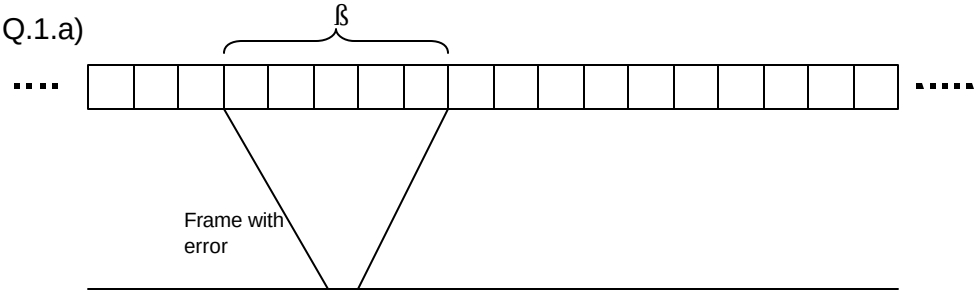
Q.1.a)



If ß=0 then the system will be same with stop-and-wait ARQ. So in this case expected number of transmissions is;

$$g = \frac{1}{1+p}$$

If ß?0 then there will be p.ß more frames to be transmitted for each errored frame. So we add this amount to previous case and the new equations will be;

$$g = \frac{1}{1-p} + \frac{p.b}{1-p}$$

$$g = \frac{1+p.b}{1-p}$$

$$g.(1-p) = 1+p.b$$

$$\Rightarrow g = 1+p.(b+g)$$

Q.1.b) ? is defined as the expected number of frames transmitted for a successful transmission. In other words we expect ? frames to be transmitted before a frame is said to be successfully transmitted from A to B. So 1/? is the part of actual packet per each transmitted packet (the part other than the retransmissions). So it can be taken as the efficiency of the system.

Q.1.c)

$$h = \frac{1}{g}$$

$$\Rightarrow h = \frac{1-p}{1+pb}$$

Q.2.a)

Q.2.b) Routing table loops occur when the algorithm is not loop free. These are the loops that are due to loops in the routing tables. A loop free algorithm does not have loops in the routing tables. However even the algorithm is loop free, packets can make loop under certain conditions. One of which is the fast changing topology. In this case there may not be enough time for algorithm to respond to a change in topology (update routing table) that causes a packet loop. One other reason may be the lack of robustness of the routing algorithm. So to sum it all; packet looping can be seen in all kinds (loop-free or looping) of algorithms and it is not due to algorithm itself, but the environmental variables. Routing table loops are due to both topology and algorithm itself and can only be seen if the algorithm is not loop free.

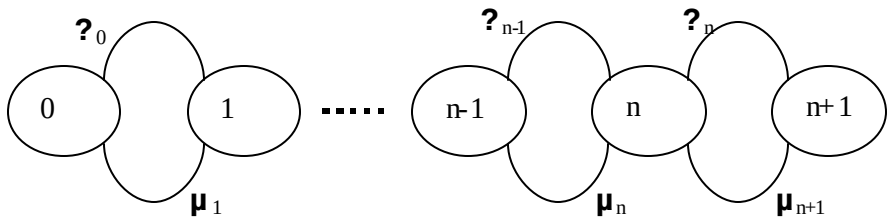
Q.2.c) In VC all packets of the same user pair travel along same path, whereas in Datagram they can travel from different routes. In VC packets always arrive in sequence, in datagram packets can arrive out of sequence and there is no control mechanism to check that. In VC packets just have short VC id, in Datagram each packet has full source and destination address. VC requires a connection to be established between source and destination to start sending, so it has large delays to start. In datagram each host has routing tables and no connection is established before a transmission occurs. Each packet is routed according to the addresses it has and the routing table at the current host.

	Virtual Circuit	**Datagram**
Pros	Reliable	Efficient channel allocation
	Flow, Congestion and sequence control	No connection required
	retransmission	
Cons	Need to establish connection	Unreliable
	In efficient use of channel	No sequence, flow or congestion control
		No retransmission

In a highly dynamic environment datagram method seems more appropriate because of these reasons:

- VC will need to establish a new connection each time the topology changes, otherwise it won't be reliable anymore. Whereas datagram routing may come with this by using hierarchical addressing and faster routing table updates.

Q.3.a)



As seen from the diagram state of the system (number of packets) depends on two parameters **μ** and **λ**.

$$r_k = \frac{l_k}{m_{k+1}}$$

$$m_1 P_1 = P_0 l_0$$

$$P_1 = P_0 \frac{l_0}{m_1}$$

$$P_1 = P_0 r_0$$

$$P_2 = P_1 \frac{l_1}{m_2}$$

$$P_2 = P_0 r_0 r_1$$

$$\Rightarrow P_k = P_0 \prod_{i=0}^{k-1} r_i$$

Q.3.b) The sum of probabilities that there are l packets in the system (l=0,1 … **8)** is equal to 1. Since there should either be 0 or k (k>0) packets in the system.

$$1 = P_0 + P_0 \sum_{i=0}^{\infty} (r_0 .... r_i)$$

Probability that there is no packet in the system

Sum of probabilities that there are k packets in the system k>0

$$1 = P_0 (1 + \sum_{i=0}^{\infty} (r_0 .... r_i))$$

$$P_0 = \frac{1}{1 + \sum_{i=0}^{\infty} (r_0 .... r_i)}$$

Q.3.c) This modal can be used to model a router with low-end cpu, needed to run advanced packet handling and queue management algorithms. So when the packet number in the queue increases more and more cpu time will be used to handle them, increasing the service times of the packets being routed.