ESD5 – Fall 2024
Problem Set 2 – Solutions

Department of Electronic Systems
Aalborg University

September 19, 2024

Problem 1 – TDMA-Based Scheduling

(a) $\log_2 4 = 2$ bits

(b) The following events can happen:

- No user responds to the invitation sent by Basil. Basil does nothing.
- More than one user answers the invitation from Basil. The users will not receive an ACK from Basil or they can receive something with the wrong address. The users need to try again in the future randomly in order to reduce the chance of collision (tossing a coin).
- ACK sent by Basil may be lost. Then, the user needs to try again in the future when another initial access frame is sent by Basil.
- Please, feel free to exploit your creativity here and propose other events.

(c) Based on the initial access frame, a link termination frame would be comprised of a reference signal sent by Basil to establish that this frame has begun. Then, Basil sends the address of the user that she wants to be terminated. The user listens to it and withdraws its connection. The user no longer has access to the network.

(d) The equivalent data rate is $R_{\text{Xia}} = \frac{R}{K}$, where K is the number of users, which is assumed to be the size of the downlink frame. Therefore, $R_{\text{Xia}} = \frac{1}{3}$ kbit/s.

(e) The diagram can be seen in Fig. 1.

Assume that:

H_{00} - initial access frame

H_{01} - link termination frame

H_{10} - DL transmission

H_{11} - UL transmission

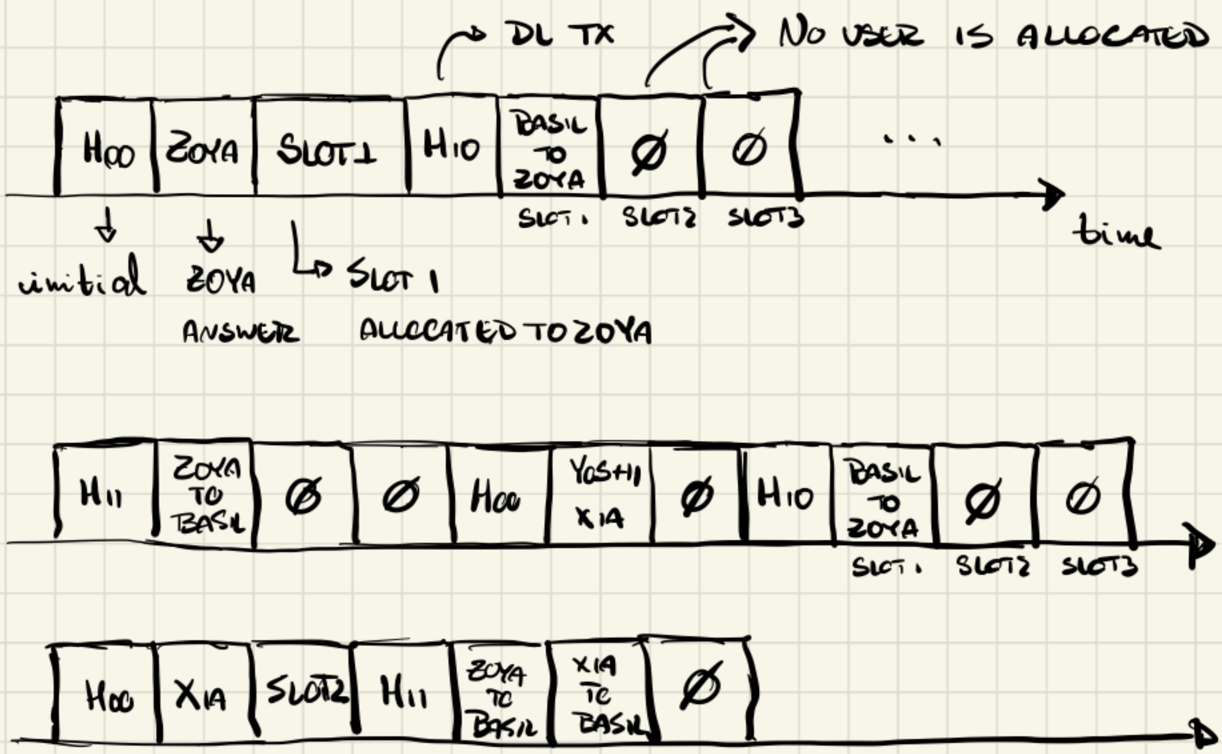

Figure 1: Solution (e).

Problem 2 – ALOHA Protocol

(a) 2 users: User 1 and User 5

(b) Applying the SIC method, 4 users' packets can be successfully decoded. The decoded order could be one of the following possible solutions:

- User 1 → User 5 → User 3 → User 2
- User 1 → User 5 → User 2 → User 3
- User 5 → User 1 → User 3 → User 2
- User 5 → User 1 → User 2 → User 3

(c) The 4-user group and even time slots establish a slotted ALOHA system with 4 nodes. Then the maximum throughput could be achieved when $p = \frac{1}{4}$, resulting in throughput at $(1 - \frac{1}{4})^{4-1} = \frac{27}{64}$.

The 16-user group and even time slots establish a slotted ALOHA system with 16 nodes. Then the maximum throughput could be achieved when $p = \frac{1}{16}$, resulting in throughput at $(1 - \frac{1}{16})^{16-1} = \frac{365}{961}$.

Summing up, the average throughput is $\frac{1}{2}(\frac{27}{64} + \frac{365}{961}) \approx 0.4$.

Problem 3 – Token Ring and Round-Robin

(a) $60 + 30 + 60 + 20 + 0 + 160 + 80 = 410$ ms

(b) Long communication time from certain nodes, like Node 5, and long delay for the following nodes even if they have little to communicate. This causes uncertainty in the availability of the channel for others, and removes any guarantees that could be made on latency from wanting to communicate to actually doing so. If nodes produce more to transmit that the channel supports, we would also have single nodes using it indefinitely.

(c) $50 + 30 + 50 + 20 + 0 + 50 + 50 + 50 + 10 + 0 + 10 + 0 + 0 + 50 + 30 = 400$ ms

(d) Increased: 0, 2, 5

Decreased: 1, 3, 6, 7

Unchanged: 4 (cannot be increased or reduced, as nothing was communicated)

(e) If we think of time when doing a full circle of the ring, Node 0 may communicate again after 300 ms. If we consider the maximum time we may use the medium (50 ms), Node 0 knows at least 6 nodes are in the system since $\frac{300}{50} = 6$.

- No, single nodes like Node 5 can take long making it look like many nodes, while nodes like 4 are hidden away, and would not be noticed. The missing guarantee on communication time makes it impossible.
- The nodes know 2 things: how long before they get the token back again and how much they need to communicate. If the token were to start at Node 1, 3, or 4 they would know that there are at least 7 nodes in the system. Exemplifying, for Node 1, $\text{num\_nodes} = 1 + \lceil \frac{300-30}{50} \rceil = 7$, while, for Node 0, it would be $\text{num\_nodes} = 1 + \lceil \frac{300-50}{50} \rceil = 6$.