Voice over IP

Outputs

- Metrics and measurement methods for real-time traffic over long 802.11b links.
- Standards contributions (TR-41.1) detailing the behavior of real-time VoIP traffic over long 802.11b links.

The market availability of Voice over Internet Protocol (VoIP) equipment continues to increase, due to the many advantages that this technology offers. These advantages include efficient resource utilization, a homogeneous network offering both voice and data, potential for other multimedia transmission (e.g. video), and lower data bandwidth requirements than traditional telephony.

As wireless local area networks (LANs) based upon IEEE 802.11b (Wi-Fi) technologies become more ubiquitous, attempts are being made to utilize VoIP over radio channels as well as the fixed location wired networks more traditionally associated with VoIP systems. However, propagation effects within the wireless channel can substantially degrade the Quality of Service (QoS) of a VoIP system. As VoIP and Wi-Fi technologies converge, knowledge about the type and extent of these effects assumes increasing importance.

In order to evaluate some of the potential impairments implicit in VoIP transmission over Wi-Fi channels, ITS has created a testbed with three 802.11b long links. Two of these links, of length 1 mile and 10 miles respectively, are being used to evaluate the effects of 802.11b long link transmission on network parameters related to VoIP. They simulate two different environments, rural and suburban, and also represent two slightly different radio setups.

The shorter link is essentially a peer-to-peer link that runs from the ITS Wireless Networking Research Center to a test location one mile distant on a nearby hill. This link uses directional antennas, but is otherwise unamplified. Since its path traverses open fields, it represents a rural environment.

The second link has one end node on the same hill, but it passes over a well-populated residential area, with all of the potential interferers that are implied by such a traversal. The link terminates in a node situated in the ITS field site on the Table Mountain plateau. This link utilizes amplification to achieve the distance required, in the form of a constant power 250 mW output amplifier and a standard 17 dB input amplifier. Although the shorter link runs in peer-to-peer mode, this longer link is terminated at both ends by wireless access points. Both links use 24 dBi directional antennas at each end and both are line-of-sight.

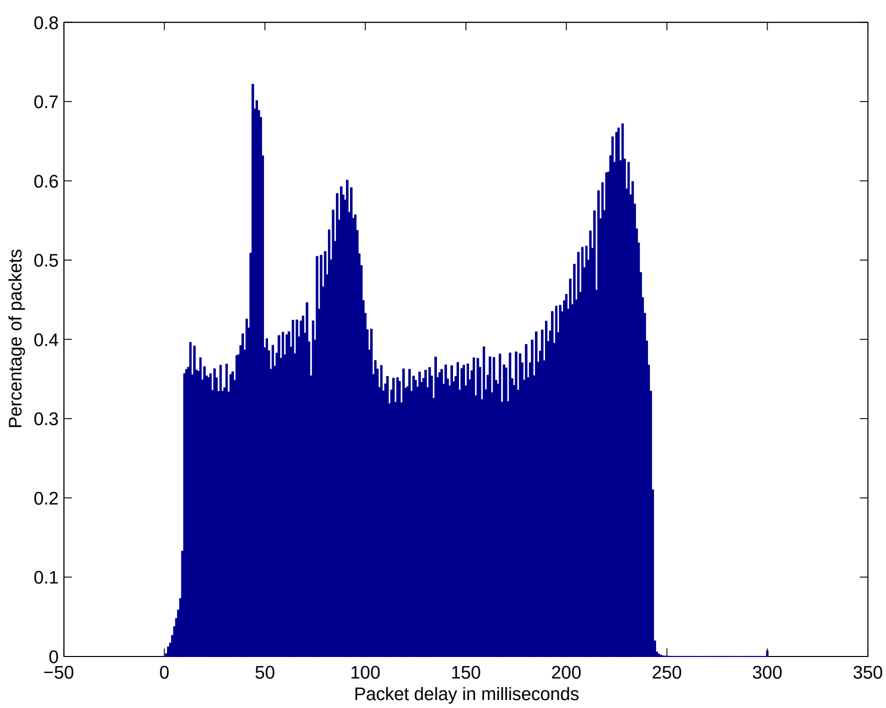

Figure 1. Packet latency distribution over a 1-mile peer-to-peer 802.11b link.

Both links achieve true realizable throughputs of approximately 4 Mbps, a value that is consistent with 802.11b technology operating at maximum burst speed. Initial experiments concentrated on the measurement of jitter and packet loss in the system. Both of these parameters are of great importance in services like VoIP that require a real-time transport capability — jitter because packets that are delayed beyond the time length of the jitter buffer must be dropped, causing gaps in the output stream, and packet loss because the real-time nature of the required transport makes it impractical to retransmit lost packets.

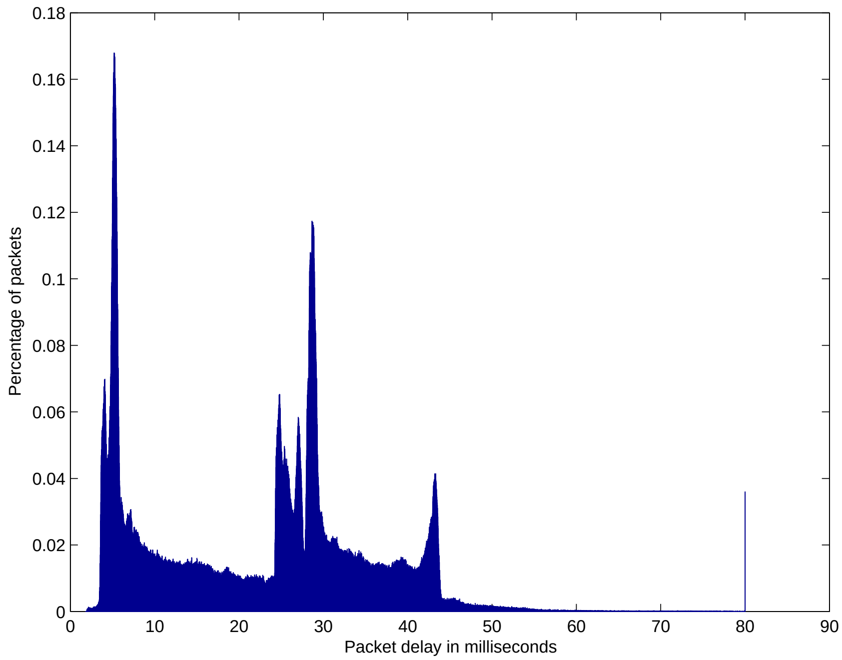

Figure 2. Packet latency distribution over a 10-mile 802.11b link.

Representative results from the two links are shown in Figure 1 (on the previous page) for the 1-mile link and Figure 2 (above) for the 10-mile link. It is immediately apparent from the figures that the shorter link has a much greater variation in latency than the longer link. Although the short link has a smaller minimum value — 0.3 milliseconds versus 1.9 milliseconds for the long link — the mean value for the short link is considerably greater than that of the long link — 129.8 milliseconds for the 1-mile link and 22.4 milliseconds for the 10-mile link. Losses for the short link also exceed those of the long link, although neither figure is high. Packet loss for this experiment was 0.11% for the short link and only 0.02% for the long link. The standard deviation of the short link delays is 94.6 milliseconds, and that of the long link delays is 45.6 milliseconds. By this metric, the jitter on the two links is similar within a factor of 2.

In real time VoIP transmission, a jitter buffer must be maintained to deal with delayed and out-of-order packets. Packets that are delivered outside the time range of this buffer are discarded. Contrary to what might be inferred from the standard deviation numbers alone, the figures show that the delay variation for the short link peer-to-peer connection is approximately six times greater than that of the long link.

A comparison using a different jitter metric, the Inter Quartile range, gives more insight into these distributions. This value expresses the time difference between packets in the third quartile of the distribution and those in the first quartile. For the short link, this metric gives 126.0 milliseconds and the long link is evaluated at 22.2 milliseconds. These somewhat counterintuitive data may indicate that the peer-to-peer mode of 802.11b transmission is a bad choice for VoIP traffic due to poor jitter characteristics. This conjecture, as well as the reasons for the multimodal nature of both delay distributions, is under current investigation.

It is clear that the wireless channel is significantly more complex than a wired channel in regard to real-time traffic. Studies of this transport mechanism must include information about the radio environment as well as traditional network parameters. In addition, new and relevant metrics and measurement methods for these information channels must be devised. ITS research is aimed at providing this information.

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