VoIP traffic

- VoIP traffic can be modeled as a two-state process, with states ON and OFF
- The transition rate from the OFF state to the ON state is λ and the transition rate from the ON state to the OFF state is μ
- The usually adopted values are:
  - μ=2.8571 s^{-1}
  - λ=1.538 s^{-1}
- In the OFF state the transmission rate is zero
- In the ON state the transmission rate is P
- The resulting (approximate) traffic characterization is

$$E\left(X\left(t\right)\right)=\frac{\lambda}{\lambda+\mu}Pt=rt$$

$$\operatorname{var}\left(X\left(t\right)\right)=2\frac{\lambda\mu}{\left(\lambda+\mu\right)^{3}}P^{2}t=rbt$$

VoIP traffic

- Thus, a VoIP traffic can be characterized as a short-range dependent flow, with parameters

$$r = \frac{\lambda}{\lambda + \mu} P$$

$$b = 2 \frac{\mu}{(\lambda + \mu)^2} P$$

Analysis of the G.726 VoIP traffic over E1 lines

- Consider n VoIP traffic flows coded by G.726 codecs@32 kbit/s and calculate the delay distributions of these flows transported through an E1 line
- For the G.726 codec at 32 kbit/s, the payload rate is equal to 32 kbit/s, however, in order to calculate the correct value of *P*, protocol overheads must be accounted for
  - The frame duration is equal to 10 ms, thus, a frame contains 40 bytes of voice content
    - In fact, with a codec speed of 32 Kbit/s, in 10 ms the number of voice bits are 32,000x0.01=320, thus, the number of voice bytes is 320/8=40
  - The protocol stack for the transport over E1 lines is RTP/UDP/IP/PPP
      - RTP header length: 12 bytes
      - UDP header length: 8 bytes
      - IP header length: 20 bytes
      - PPP header and trailer length: 8 bytes
    - The total protocol overhead is 48 bytes per packet
    - Thus, for the G.726 codec @ 32 kbit/s over E1, the value of *P* is:
      - $P = 8x(40 + 48)/0.01 = 70{,}400$ bit/s

Analysis of the G.726 VoIP traffic over E1 lines

- Thus, for the G.726 VoIP codec over RTP/UDP/IP/PPP:

$$\begin{cases} r = \dfrac{\lambda P}{\lambda + \mu} = \dfrac{1.538}{1.538 + 2.8571} 70,400 = 24,635 \\ b = 2\dfrac{\mu P}{(\lambda + \mu)^2} = 2\dfrac{2.8571}{(1.538 + 2.8571)^2} 70,400 = 20,825 \end{cases}$$

Analysis of the G.726 VoIP traffic over E1 lines

- Thus, the probability of exceeding a delay threshold d is equal to:

$$\Pr\left(D > d\right) = \exp\left(-2\frac{C\left(C - nr\right)}{nrb}d\right) = \exp\left(-2\frac{2.048\times 10^6\left(2.048\times 10^6 - 24,635\times n\right)}{5.13\times 10^8\times n}d\right)$$

Example with VoIP traffic and FIFO scheduler

- The chart shows the probability of exceeding a delay threshold *d*, with *d* = 1 ms, 10 ms, 100 ms, for a variable number of G.726 VoIP sources on a E1 line, FIFO scheduler (*D* is the queueing delay)