2. a. a circuit-switch network is more appropriate for this application. Because:
   1). the data rate is fixed, so a circuit can be set up with the appropriate capacity so that no
      bandwidth will be wasted.
   2). the application runs for a long time, so the cost of setting up is worthy.
   3). Small delay between data units (k is small and fixed), so there won’t be much idle time.

   b. Congestion control may be still needed, because:
   Even though the traffic intensity $L_a/R < 1$ in this case, if there are $Q$ (may be very large) such
   applications send packets simultaneously, $d_{queue}$ may be large. And, if the routers are not
   high-speed, $d_{proc}$ could be large too. Since the queue is finite, some congestion control is
   needed to avoid packet loss.

3. a. $4n$
   b. $2n$

4. a. $d_{trans} = 2 \times \left( \frac{10 \text{cars}}{5 \text{cars/min}} \right) = 2 \times 2 \text{min} = 4 \text{min}$

   $d_{prop} = 2 \times \left( \frac{100 \text{km}}{100 \text{km/hour}} \right) = 120 \text{min}$

   $d_{end-to-end} = d_{trans} + d_{prop} = 124 \text{min}$

   b. $d_{trans} = \frac{7 \text{cars}}{5 \text{cars/min}} \times 2 = 1.4 \text{min} \times 2 = 2.8 \text{min}$

   $d_{end-to-end} = d_{trans} + d_{prop} = 2.8 \text{min} + 120 \text{min} = 122.8 \text{min}$

5. a. total = $M \times \frac{L + h}{R} + (Q - 1) \times \frac{L + h}{R} + t_s$

   (Note: this first part is the time for the $M$ packets to be pushed out the first switch; the second
   part is the time for the last packet goes through the rest ($Q-1$) switches); the third part is the
   setup time)

   b. total = $M \times \frac{L + 2h}{R} + (Q - 1) \times \frac{L + 2h}{R}$

   (Note: no setup time)

   c. total = $Q \times \frac{ML + 2h}{R}$
d. \( total = \frac{ML + h}{R} + t_s \)

8.

a. \( d_{prop} = \frac{m}{s} \)

b. \( d_{trans} = \frac{L}{R} \)

c. \( d_{end-to-end} = d_{prop} + d_{trans} = \frac{m}{s} + \frac{L}{R} \)

d. Just out of Host A and on the link

e. The first bit of the packet is still on the link, not reach Host B yet.

f. Already on Host B.

g. \( \frac{L}{R} = \frac{m}{s} \Rightarrow m = \frac{L \times s}{R} = \frac{100 \text{bits} \times 2.5 \times 10^8 \text{m/s}}{28 \text{Kbps}} \approx 893 \text{Km} \)

20.

a. \( d_{prop} = \frac{d}{s} = \frac{3600 \text{km}}{2.4 \times 10^3 \text{m/s}} = 0.15 \text{sec} \)

b. \( R \cdot t_{prop} = 10 \text{Mbps} \times 0.15 \text{s} = 1.5 \text{bits} \)

c. \( \frac{x \text{bits}}{R \text{bps}} = 60 \text{sec} - 0.15 \text{sec} \Rightarrow x = 59.85 \text{sec} \times 10 \text{Mbps} = 598.5 \text{Mbits} \)