A Networked Approach for Range Telemetry Applications

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Long Abstract

Today's test applications are faced with a shrinking spectrum and increased bandwidth demand due to a greater number, and increased sophistication, of sensors. This paper describes a new method for radio spectrum management using 802.11 wireless technology, and discusses the system design issues when applying this technology to the range environment. The paper illustrates how COTS WLAN may be applied to a multi-client, test and evaluation network.

Real-time aircraft telemetry data requirements have grown exponentially. This is primarily due to increased technical complexity of weapons systems and military air vehicles. As the complexity grows, more real-time flight test data is required to maintain today's level of test safety and efficiency. In addition, the electromagnetic spectrum allocated to aeronautical flight test has decreased over the past few years and continues to be threatened by the commercial telecommunications industry. [1]

The challenges facing the test community include managing the volume of sensor collected information on-board the test vehicle; reliably routing collected information from the vehicle to the ground in a bandwidth efficient manner; and effectively distributing information to, all in a cost efficient manner, using equipment that is physically compact, low power and non-intrusive to the vehicle under test.

The volume of sensor information can be managed by the use of smart sensors, which perform pre-processing of raw data prior to delivery, and by an intelligent data acquisition system, which dynamically selects sensor data that will be transmitted over the telemetry link. The intelligence may be autonomous to the data acquisition system, or controlled via the ground. The ground control solution implies a reverse command and control channel not normally considered as part of the test architecture.

The telemetry link itself must use a bandwidth efficient modulation scheme. Ideally, the link could be shared among multiple users to support a multi-vehicle test scenario. The implication is for a digital, time-shared modulation scheme.

In the dynamic allocation environment described, efficient dissemination and evaluation of information to consumers is mandatory. A networked distribution system, using standard protocols and intuitive means for data access, is suggested.

Given sufficient funding, an optimal solution that satisfies the described needs could be developed from the ground up with custom hardware and software solutions. The test community, of course, labors under limited budgets and resources inherent in today's environment. The use of Commercial-off-the-Shelf (COTS) hardware and software can significantly reduce the development cost of the system.

A potential architecture is based on 802.11 technology, which is a group of standards that define wireless LAN data communication systems. [2]

On July 1997, the IEEE approved the 802.11 standard which allowed for 2.4–2.4835 GHz wireless LAN communication systems using Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS) modulation at 1 to 2 Mbps. On September 1999, they approved the 802.11(b) standard which improved upon the previous standard by limiting the modulation to DSSS and increasing the data rate range from 1 to 11 Mbps. Also on September 1999 the 802.11a standard was approved that allowed for wireless LAN systems in the 5.15–5.35 GHz and 5.725–5.825 GHz frequencies. At these frequencies the available bandwidth is 300 MHz as apposed to the 83.5 MHz in the 802.11(b) band.

The U.S. 802.11a standard has been adapted in Europe to conform to that region's regulations; that variant will be called 802.11h. For 802.11a to operate in Europe, an IEEE 802.11h task group was formed and ratified a standard that used additional techniques to meet the continental guidelines: TPC (transmission power control) and DFS (dynamic frequency selection). TPC is a dynamic power management system, using minimum power to reach active users

rather than using a uniform power output. DFS ensures a reduction in interference with other systems, notably RADAR.

The data rate ranges significantly increased for 802.11, from the 802.11(b) 11 Mbps to 54 Mbps. but utilizes different frequencies depending upon user and their respective needs. The unique points of 802.11a include the ability to support multiple data rates from 6 to 54 Mbps utilizing a variety of modulation techniques, the use of convolutional error detection and correction, and the application of Orthogonal Frequency Division Multiplexing (OFDM).

The OFDM system provides a wireless LAN with data payload communication capabilities of 6, 9, 12, 18, 24, 36, 48, and 54 Mbps. Newer versions of 802.11 currently under consideration increase data throughput to over 100 Mbps. The occupied bandwidth of the signal is 16.6 MHz, regardless of data rate. This results in a >3 bits per Hertz occupancy factor at 54 Mbps. The system uses 52 subcarriers that are modulated using binary or quadrature phase shift keying (BPSK/QPSK), 16-quadrature amplitude modulation (QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, or 3/4. The OFDM symbol duration is 4 microseconds, regardless of data rate. A guard interval of 0.8 microseconds for multipath rejection exists.

The use of wireless technology in the range environment is attractive from a number of viewpoints, but is not without pitfalls. The system designer must address numerous design issues to produce an effective data link system. These system design issues include frequency of operation, environmental conditions, effective data throughputs, protocol considerations, need for encryption, and link performance. A key design issue that must be overcome is the high Peak to Average Power Ratio (PAPR) inherent to the OFDM waveform, which results in the need for high-backoff RF power amplification (and subsequent high DC power consumption requirements). These issues will be addressed later in this paper.

An architecture which satisfies the needs for managing the volume of sensor collected information, routing collected information from the vehicle to the ground in a bandwidth efficient manner and efficiently distributing information to consumers in a cost effective manner is shown in Figure 1.

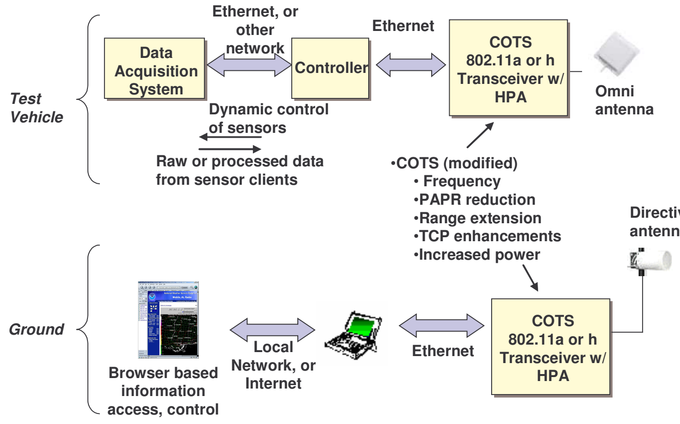

Figure 1 Network Based Telemetry Architecture

The architecture shown in Figure 1 provides distinct advantages for the range telemetry application. These advantages include:

- Networked based operation
- Duplex link, providing an efficient C&C link to the test vehicle that can be used for dynamic data acquisition and sensor control
- Robust performance due to ARQ protocol, ensuring guaranteed data delivery
- Integrated data privacy, soon to be the Advanced Encryption Standard (AES). [3]
- High data throughput, with adaptable or settable data rates between 6 and 54 Mbps
- Physically compact transceiver
- Expandable and flexible. The architecture is standards-based, and future 802.11 improvements can be easily absorbed.
- Cost effective, based on modified COTS hardware

References

[1]http://www.edwards.af.mil/ti/future_inst/artm.html

[2] IEEE Std 802.11a-1999 (supplement to IEEE Std 802.11-1999). Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification

[3] http://csrc.nist.gov/encryption/aes/