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MODEM SPEED VS. EFFECTIVE DATA RATES: IPMOBILENET'S STRATEGY FOR SUCCESS

Manufacturers of wireless data equipment feature data rates of 9.6 Kbps, 19.2 Kbps, 32 Kbps, 64 Kbps, and up. These numbers reflect the bit signaling rate in a single radio modem on a system. They do not reflect actual throughput on a multi-user system. A system that has the best bit signaling rate or modem speed is not guaranteed to have the best multi-user throughput. IPMN utilizes many advanced techniques and technologies to achieve superior effective data rates in multi-user, varied message model settings. The purpose of this paper is to discuss the effects of these methods on increasing effective data rates and performance.

IPMN techniques and technology focus on a number of parameters that have significant impact on the effective data rate. These include:

1. **MESSAGE SUCCESS RATE**: Radio modem performance, link layer protocol, forward error correction, radio air data rate.

2. **FORWARD ERROR CORRECTION**: "Spare parts" are sent with every packet of data to reconstruct damaged messages (transparent to the user) without requiring retransmission.

3. **NETWORK PERFORMANCE**: Data slot management, dynamically allocates multiple simultaneous data transmissions, dynamic channel loading.

4. **LOW MESSAGE OVERHEAD**: IPMobileNet's native IP solution uses low overhead message headers and eliminates the overhead and other challenges associated with middleware or IP-emulation software.

MESSAGE SUCCESS RATE

First-time message success rate has the most significant impact on the effective data rate. If a 2 kilobyte message is sent to the mobile, but the message is corrupted due to a low RSSI or multi-path fade, then the message must be resent. This is important, because when messages are not successfully received, the entire message may be resent. Multiple re-tries are disastrous to throughput rates. Each time a message must be resent, it effectively cuts your data rate (or throughput) in half. For a mobile unit that operates in an area that is on the edge (fringe) of the coverage region, the message may be resent several times, rapidly eating-up bandwidth that is needed for other users on the system. While over-the-air data rates reflect system capacity on a theoretical level, it is clear that high message success rates give increased system performance and capacity.

IPMN uses several strategies to ensure high message success rates, which translates into superior system performance:

- **Patented Intelligent Diversity Reception**: Mobiles and base stations actively seek the strongest and most reliable signal from multiple receivers. The intelligent diversity module polls each receiver 50,000 times per second, and automatically switches to the receiver that has the best signal. Diversity reduces the destructive effects of a multipath fading by up to 100 times.
- **Radio Performance**: Critical radio characteristics include receiver sensitivity, adjacent channel rejection, FM capture ratio, channel switching times and TX/RX switch times. Mobiles and base stations are designed to receive and reconstruct marginal RF transmissions.
- **Collision Tolerant Modems:** Modems are designed to mitigate multiple messages lost during simultaneous transmissions. Downlink collisions are prevented by the IPNC. IPMobileNet has patented anti-collision technology on each base station.
- **Bit Interleaving:** Bit interleaving and data scrambling is employed to minimize the effect of burst noise. This effectively spreads "important" bits out in time to improve immunity to a deep multi-path fade.

FORWARD ERROR CORRECTION (FEC)

Any wireless manufacturer can modify data packet sizes, minimize FEC packets, and otherwise increase over-the-air rates. The effect of these strategies to increase a single mobile's operating speed is to degrade system reliability and first time message success rate in a live, operational system.

The real proof of a system's performance is based on the number of mobiles that may be supported on a per-channel basis. Actual throughput and system performance is based on the ability to successfully transmit and receive messages on the first try, avoiding retries that consume available bandwidth and decrease throughput. IPMobileNet design engineers devote their development efforts to increasing data rates without compromising message success rates. We are committed to providing real value to our customers by understanding the mobile data environment in which these systems are deployed.

One method of improving the effective data rate is to minimize the size of forward error correction (FEC) packets. IPMobileNet rejects this strategy because minimizing FEC packets has a disastrous effect on system performance.

FEC is a packet of "spare parts" that is sent with every message to ensure that messages are successfully received. While a listener may be able to piece together the meaning of a voice message that breaks up over a radio or cell phone, modems that receive data require a much higher level of message integrity. IPMobileNet modems use the FEC "spare parts" embedded in each data packet to reconstruct data that was lost due to fades (Doppler or Raleigh), or poor signal. Fades and poor reception may be attributed to vehicle movement, physical obstructions (such as buildings, mountains, or foliage), or simply because the user is trying to receive from a location on the boundaries of the coverage area.

Sending fewer FEC spare parts leaves more room for content (and increases amount of data that may be sent in any given packet), but it negatively impacts the ability for messages to be received successfully. This is important, because when messages are not successfully received, the entire message must be re-sent. Multiple re-tries are disastrous to throughput rates. Each time a message must be resent, it effectively cuts your data rate (or throughput) in half. While over the air data rates reflect bit signaling rate, it is clear that high message success rates give increased system performance and capacity.

NETWORK PERFORMANCE

The technologies and strategies employed for the management and control of a private radio system also has a significant impact on overall system performance. Control features directly impact the effective data rates of a multi-user system. Network controllers manage and dynamically allocate multiple simultaneous data transmissions on a single frequency without collisions, retries, or waiting. This routing of data and channel management if done improperly can reduce the effective data rate by up to 50%.

The IP Network Controller (IPNC) uses a Linux software platform, operating on a tower or rackmount server. The IPNC routes messages to/from mobile users, handles bandwidth allocation, multi-access protocols, hand-offs, load leveling, wireless network synchronization and time slot allocation. The features and efficiencies of the IPNC have continually evolved since its introduction in 1999, including advanced routing strategies for seamless roaming in multiple channel and/or base station systems, Time Division Multiplexing, simultaneous uplink and downlink traffic management, and more.

LOW MESSAGE OVERHEAD

One method of improving the effective data rate is minimizing the non-essential data that is sent over-the-air. In IPMobileNet systems, the complete IP message (including IP header) is sent over the air. No additional address translation or wireless header is required since all the information needed to route any packet is in the IP header. IP is the native mode of communication for all wired and wireless IPMobilenet network components.

IP connectivity on other systems is achieved through middleware, installed on each mobile data computer on the system and at a server on the LAN or dispatch center. These systems embed their proprietary, non-IP header in each message, as well as the header associated with the IP emulation software. This extra overhead (non-essential data) utilizes valuable bandwidth that could be used for sending and receiving essential mobile computing data.

In some other systems, a mobile user (radio modem) is required to send a request to broadcast over the air. The controller must receive this request, and the controller must send a message over the air to the mobile to give permission to transmit. The added transaction time and the use of available bandwidth for non-essential communication

significantly slows the transaction times for sending and receiving essential data. IPMobileNet's modified slotted ALOHA network management scheme eliminates the need for requesting permission to transmit a message, saving time and bandwidth.

SUMMARY

Increasing modem speeds can in some cases provide a nominal increase in the bit signaling rate in a static, laboratory environment. In a real-world multi-user system application however, increased modem speed comes at the cost of effective data rates, throughput, and system performance. IPMobileNet's methods of increasing system performance (message success rate, forward error correction, network performance and low overhead) provide real **effective data rate improvement** in a multi-user environment without any compromise in coverage or increases in cost.