the network.
- Quality of service for voice traffic is simply an initial configuration task and has no monthly cost consequences.

In summary, the actual deployment of network links and connections for new networks or network upgrades should be planned after an analysis of the bandwidth and reliability goals of the network and the available network provider options to meet those goals. Successful networks deployed by 9-1-1, public safety and Homeland Security organizations include combinations of the following:

- Local commercial carriers – AT&T, Verizon, CenturyLink, etc.
- Local or regional fiber optic communications providers
- Cable TV companies with fiber optic backbone networks
- Local or regional wireless services providers
- Purchased wireless communications links – microwave links, Wi-Fi, etc.
- Existing Public Safety radio networks with microwave/wireless links among sites

These can be interconnected to create reliable, cost effective TCP/IP networks that will satisfy the functional considerations described in this paper.

Close attention to your bandwidth and reliability requirements will help you minimize the costs of your Emergency Services Network and assure that it meets your operational goals.

Contact Avistas today for a
Complementary Executive Review of your current situation.

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