# PERFORMANCE ANALYSIS OF A BALANCED-ENERGY AWARE ROUTING MAC PROTOCOL FOR UNDERWATER SENSOR NETWORKS


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***Abstract***

The main purpose of the underwater sensor networks to predict tsunami, measuring mineral resources, etc. Consumption of energy, between source and sensor nodes in underwater is the most difficult task. The base station receives the sensed data from the sensor nodes through the most challenging environments of underwater networks. Usually, the VBF routing protocol is used for underwater wireless sensor networks to achieve efficient communication. Here, a modified MAC routing protocol called BEAR-MAC is used for efficient aquatic monitoring. Form the detailed results summary, the proposed model proves extended lifetime of the underwater networks nodes. The Cross layer approach used to increase the throughput, energy and time efficient. Adaptive depth based back off algorithm is introduced to cut down the back in time for the nodes. The simulation results of the BEAR-MAC protocol is obtained using Aquasim, shows that BER, throughput, energy consumption are better than the EAVAR MAC protocol.



**Keywords—**BEAR-MAC; cross-layer approach; Adaptive depth based back off algorithm.


## 1. Introduction

Underwater data collection, monitoring the status of pollution, offshore exploration, prevention of natural disaster, these applications is enabled by sensor nodes at the water surface. Several Unmanned or Autonomous Underwater Vehicles (UUVs, AUVs) are using underwater sensor nodes[1]. Gathering of scientific data and exploration of natural ocean resources are found by the UUVs or AUVs. Underwater communication between underwater devices need to construct all above applications. Self-configurations are possessed by underwater sensor nodes and vehicles, i.e., They are able to manage their behavior, movement and location detail and to transmit control data to the onshore station by exchange configuration[2],[3]. Large number of sensors and equipment used to perform directed monitoring activities in Underwater Acoustic Sensor Networks (UW-ASN); achieving this goal, sensors and vehicles are autonomous networks that can adjust the characteristics of the ocean environment. Acoustic communication is the traditional technology with physical layers in submarine networks. In general, only radio signals can transmit over long distances at extra low frequencies (30-300Hz) through conductive ocean water, which requires a large antenna and high transmitting power. Such high attenuation does not affect optical waves, but scattering. In addition, high degree of accuracy is required for distribution of optical signals when controlling lasers with narrow beams. Thus, communication in underwater based on the acoustic wireless communication.[4]

## 2. Underwater Network & Restrictions

This section describes the physical properties used for UWSN and the important problems of particular signal propagation. Underwater sensor networks consist of multiple sensor nodes and underwater vehicles, allowing for monitoring climate change, search and survey operations, tactical detection, pollution management, marine life studies and early detection of natural ocean disturbance[5], [6]. The scenario of different sensor nodes on the underwater communication network is shown in fig 1. Every sensor in a network serves both as a node and consists of sensors, ROVs, server sink node, ground station and AUV. All nodes supply wireless communication and processing of data. The ocean condition challenges the UWSN to construct itself, and is challenging to execute[7]. Transmission of data is restricted by several features including high probability of error, limited bandwidth, loss of possession and degradation, rapid loss of communication, huge delays in propagation, high bit rate errors and minimal power consumption[8]–[10]. Due to salinity and other ocean conditions the aquatic network has low bandwidth and is quickly dispatched by the high frequency signal. Acoustic signals are best suitable for data communication. The next big problem is the simulation of channels; it has been used to measure signal losses between the source and receiver. Ambient noises are the main factors affecting channel simulation[11]. Any of the natural noise in the environment is known as ambient noise, such as ocean noise, sea creatures & other person-made vibration. The goal is to develop an acoustic communication network with an effective routing protocol that can achieve greater efficiency in achieving high performance, better PDR with improved battery capacity and reduced battery power usage by achieving efficient energy usage.[2], [12], [13].

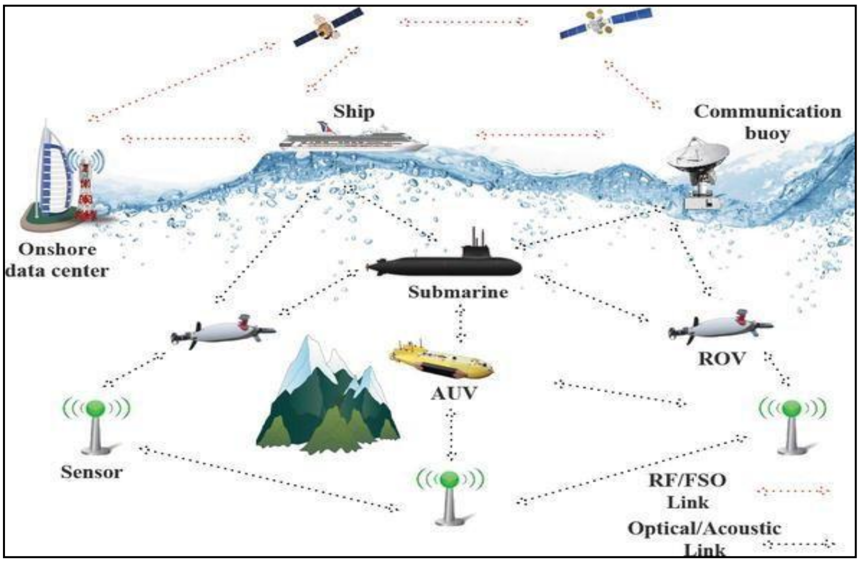

**Fig.1.** Underwater Transmission Network Situation

## 3. Methodology

The presented model of the structure is transmitted with both stable and active foci as shown in fig.2. In this paper, we propose that the implementation of waiting times on RTS / CTS transmissions in case of channel condition can minimize collisions[14]. The BEAR-MAC protocol operates on two fundamental conditions. They are 1. Waiting time for RTS should be greater than the average delay in propagation. 2. Waiting time for CTS will be larger than the RTS distribution period, with double the delay in transmission. Time synchronization is possible for BEAR-MAC[15]. By continuously monitoring the transmission schedules of the neighbors, BEAR-MAC helps a transmitter to make multiple connections to multiple receptors and to avoid node delays in the disturbances. To obtain the depth-based scheme, depth and angle information was used. We implement ToA (Time of Arrival) ranging technique to measure the distance between the sink node and itself[14], [16]. BEAR-MAC increases the possibility of collisions by using local information obtained (i.e., node depth and angle information) which best attempts to reduce the number of forwarding hop for all packets. In back-off processes we use the information on depth and angle to cut back time for main nodes. The shallower nodes and the smaller angle nodes serve as key nodes in the collision domain, and are always chosen by senders as the next hop [17], [18]. We introduce Aqua-Sim simulations, an extension kit based on the Network Simulator-2 underwater sensor network simulation[19], [20].

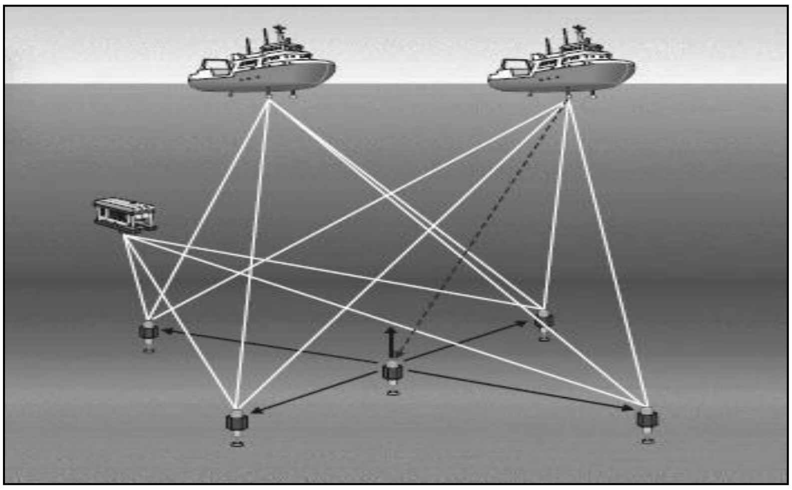

**Fig. 2.** Proposed Underwater Ecosystem Network Model

## 4. Performance Analysis

For proposed and current protocols, a different network parameter analysis is carried out by comparing the outcome of observed parameters from the simulation using aquasim like energy consumption, performance, packet transmission ratio and delay parameter. The observed changes are discussed in the following sessions..

### *A. Bit Error Rate Vs Time*

The bit error rate (BER) is the ratio between error bits to the total number of bits received on the transmission.

$$BER = \frac{\text{No of bits in error (at receiver)}}{\text{Total no of bits(transmitted)}}$$

The visual interpretation is indicated in Fig. 3 which implies that BER has steady decreases with increasing time the comparison of graph shows that BER is far improved by BEAR MAC than EAVAR. From the performance observed at 50s the bit error rate is 352.98 for EAVAR and 129.67 for BEAR-MAC. Therefore, the efficiency of the data transmission increases thus in proposed model.[21], [22].

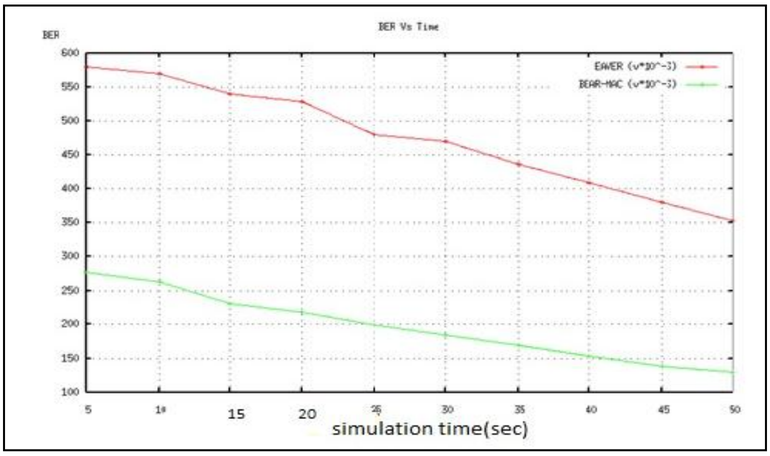


**Fig. 3.** Bit Error Rate Vs Time:

The tabulation of BER verses time for the both the model is shown in table 1.

**Table 1.** Bit Error Rate Vs Time

| Time (Sec) | EAVAR | BEAR-MAC |
|---|---|---|
| 5 | 580.78 | 276.95 |
| 10 | 570.54 | 262.78 |
| 15 | 540.68 | 230.87 |
| 20 | 528.79 | 218.68 |
| 25 | 480.57 | 198.74 |
| 30 | 469.88 | 184.95 |
| 35 | 436.89 | 169.74 |
| 40 | 408.52 | 152.97 |
| 45 | 380.76 | 137.84 |
| 50 | 352.98 | 129.67 |

### *B. Delay Vs Time*

The median time it takes for the packet to reach the destination point from the source point is set as delay. The visual figure represented that the packet delay rises as time interval rises, as seen in Fig.4.

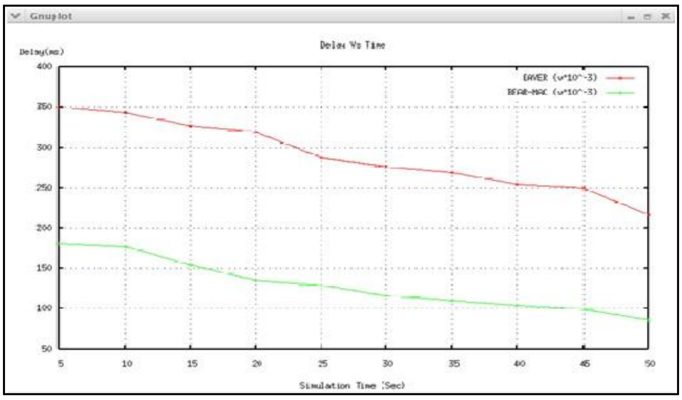


**Fig.4.** Delay Vs Time.

The tabulation of delay time values with respect to the simulation time is shown in Table 2. For EAVAR the output review, delay for 50 secs is 216.32ms but for BEAR-MAC the delay is 86.39ms for 50 secs.

**Table. 2.** Delay Vs Time

| Time (Sec) | EAVAR (ms) | BEAR-MAC (ms) |
|---|---|---|
| 5 | 350.23 | 180.36 |
| 10 | 343.45 | 176.98 |
| 15 | 326.87 | 154.89 |
| 20 | 319.78 | 135.67 |
| 25 | 287.18 | 129.56 |
| 30 | 275.94 | 115.78 |
| 35 | 269.35 | 109.71 |
| 40 | 253.81 | 103.84 |
| 45 | 249.54 | 99.75 |
| 50 | 216.32 | 86.39 |

### *C. Throughput Vs Time*

Throughput is the number of important bits per unit of time sent out by network from a given source address to some destination, excluding overhead protocols and excluding retransmitted data packets. The simulation results of the observed data throughput for both the model is shown in figure tabulated as shown in Table 3. Also it differs by time period which can be seen in fig. 5.

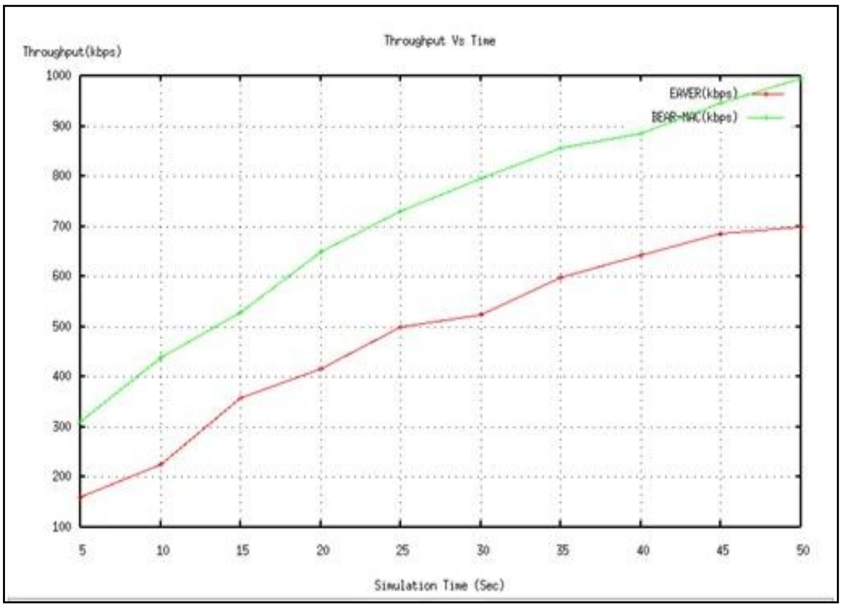


**Fig. 5.** Throughput Vs Simulation Time

The EAVAR throughput has a maximum rate of 697.99kbps for 50 sec, but the maximum BEAR-MAC throughput is 996.34kbps for 50 sec.

**Table. 3.** Throughput Vs Time

| Time (Sec) | EAVAR (kbps) | BEAR (kbps) |
|---|---|---|
| 5 | 160.17 | 310.22 |
| 10 | 225.23 | 437.54 |
| 15 | 358.19 | 529.34 |
| 20 | 415.27 | 648.69 |
| 25 | 498.53 | 730.78 |
| 30 | 523.89 | 795.93 |
| 35 | 598.56 | 856.91 |
| 40 | 643.78 | 886.93 |
| 45 | 686.56 | 945.89 |
| 50 | 697.99 | 996.34 |

### *D. Energy Consumption Vs Time*

The rate of energy of nodes is used to send the data packets to the destination are called as the energy consumption. When there are more nodes involved it absorbs more resources. The mathematical equation is also follows

Energy Consumption E = Pt
Where, P = Power
t = Simulation Time.

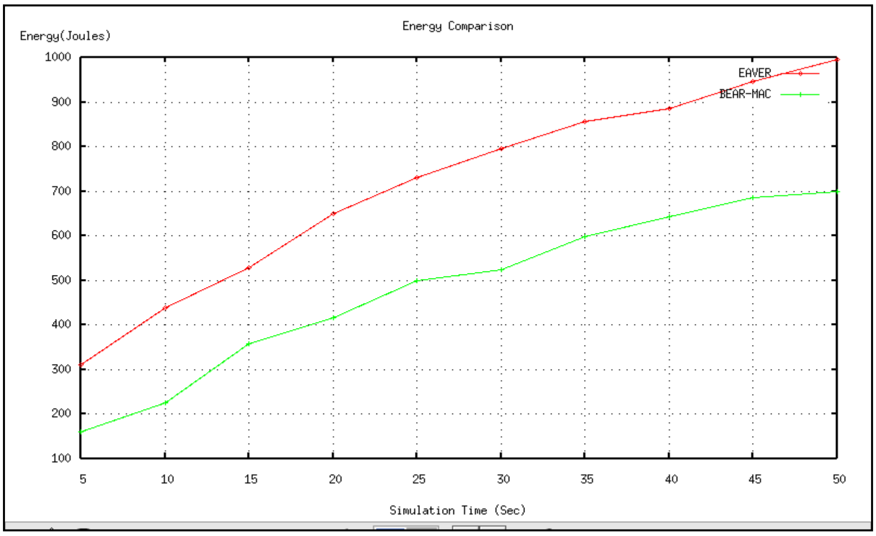


**Fig. 6. Energy consumption vs Simulation Time**

The visual representations as shown in figure 6 shows that power also grows sequentially with just the duration of time.From the output study the energy consumed by EAVAR for 50secs is 17, 9876 joules where 16.4532 joules are used as the energy for BEAR-MAC.

**Table 4.** Energy Consumption Vs Time

| Time (Sec) | EAVAR (Joules) | BEAR-MAC (Joules) |
|---|---|---|
| 5 | 2.5675 | 2.0532 |
| 10 | 3.5667 | 3.1639 |
| 15 | 5.6544 | 4.1247 |
| 20 | 7.5432 | 6.6542 |
| 25 | 9.7896 | 8.9761 |
| 30 | 11.4359 | 10.5432 |
| 35 | 12.6548 | 11.2314 |
| 40 | 13.4564 | 12.8544 |
| 45 | 15.6786 | 14.8764 |
| 50 | 17.9876 | 16.4532 |

### *E. Summary of results*

The results summaries and detailed comparison of the performance of EAVAR and BEAR MAC Protocol are illustrated in the following figures 7-10. The graphical views clearly give accountability that BER and Delay is better only for BEAR MAC with the diminished value, which quite challenging in Underwater Communication. The throughput is highly notified from the result.

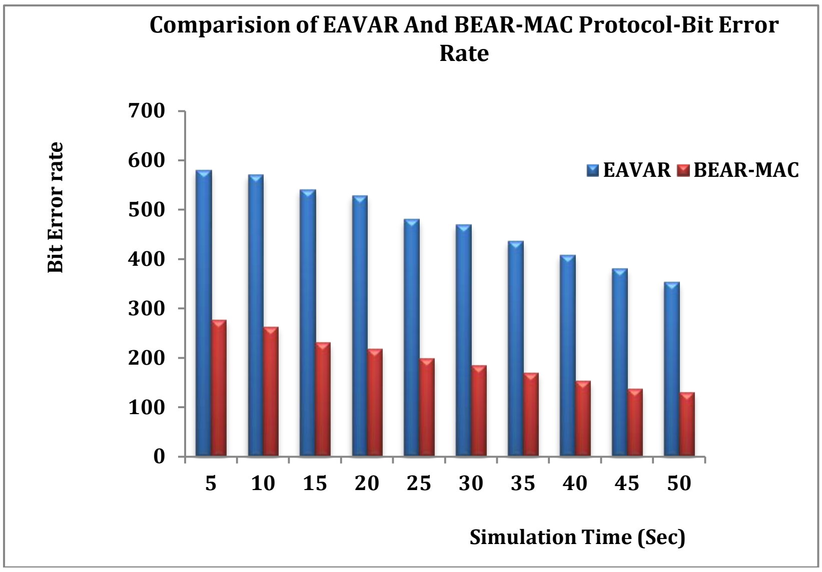


**Fig.7.** Comparison of BER for EAVAR Vs BEAR MAC

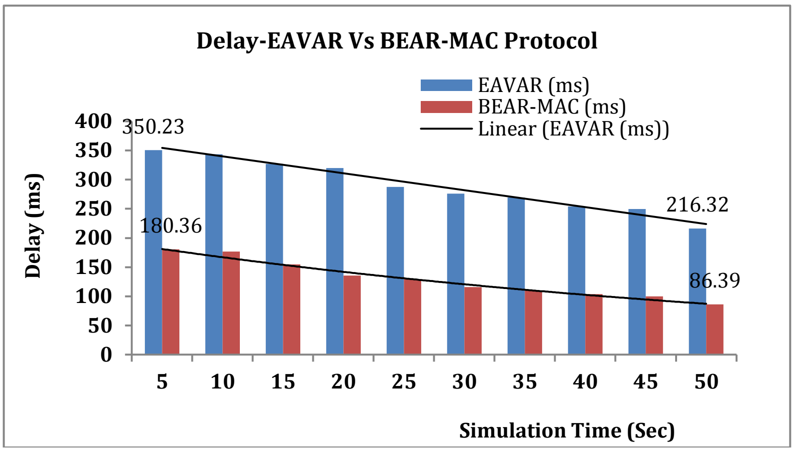


**Fig.8. Comparison of delay for EAVAR vs BEAR-MAC**

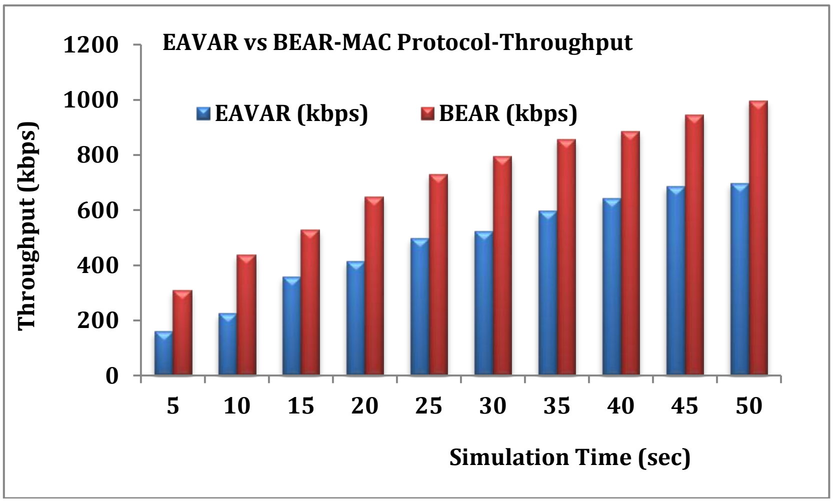


**Fig.9.**Throughput comparison of EAVAR Vs BEAR-MAC

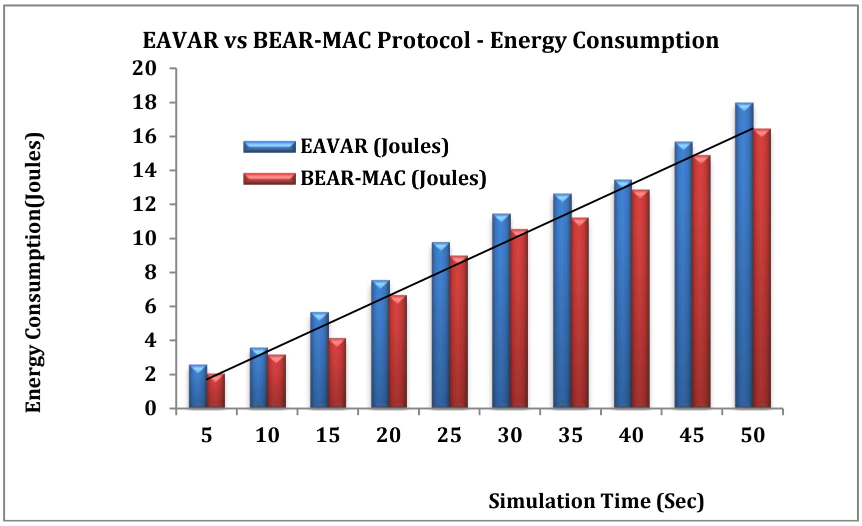


**Fig.10.** Comparison of Energy Consumption for EAVAR Vs BEAR MAC

## 5. Conclusion & Future Work

The proposed protocol model is compared with the EAVAR protocol. The EAVAR protocol is used for its near similarity in terms of communication system and protocol mechanism. Better usage of power and healthy energy efficiency in the network, extended the network life. For a fixed transmission range, more energy was consumed in direct communication mode compared to the multihop communication mode. The proposed BEAR-MAC, an adaptive routing protocol, according to these probes, takes advantage of the position information, selects the neighbors, selects the initiating and successor nodes based on performance function, quality and finally selects the forwarder node, one with a residual network capacity. The results give better performance in terms of BER, Data Throughput and achieve better energy efficiency with less delay.

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