1. Consider a router with 1000 line cards and an interconnection network that forward cells and has a maximum delay under normal loading conditions of 200 cell times. How large should the sequence numbers be in this case? Evaluate the complexity of the resequencer that is required at each output line card and quantify the various resources it requires.

The sequence numbers must cover a range that is larger than the maximum delay, so in this case an eight bit sequence number would be appropriate. First, the output line card needs 1000 registers or memory locations in which to store the sequence numbers of the next cell it expects to receive from each of the 1000 input line cards. It also needs a holding area to store out-of-order cells for each of the input line cards. This holding area should have room to store at least 200 cells. Each of the line cards also needs a vector of pointers to this holding area, with one position in the vector for each sequence number. This implies 256,000 pointers altogether.

2. Consider an instance of the basic time-based resequencer with $T=8$ slots. Suppose that at times 0, 1 and 2 the resequencer receives cells that all have a timestamp of 5, at time 3, it receives a cell with a timestamp 4 and at time 4 it receives a cell with timestamp 6. Show the state of the resequencer at times 3, 4, 5, 6 and 7.
3. Suppose you wanted to implement a version of Henrion’s strict resequencer for a system that sent variable length packets. Could you still use the timing wheel approach with variable length packets? If so, what would be the appropriate time unit for timestamps in packets how often would you advance the timing wheel pointer? How large do you think the timing wheel be in this case, compared to the case of a system that uses fixed length cells?

The time unit can correspond to the amount of time it takes for an input line card to send a minimum length packet to the interconnection network. This is sufficient to guarantee that no two packets from the same input line card will have the same timestamp, which is all we really care about from the standpoint of correctly resequencing packets. With this definition of the time unit, the timing wheel pointer can be advanced by one slot for every time unit that goes by.

The required size of the timing wheel is directly proportional to the maximum delay we expect to see in the network. If we compare systems with 64 byte cells to systems with variable length packets ranging from 64 to 1500 bytes, we would expect the maximum packet delay to grow by a factor of about 24. So, the packet-based resequencer should have 24 times as many slots as a comparable cell-based resequencer.

4. Consider an adaptive resequencer with a window size $W=50$ and a delay difference bound $\Delta=50$. Assume that the window boundaries occur on multiples of $W$. Suppose that after time step 94, the maximum delays seen in the current and previous windows are $d_0=20$ and $d_{-1}=35$. What is age threshold $T$, at this point?

If cell $A$ is received at time 95 with a timestamp of 55, what are the values of $d_0$, $d_{-1}$ and $T$.

$40, 35, 90$

Suppose that a cell $B$ is received at time 120 with a timestamp of 60 and that no other cells are received. At what time are $A$ and $B$ forwarded?

$A$ is forwarded at time 165 and $B$ at time 230.