Exercise 2
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1. Consider a memory device with a single read/write port and N internal memory banks. Each memory bank operates at $1/N$ rate compared to the read/write port operating speed (this means that the memory operations are pipelined, i.e., there is up to N concurrent memory ops and each op takes N cycles to complete). The internal data bus connecting the memory banks and input/output port is non-blocking.

   At each time-slot (time-slot = the time it takes to complete a memory operation at the operating speed of read/write port) a single memory operation is initiated with probability p. The operations are uniformly distributed, i.e., the probability that a memory operation is destined to any memory bank is $1/N$.

   (a) What is the probability that k memory operations are destined to a particular memory bank in N time-slots?

   (b) What is the probability that more than one memory operation is destined to a particular memory bank in N time-slots?

2. Consider the same memory device as in the previous task. Assume that a blocked memory operation stalls the processing unit using the memory device, that is, blocked operations can be considered lost (that is, there is no queueing).

   (a) In the case that there is no buffering, only one of the memory operations in a specific memory bank can processed while others are blocked. What is the average number of blocked operations? Give an example for $N = 8$ at full load ($p = 1$).

   (b) Blocking probability can be reduced by speeding up the memory banks or increasing their number. How many memory operations a memory bank should accept during N time-slots to keep the average number of blocked memory operations due to memory bank blocking below 10^{-2} when $N = 8$ and $p = 0.85$? How many memory banks operating at the original speed is required to fulfill the same blocking limit?

3. Describe

   (a) The structure and fields of an Ethernet frame

   (b) New options to the frame structure provided by Gigabit Ethernet

   (c) The structure and fields of ATM cell

   (d) The structure and fields of ATM AAL5 frame

4. When voice (and other delay sensitive data) is sent over packet networks the delay to fill a packet has to be taken account for. Consider uncompressed voice, i.e., 64 kbit/s and compressed voice, 16 kbit/s and 8 kbit/s in the following cases:

   (a) In Voice over IP systems (VoIP) packets has to be sent at short intervals to avoid too long delays. What is the ratio between actual voice data and the whole frame length if IP packets are sent over Ethernet at rate of 20 and 50 packets per second? Use 40 octets for total overhead caused by IPv4, UDP and RTP headers.

   (b) How long it takes to fill ATM AAL1 payload (AAL1 "frame length" is 48 octets including the overhead: one octet per cell)? Compare AAL1 efficiency with VoIP over Ethernet.

5. Ethernet frames are transported over SDHng in GFP-F frames by discarding the preamble and SFD fields as well as the interframe gap. The optional GFP-F FCS is not used as the Ethernet CRC field is sufficient for error detection. The resulting GFP-F frames are then transported in SDH transmission system using VC-4 containers. What is the maximum SDH bit rate required to transport Ethernet frames from a single 100 Mbit/s source if the average length of the Ethernet payload is 200 octets? How much transport capacity is lost if the VC-4 container is not shared with other sources?