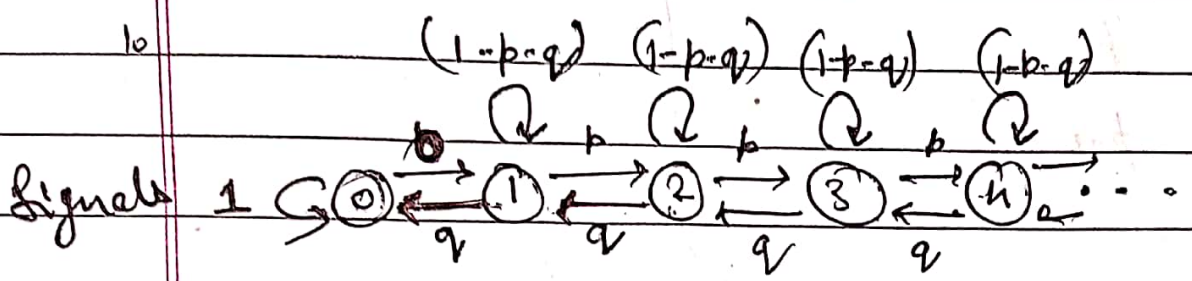
1. Theoretical



P(x signals → x+1 signals in past second) = p

P(x signals → x-1 signals in past second) = q

P(x signals remain) = 1-p-q

Transition Matrix

$$P = \begin{bmatrix} 1 & 0 & 0 & 0 & \cdots & 0 & \cdots \\ q & 1-p-q & p & 0 & \cdots & 0 & \cdots \\ 0 & q & 1-p-q & p & 0 & \cdots & 0 \\ 0 & 0 & q & 1-p-q & p & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \end{bmatrix}$$

2. $q + 2q^2 + 3q^3 + 4q^4 \cdots$

$2q(1-pq) + 3q^2(1-p-q) + 4q^3(1-p-q)^2 + 5q^4(1-p-q)^3$

$3q(1-p-q)^2 + 4q^2(1-p-q)^2 + \cdots$

$\Rightarrow$ $T = \sum_{i,j,k} (i+j+k)\, i q^i (1-p-q)^j p^k$ = Expected time

3. Martingale constructed at state 0. {signals = 0}
Since every other state will be 0 after it.

4. Yes, it will also shows Martingale behaviour at state: signals = 0.