1.

a)

In order to be used in a CDMA system, the keys should be perfectly or at least highly orthogonal. Since $K(A)$ fits two times within $K(B)$, in order to guarantee that A's data is correctly decoded, it must be guaranteed that $K(A)$ is orthogonal to each half of $K(B)$. If this is the case, then the orthogonality of $K(A)|K(A)$ with $K(B)$ is also true, where "|" means concatenation.

$$K(A) \cdot K_{1,1}(B) = (-1, -1, +1, +1) \cdot (+1, -1, +1, -1) = 0$$

$$K(A) \cdot K_{1,2}(B) = (-1, -1, +1, +1) \cdot (-1, +1, -1, +1) = 0$$

$K(A)$ and $K_1(B)$ are orthogonal.

$$K(A) \cdot K_{2,1}(B) = (-1, -1, +1, +1) \cdot (+1, +1, -1, -1) = -4$$

$$K(A) \cdot K_{2,2}(B) = (-1, -1, +1, +1) \cdot (+1, +1, -1, -1) = -4$$

$K(A)$ and $K_2(B)$ are not orthogonal.

Conclusion: $K_1(B)$ should be used.

b)

$$S(A) = +1 \cdot K(A)| - 1 \cdot K(A) = (-1, -1, +1, +1, +1, +1, -1, -1)$$

$$S(B) = -1 \cdot K(B) = (+1, -1, -1, +1, +1, -1, -1, +1)$$

$$R = S(A) + S(B) + N = (+2, -3, 0, +2, +3, 0, -2, 0)$$

$$DR_1(A) = K(A) \cdot R_1 = (-1, -1, +1, +1) \cdot (+2, -3, 0, +2) = +3 > +1 = "0"$$

$$DR_2(A) = K(A) \cdot R_2 = (-1, -1, +1, +1) \cdot (+3, 0, -2, 0) = -5 < -1 = "1"$$

c)

Quasi-orthogonal pseudo-noise sequences exist in greater numbers than pefectly orthogonal code words of the same length. Besides, they are less demanding in terms of synchronization.

2.

a)

The first step is to calculate $\frac{E_b}{N_0}$. Knowing that $M = 8$ for 8-PSK, the bitrate is $R = B \cdot log_2(M) = 10 \times 10^6 \cdot 3 = 30 \times 10^6$ bit/s. We can now calculate $\frac{E_b}{N_0}$:

$$\frac{E_b}{N_0} = \frac{P_r \cdot T_b}{N_0} = \frac{10^{\frac{-77,85}{10}} \cdot \frac{1}{R}}{10^{\frac{-170}{10}}} = \frac{10^{\frac{-77,85}{10}} \cdot \frac{1}{30 \times 10^6}}{10^{\frac{-17}{10}}} \approx 54,69.$$

We can now calculate the BER:

$$BER_{8-PSK} = 2Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}} \cdot sin\left(\frac{\pi}{8}\right)\right) = 2Q(4) = 6,33 \times 10^{-5}.$$

Given that the length of the frame is $l = 30 \times 8$ bit, the FER can be easily calculated:

$$FER = 1 - (1 - BER)^l = 1,51\%$$

b)

Two antennas transmitting over flat ground is a typical scenario to apply the Two-Ray Path Loss model:

$$P_r = P_t \cdot \frac{G_t \cdot G_r \cdot (h_t \cdot h_r)^2}{d^4}$$

The antenna gains can be calculated based on the effective aperture, which is a function of the physical aperture:

$$A_{eff} = \eta \cdot \mathrm{A}_{phy} = \frac{\lambda^2}{4\pi}\mathrm{G}$$

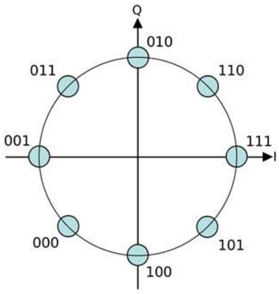
Solving for d, it results in $d \approx 61268\, m$.

One has to check whether this distance is greater than the crossover distance. In case it is not, the Friis Path Loss model should be used instead.

$$d_c = \frac{4 \cdot \pi \cdot h_t \cdot h_r}{\lambda} \approx 1047,2\, m$$

This confirms that the Two-Ray Path Loss model was the correct choice, since $d > d_c$.

c)



d)

This is an easy one:

$$\frac{R}{B} = log_2(M) = 3\ bit/s/Hz$$

3.

a)

$$Psize = \mathrm{RTP} + \mathrm{UDP} + \mathrm{IP} + \mathrm{image} \;=\; 12 + 8 + 20 + 2000 = 2040\ bytes$$

The maximum MAC DATA frame payload size is 1500 bytes, which means that we need to send two MAC DATA frames (one of them full), each of which will receive a separate ACK.

$$T_{image} = DIFS + Backoff + PHo + \frac{(MACh + 1500 \times 8)}{R} + SIFS + PHo + \frac{ACK}{R} + \mathrm{SIFS} + PHo + \frac{(MACh + (RTP/UDP/IP + data - 1500) \times 8)}{R} + SIFS + PHo + \frac{ACK}{R} =$$

$$= 0.020 + 0.100 + \left(0.054 + \frac{34 \times 8 + 1500 \times 8}{54000}\right) + 0.010 + 0.054 + \frac{14 \times 8}{54000} + 0.010 + \left(0.054 + \frac{34 \times 8 + (2040 - 1500) \times 8}{54000}\right) + 0.010 + 0.054 + \frac{14 \times 8}{54000} = 0.682ms$$

b)

Since the frame rate is 25 images/s, each camera sends a video image each 0.04s. We already know the duration of the transaction of one image, which is $T_{image} = 0.682ms$. We just have to calculate how many image transactions fit within 0.04s=40ms:

$$Ncameras = \lfloor 40/0.682 \rfloor = 58$$

c)

In each interval of 0.04s, each camera sends one image. As such, the total throughput is calculated as follows:

$$Throughput = \frac{Ncameras \times Psize \times 8}{0.04} = 23.2\ Mbit/s$$

It is lower than 54 Mbit/s, so it makes sense.

d)

$FER_{MAC} = (FER_{PHY})^{1+7} = 0.03^{8} = 6.561 \times 10^{-13}$

4.

a)

One must take into account that if more than one routing table entry matches the destination address, the longest match prevails. This rule must be considered when the packet is forwarded by H1. In this case, the packet goes to R1, where there is no entry matching the destination prefix. In this case, the packet is routed to R4 by default, which is directly connected to the destination subnet. The complete path is: H1_R1_R4_H2.

b)

Local routers can be found using the Router Discovery Protocol, which is based on ICMP. This same protocol, with specific extensions, constitutes the basis for agent discovery in Mobile IPv4.

c) The ICMP Redirect message can be used by a router to warn a host that a better route (through a different router) is available to send packets to a given destination.

d) IPv6 link-local addresses can be built from the MAC address. The Neighbor Discovery Protocol can then be used to check that the resulting link-local address in unique in the subnet.