TD INF567

Capacity Regions and ARQ

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1 Deterministic Access Schemes

Consider an AWGN broadcast channel (downlink) with two users and a transmitter with transmit power $P_t = 46$ dBm and a signal bandwidth of $B = 18$ MHz (used for LTE without guard bands). Assume users are at distances 200 m and 1000 m from the transmitter, respectively. We consider the following path-loss model: $p_r = p_t K d^{-\alpha}$ with $K = 2.68e-4$ and $\alpha = 3.48$ (typical for a urban area at 2 GHz). The noise power spectral density is $N_0 = -174$ dBm/Hz. We assume that user 1 requires a data rate of 75 Mbps.

Question 1 *Assuming equal-power TDMA, what is the achievable data rate for user 2?*

Question 2 *Compare this result with the achievable data rates if equal-bandwidth FDMA or Successive Interference Cancellation are used.*

We now consider the AWGN Medium Access Channel (uplink) with two users and one receiver. Assume user i transmits with power p_i and has channel gain g_i, $i = 1, 2$. Let (R_1, R_2) a vector of achievable rates for users 1 and 2 respectively.

Question 3 *Explain why we have:* $R_1 + R_2 \leq B \log_2 \left(1 + \frac{p_1 g_1 + p_2 g_2}{N_0 B}\right)$.

Question 4 *Show that this bound is reached.*

2 ARQ and HARQ

We consider several ARQ scenarios[1]. At the beginning of every scenario, stations A and B are idle after having successfully established the connection. There is no timer running. If, when receiving a correct frame, a station has no information frame to send, it acknowledges immediately the received frame with a control frame. We assume that stations have an anticipation window of 4 frames. We first consider Scenario 1 from Fig. 2.

[1] Acknowledgment: Xavier Lagrange, IMT Atlantique

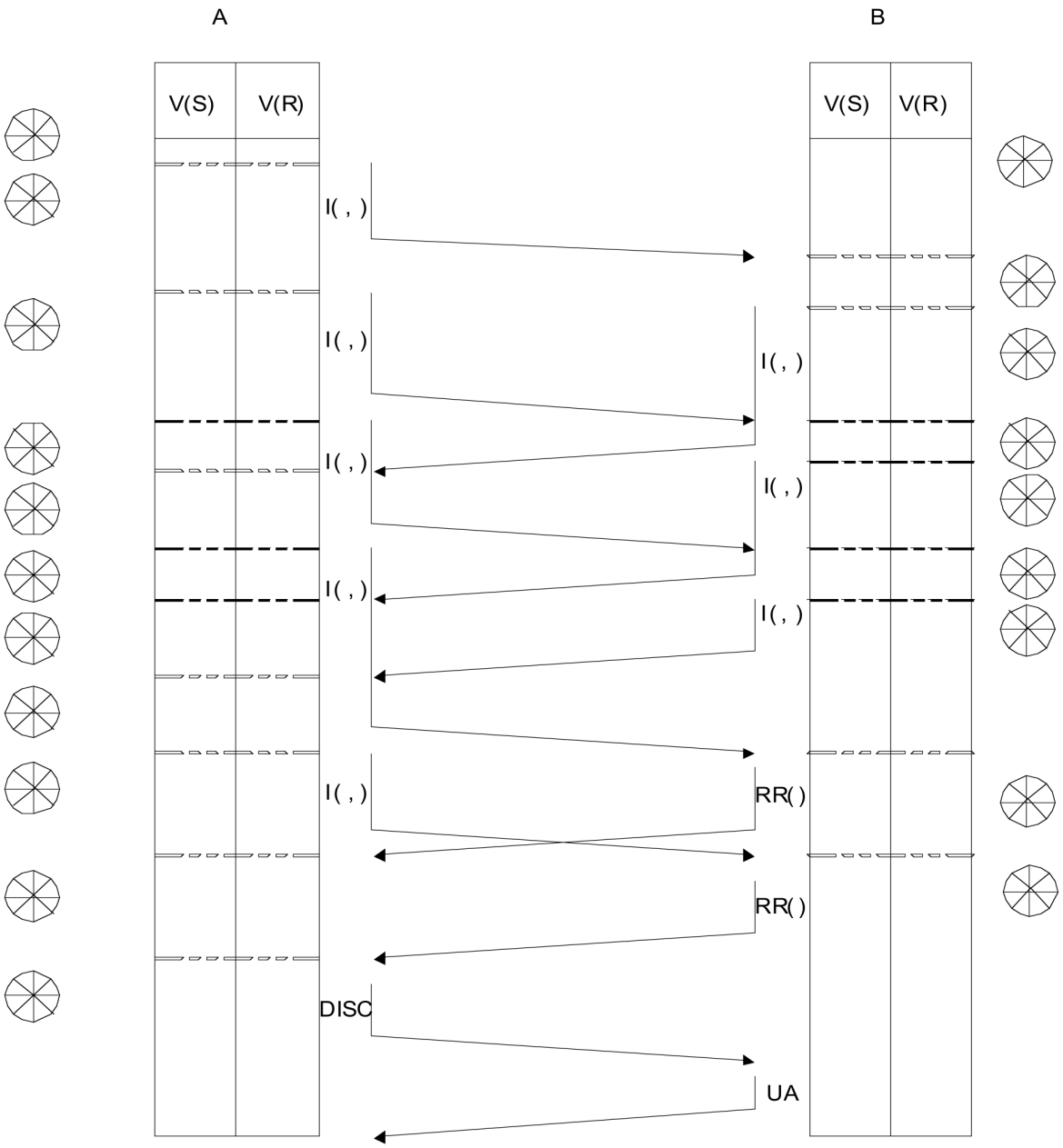

Figure 1: ARQ scenario 1.

Question 5 *Complete the frame exchange of Scenario 1 by indicating frame types, N(S), N(R), V(S) and V(R) and the status of the anticipation window.*

Now assume that stations have an anticipation window of 3 frames and that no timer times out.

Question 6 *How is the frame exchange modified? Give only the beginning of the exchange.*

We now turn to Scenario 2, see Fig. 2. A wants to transmit 3 information frames to B. B has nothing to transmit. The first frame is correctly received and the corresponding ACK also. The second frame from A is received by B with a CRC showing an error. Other frames are correctly received.

Question 7 *Complete the frame exchange of Scenario 2.*

In Scenario 3, the first frame of A is correctly received by B but others are not. The ACK sent by B is also received in errors.

Question 8 *Complete frame exchange of Scenario 3. Specify the values of the bit P/F.*

A station A communicates with a satellite B according to the protocol LAPB. The altitude of the latter is 200 km. All processing delays are negligible. Stations communicate at a data rate of 28800 bps and send 64 Bytes information frames with 6 Bytes of header. Every frame is immediately acknowledged with a RR of 6 Bytes. Assume that there is no transmission error.

Question 9 *What is the minimal anticipation window size for an efficient transmission from A alone to B?*

Question 10 *The satellite is now at a distance of 36000 km. Same question.*

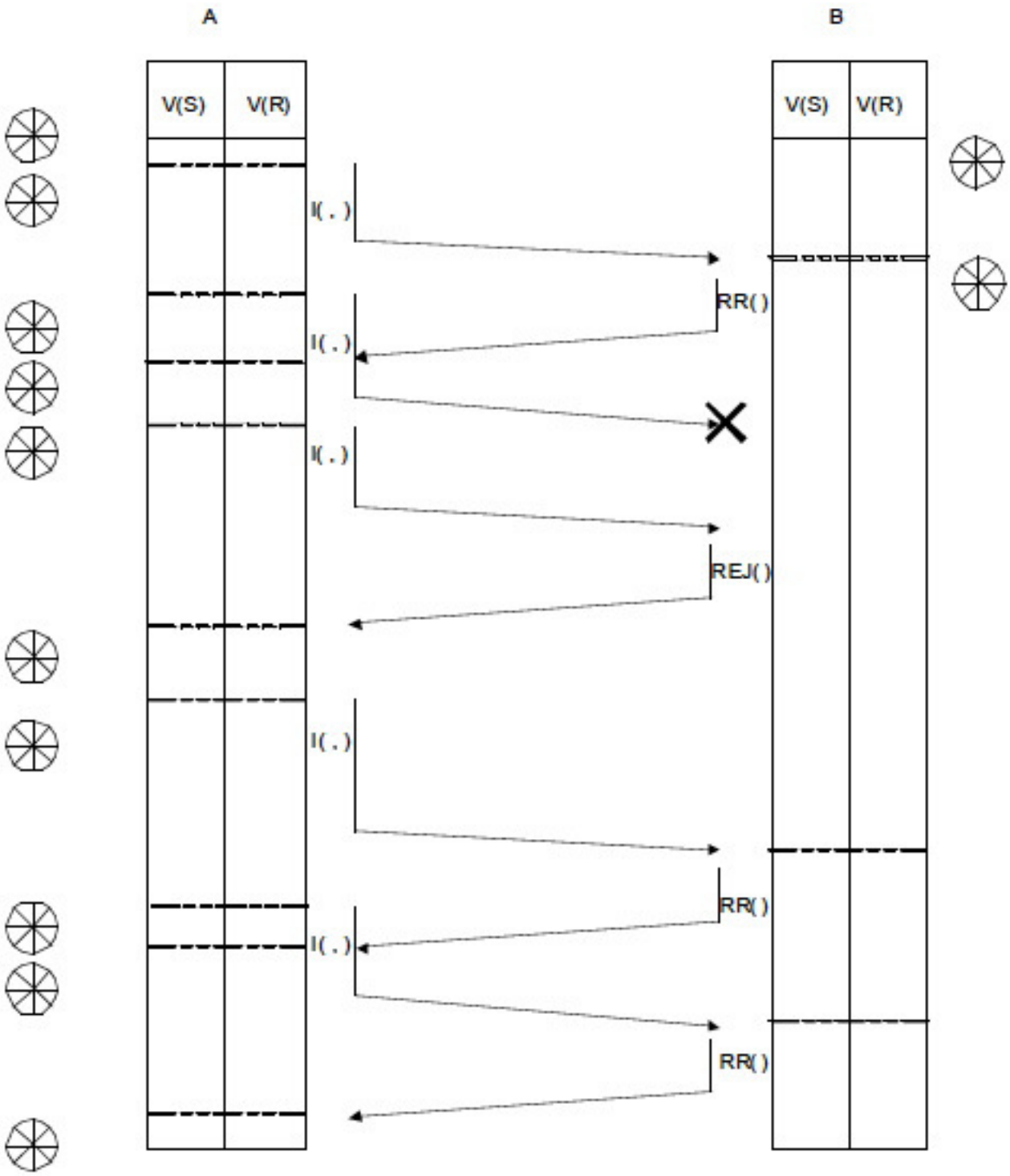

Figure 2: ARQ scenario 2.

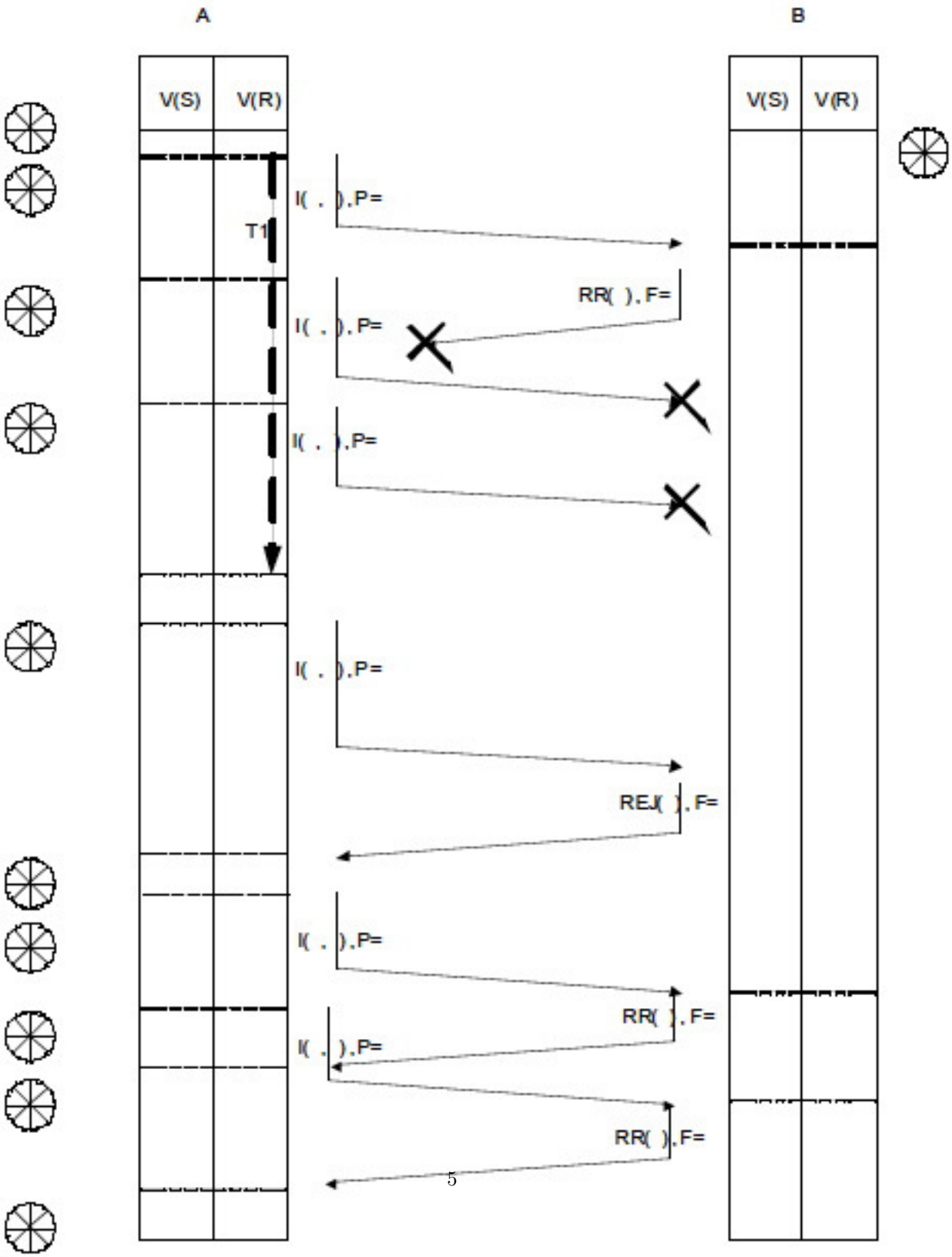

Figure 3: ARQ scenario 3.