EFFICIENT NET ACCESS SCHEDULER IN MIL-STD-188-220A

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ABSTRACT

The presence of multiple stations on a single net requires a method for controlling the net access opportunities for each station. In order to minimize conflicts, various net access delay (NAD) schemes have been proposed to access CSMA timing slots randomly for channel requests. The current load factor NAD (L-NAD) algorithm used the load factor ($F_{load}$) which was computed based on neighboring station’s precedence level and number of FMUs required to transmit all of the data at the precedence level. It is desirable to adjust the scheduling interval to give neighboring stations with higher priority or longer queue of equal priority more opportunities to transmit. Since the NAD scheduler algorithm is a most critical control factor for network performance, the current L-NAD is modified to improve further the performance of the Tactical Internet Division and Below (TIDB).

INTRODUCTION

NAD algorithms constitute part of the MIL-STD-188-220A [Ref. 1,2] protocol. This protocol is implemented in the tactical router known as Internet Controller (INC). The first successful demonstration of a Tactical Internet occurred during TF XXI in 1997. Many valuable lessons were learned from this experiment; particularly about the effects of large numbers of users competing for air time in a Tactical Internet.

NETWORK ACCESS ALGORITHM

If a station is not busy transmitting voice, it calculates the NAD scheduler timer continuously. Two NAD schemes are currently implemented in the tactical Internet Controller (INC) to support SINCGARS nets: the Load NAD (L-NAD) and the Radio Embedded NAD (RE-NAD) described in MIL-STD-188-220A. The RE-NAD scheduler is dependent upon network size, connectivity, traffic load and local station’s recent use of the channel. The RE-NAD scheduler has been proposed for efficient data performance when all stations transmit data traffic evenly with light voice load. The L-NAD scheduler described next was used in TFXXI as an enhancement to the RE-NAD.

L-NAD ALGORITHM

The current NAD scheduler timer ensures that each station has an equal chance of accessing the channel. Upon expiration of the previous $T_c$ the continuous L-NAD scheduler interval ($T_c$) is recalculated if the channel is not busy by voice:

$$T_c = SchedIntMinFix + \text{random (SchedIntLimit)}$$

where

- $SchedIntMinFix = \text{fixed time offset}$
- $SchedIntLimit = SchedIntLimitFactor \ast (\text{Number of Active Stations}/16) \ast F_{load}$

The random part of the scheduler timer (SchedIntLimit) is bounded by SchedIntLimitLow and SchedIntLimitHigh. The SchedIntLimitFactor and SchedIntLimitHigh parameter are selected as settable scheduler related parameters.

The $F_{load}$ computation of each station is made from:

$$F_{load} = \text{SegmentOffset} + (\text{SegmentWidth}) \ast m / (n+1)$$

where

- SegmentOffset = lower bound of the segment chosen by the given station’s precedence level,
- SegmentWidth = duration of its precedence
- $F_{load} = \text{Maximum Load Factor} / \text{Number of Precedence}$
- $m = \text{Number of unique quantized queue lengths}$
- $n = \text{Station’s positioning within the ordering of quantized queue lengths}.$
MODIFIED L-NAD SCHEDULER ALGORITHM

The value of Maximum Load Factor (MaxLoadFactor) is fixed to 18 in MIL-STD-188-220A while the value of SchedIntLimit is bounded by the SchedIntLimitHigh before randomizing it. The average value of Fload is 9 when a station sends light traffic. When a station has higher precedence and large queue lengths compared with others then the scheduler timer goes faster. The current Fload does not update the scheduler timer adaptively based on traffics. When SchedIntLimit is greater than the upper bound of SchedIntLimitHigh, the SegmentOffset and SegmentWidth of Fload are not efficiently distributed by the precedence and the queue lengths as it was intended.

It is proposed that the SegmentOffset and SegmentWidth be scaled by the given MaxLoadFactor value instead of using a fixed value of 18. To evaluate the efficiency of the modified L-NAD algorithm a detailed OPNET™ (simulation tool by MIL3, Inc.) model has been developed for the MIL-STD-188-220A protocol (see Figure 1).

TIDB TRAFFIC REQUIREMENTS

TIDB requires a tactical radio network which can provide robust performance under heavily mixed voice and data traffic as well as data priority net conditions. A company size net of 16 members is used to generate various types of TIDB traffic: (1) SA UP messages, (2) SA DOWN messages (K5.1 friendly reports, K4.99 enemy reports and supplement C2 messages), (3) Command Control (C2) messages and Multicast messages. The medium TIDB traffic (shown in Figure 2) is halved and doubled to generate the low and high end of traffic. All messages are exponentially distributed to generate the script input file for the simulation. In this study a benign environment is assumed without cosite interference.

<table>
<thead>
<tr>
<th>Station Id</th>
<th>Node Name</th>
<th>MagSize</th>
<th>MagSize</th>
<th>SegOffset</th>
<th>SegWidth</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>CP/AR</td>
<td>20 Byte</td>
<td>20 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>4</td>
<td>MED/HC2BA</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>15 Byte</td>
<td>15 Byte</td>
<td>15%</td>
</tr>
<tr>
<td>5</td>
<td>TRS/HQ2B</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>6</td>
<td>SUPPLY/A</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>15 Byte</td>
<td>15 Byte</td>
<td>15%</td>
</tr>
<tr>
<td>7</td>
<td>CP/HC2A</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td>NVT/HC2B</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>15 Byte</td>
<td>15 Byte</td>
<td>15%</td>
</tr>
<tr>
<td>9</td>
<td>MNT/HC2B</td>
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<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>10</td>
<td>CP/AR06</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>15 Byte</td>
<td>15 Byte</td>
<td>15%</td>
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<td>11</td>
<td>SD/AR06</td>
<td>512 byte</td>
<td>512 byte</td>
<td>256 Byte</td>
<td>256 Byte</td>
<td>25%</td>
</tr>
<tr>
<td>12</td>
<td>RL/1A</td>
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<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>13</td>
<td>RL/2A</td>
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<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>14</td>
<td>RL/3A</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
<tr>
<td>15</td>
<td>FL/3A</td>
<td>30 Byte</td>
<td>30 Byte</td>
<td>10 Byte</td>
<td>10 Byte</td>
<td>10%</td>
</tr>
</tbody>
</table>

Figure 2. TIDB Medium Data traffic

MODIFIED L-NAD WITH TIDB TRAFFIC

Among the sixteen stations of a company net eight stations are active data transmitters. Among them, the SA server transmits the SA DOWN messages, which dominate the TIDB traffic (more than 85% of total data traffic). This traffic characteristics lead us to the conclusion that the current L-NAD algorithm is not efficient because that algorithm is based upon the assumption that all stations transmit messages evenly into the nets. Figures 3 and 4 present the computation of m, n, and Fload at stations 10 and 11 with medium TIDB traffic with MaxLoadFactor of 18 and 3. The current L-NAD performance is assumed with MaxLoadFactor=18. In the TIDB traffic simulation station 10 transmits messages “lightly” and station 11 is the SA server. The values of m and n at station 11 (SA server) and station 10 (light user) vary adaptively dependent upon its precedence and queue lengths. The value of Fload becomes smaller when a station transmits messages frequently since m and n are changed dynamically. The shortened scheduler timer (Tc) allows more messages transmitted into a net as designed. Figure 5 presents the average Tc for all stations. It can be seen that the scheduler becomes faster with MaxLoadFactor=3 than MaxLoadFactor=18.


**SIMULATION RESULTS**

*Data Performance Analysis:* The MaxLoadFactor is changed to investigate its effect on TIDB network performance. The MaxLoadFactor is increased by 3 such as \{3, 6, 9, 12, 15, and 18\} in this study because the Segment Offset is computed by dividing the MaxLoadFactor by the precedence levels (possibly 3). That value is limited by 18. Other default values [Ref. 3] of MIL-STD-188-220A parameters are used in this study to investigate the effectiveness of the modified L-NAD algorithm over the current L-NAD. Figure 6 presents the SA age of SA UP messages and cumulative density function (CDF) versus delay of SA DOWN, C2 unicast and Multicast messages for TIDB medium traffic. It shows that MaxLoadFactor of 3 yields the best SA age and maximum completion and minimum delay for SA DOWN messages. MaxLoadFactor of 6 performs best among various MaxLoadFactor for C2 and Multicast messages.

Since the numbers of C2 unicast and multicast messages are small over a two hour simulation run time, six random seeds are used to compute the completion and average delay of each message type; and, then we average them to obtain reliable statistics. Figures 7 through 10 present the completion and average delay of SA, C2 unicast and Multicast messages with the low, medium and heavy TIDB traffic and 60% voice load.
both SA age of SA UP and message completion of SA DOWN. Since the most of undelivered SA messages are caused by the discards in the queue, the fast scheduler with MaxLoadFactor of 3 performs better for SA broadcast messages. The most of undelivered Multicast messages are caused by the CSMA collision on the net and type-4 queue size of 20 prevents the Multicast message discards. The best completion of Multicast is obtained by MaxLoadFactor of 12 or 15 as shown in Figure 10.

Figure 6. CDF Versus Delay for TIDB Medium Traffic

Figure 7. SA Age versus MaxLoadFactor

Completions of C2 unicast messages are not changed significantly by the different value of MaxLoadFactor's because C2 messages re-transmit if ACK is not received. MaxLoadFactor of 3 leads to the best performance for

Figure 8. SA DOWN Completion and Average Delay

Figure 9. C2 Unicast Completion and Average Delay
Voice Performance Analysis: The voice completion differences are within 2% for various MaxLoadFactor values (see Figure 12) and are due to statistical uncertainty. That is, voice performance is not affected by the fast scheduler in the benign environment. With co-site interference (inter and/or intra net) the probability of collision between data and voice becomes higher. Thus, the modified L-NAD scheduler algorithm must take into account voice activity to further decrease the net access conflict between voice and data traffic. Such a modification will be investigated in the future.

CONCLUSION

A MaxLoadFactor of 3 gives the best SA performance with TIDB data traffic. SA age with the modified L-NAD improves by more than 28% over the current L-NAD algorithm. For medium traffic, SA DOWN completion improves by a factor of 80% and average delay by 2070. For Multicast messages MaxLoadFactor of 15 gives the best completion. The modified L-NAD scales the SegmentOffset and SegmentWidth by the specified value of MaxLoadFactor, while the current L-NAD is a pure randomizer for TIDB traffic.

REFERENCES