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MODELING OF DOD 25-KHZ UHF DAMA SATELLITE NETWORKS

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ABSTRACT

This paper considers the problem of optimizing "rules based" algorithms for use by a controller for assignment of satellite transponder resources for the DoD Demand Assigned - Time Division Multiple Access (DA-TDMA) protocol used on 25-kHz UHF SATCOM channels. The Block Oriented Network Simulator BONeS^{TM} by COMDISCO, Inc. was used to develop a baseline model consisting of a DA-TDMA controller, satellite channel, and user terminals. Using service delay as a metric - the number of user terminals, call rates, call durations, call precedence level distribution, and bandwidth available for resource assignment were varied. The mean and variance of the service delay was determined for several such cases. In this paper we present a brief overview of the protocol and model and simulation results are presented in the poster session.

1 INTRODUCTION

Demand for the use of 25-kHz Ultra High Frequency (UHF) satellite transponders typically far exceeds the available capacity. To increase channel utilization, the DoD is requiring all users of UHF Satellite Communications (SATCOM) to be Demand Assigned - Time Division Multiple Access (DA-TDMA) capable.

TDMA is a multiple access technique in which many users share the same channel on a time division basis. Users burst their traffic in a periodic time frame (time slot) and for the duration of their burst they have dedicated access to the transponder. DA refers to the dynamic assignment of channel resources based on user demand. Service is temporarily assigned and when the service is no longer needed the user relinquishes the resource to the control authority for reassignment.

The Military Standard (1992) for the 25-kHz UHF DA-TDMA waveform is organized as a sequence of repetitive 1.3866 second frames. The frame structure consists of both overhead and data slots as shown in Figure 1.

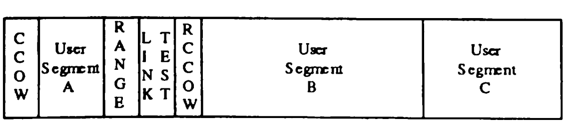

Figure 1: UHF 25-kHz DAMA Frame Structure

Channel Control Orderwires (CCOW) are issued by a centralized controller (essentially a data link manager) and are used to request terminal status, establish and tear down circuits, and other network management and control functions. Return Channel Control Orderwires (RCCOW) are issued by user terminals to report terminal status, request and cancel service, and report the completion of service. The RCCOW slot (channel) acts as a slotted aloha channel as described by Stallings (1985).

The waveform standard describes the fields within the frame structure and the information contained in those fields but it does not describe how the controller should make use of this information or how it should make resource assignments. By modeling the protocol, design trade-offs can be made to optimize network performance prior to implementation.

2 IMPORTANT SERVICE METRIC

Before describing the model we first need to discuss the service being provided by the controller, specifically the attributes of the service that are important to the user. We need a metric that can be used to measure some aspect of network performance in order to indicate how well the network is performing under various loading conditions.

The most important service metric is service delay (the time from when the user first requests the service until the service is granted). There are two basic contributors to service delay:

- Delay associated with transmitting the service request from the terminal to the controller. (We will call this terminal transmit delay.)
- Delay associated with the controller processing the request and granting the service (We will call this controller processing delay.)

Controller processing delay is affected by the following variables:

- Propagation delay.
- Number of terminals in DA-TDMA network and rate of RCCOW service requests.
- Number and types of slots in the controller's "resource pool".
- Distribution of connect time (how long the service is held by the users; this can be a function of the type of data transmission, i.e. voice or data).

- Call precedence level and the distribution of call precedence levels and the controller resource assignment algorithm.
- Preemption algorithm (to service higher precedence requests) and RCCOW throttling algorithm.

Terminal transmit delay is likewise affected by the number of terminals and the rate of RCCOW transmission, propagation delay, etc. Terminal transmit delay is affected by the following additional variables.

- Queue delay associated with waiting for clear-to-send conditions to be met prior to transmitting RCCOW.
- Contention back-off and retransmission delay of RCCOWs which do not receive an acknowledgment.

The primary job of the controller then is to minimize service delay for a heterogeneous group of multi-service users and to do it in some *optimum* fashion, where *optimum* is defined by the user community.

3 MODEL DESCRIPTION

The Block Oriented Network Simulator BONeS^{TM} environment was used to develop the model. What follows is a summary of model highlights.

The satellite channel is modeled as simple delay; contending RCCOWs are thrown away. The terminal, modeled as an Army AN/PSC-5 manpack radio, is a two port device supporting both a voice and data circuit. Terminals generate RCCOW messages and service requests (inhibiting additional service requests while being serviced) based on a Poisson distribution. When terminals do not receive an acknowledgment to an RCCOW, it is retransmitted in accordance with the requirements of the waveform standard.

The controller processes all RCCOW requests and maintains a data base of channel resources (available and assigned) and also terminal status (available, unavailable, and busy). If a user makes a service request that can be serviced immediately (channel resource and called party available), the controller assigns the resource. If the request cannot be serviced immediately, the user is notified and the request is placed in a first-in first-out (FIFO) with precedence queue. When channel resources become available the highest precedence, longest in-queue requests are serviced. The controller can monitor time in queue and if it exceeds some threshold, start to issue timed connects or preempt lower precedence users. These (and other) choices are a function of the implementation.

When RCCOW contention exceeds some threshold the controller throttles back on the RCCOW channel. When terminals do not receive an acknowledgment to a service request, a contention field within the service request RCCOW is incremented and the RCCOW retransmitted. The controller maintains a running average of the number of retransmissions and if it exceeds a threshold value, the controller (in this implementation) starts counting (modulo-3) and inserting the number in the Required Precedence field of the CCOW. Terminals having RCCOWs to transmit which do not meet or exceed this minimum precedence are prohibited from transmitting an RCCOW during that frame.

Simulation parameters include the following:

- Number of terminals (port IDs).
- Number and distribution of Priority 1, 2, 3 service requests.
- Mean and variance of voice and data call durations.
- Number and distribution of data slots which can be assigned to users by the controller.

4 NETWORK SIMULATION

We have provided a very brief overview of the protocol, introduced service delay as the important metric (from the users standpoint), described parameters that affect service delay, and outlined some of the mechanisms available to the controller to minimize service delay. In the poster session we will present simulation results for several different scenarios showing the mean and variance of service delay as a function of the indicated parameters and controller algorithms.

5 SUMMARY

There are an infinite number of operational scenarios and possible controller implementations that can be developed and modeled, for which the resource assignment rules can be optimized. Because these networks are not static and user communities may define optimum differently, we cannot expect any single set of rules to apply for all situations. What is needed is a controller that can match the rules to the operational scenario and the user communities definition of optimum.

From both a resource utilization efficiency standpoint and from an interoperability standpoint, the DoD needs to be moving towards the pooling and dynamic sharing of all radio frequency transmission resources under one control authority. Modeling can be an effective tool to help develop and optimize the Multiple Resource Controller algorithms.

REFERENCES

Military Standard, MIL-STD-188-183, 1992, *Interoperability Standard for the 25-kHz UHF TDMA/DAMA Terminal Waveform*.

Stallings, W., 1985, *Data and Computer Communications*, New York, Macmillan Publishing Co.