1. The definition for point-to-point connection is that a source can be connected only to a single destination and to a certain destination only one source can be connected. The definition for multicast connection is that a source can be connected to one or more destinations and to a certain destination only one source can be connected. In a switch source is an input port and destination is an output port.
   (a) What is the number of possible point-to-point connection patterns in N × N switch if all ports are connected?
   (b) What is the number of possible point-to-point connection patterns in N × N switch if there can be non-connected ports?
   (c) What is the number of possible multicast connection patterns in N × N switch?
2. (a) How much information is in transit ("on wire") on a 1000 km long transmission cable if the transmission speed is a) 10 Mbit/s b) 155 Mbit/s? Use $2 \cdot 10^8$ m/s as the propagation speed of the transmitted signal.
   (b) How long is transmission time of one ATM cell on transmission line operating at 155 Mbit/s?
   (c) How long does it take to fill the payload of one ATM cell from a source with transmission speed of 64 kbit/s?
3. Refer to Exercise 1 Task 3. Consider a cell switch with $N$ input and output ports. In each time-slot at each input port, the probability that that a cell arrives is $p$. The incoming traffic is uniformly distributed, i.e., the probability that an incoming cell is destined to any output port is $1/N$.
   (a) In the case that there is no buffering, only one of the cells arriving in a specific port can pass while others are lost. What is the average number of lost cells? Give an example for 8x8 ($N = 8$) switch at full load ($p = 1$).
   (b) Loss probability can be reduced by using buffering. If buffers are placed at output ports, they must operate at higher speed than the line-speed. How many cells an output buffer should accept during one time-slot to keep the average number of lost cells due to output port blocking below $10^{-5}$ when $N = 8$ and $p = 0.85$?
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.