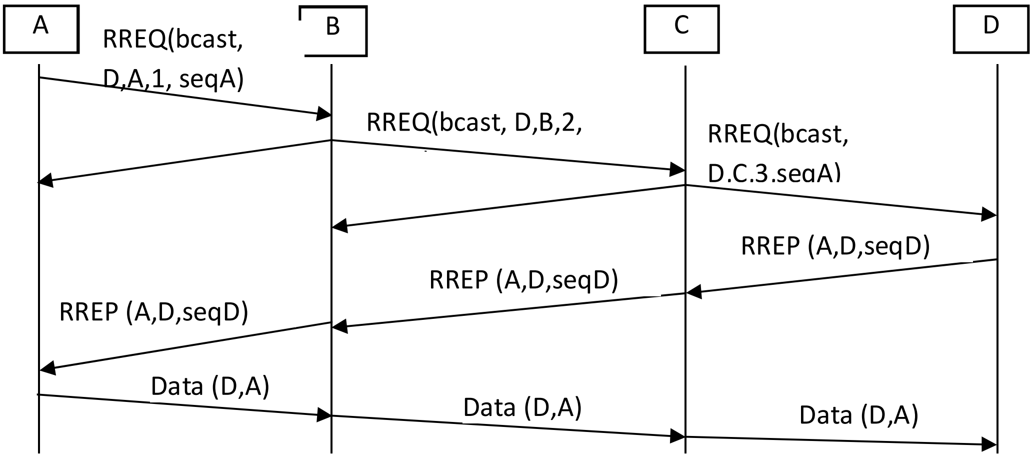
1.

a)

Both routing protocols are reactive, which means that routes will only be established when there are packets to be sent. This decreases the routing protocol overhead at the cost of additional latency. The protocols also have significant differences. In DSR, the sender has complete knowledge about the nodes that compose the route and transmits this information in the header of data packets. While this increases the overhead of (routing and) data packets, it avoids the use of routing tables, which means that DSR can be supported by nodes with tiny memory capacity. In contrast, AODV is a distance-vector routing protocol and thus relies on routing tables. The latter must be present at each node, indicating the next hop and hop distance for each known destination, besides additional route maintenance info, such as sequence numbers to avoid loops. This increases the memory requirements relative do DSR, but decreases the header size of data packets.

b)



Routing Table A			
Destination	**Next Hop**	**Distance**	**Sequence Number**
D	B	3	seqD

Routing Table B			
Destination	**Next Hop**	**Distance**	**Sequence Number**

A	A	1	seqA
D	C	2	seqD

Routing Table C			
Destination	**Next Hop**	**Distance**	**Sequence Number**
A	B	2	seqA
D	D	1	seqD

Routing Table D			
Destination	**Next Hop**	**Distance**	**Sequence Number**
A	C	3	seqA

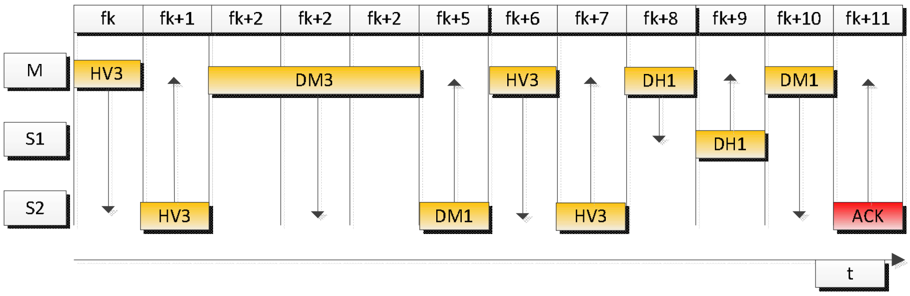
2.

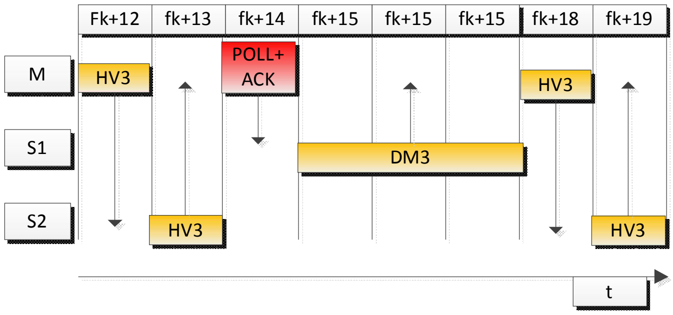
a) and b)

The HV3 packet encapsulates the maximum data payload size (30 octets), since it includes no FEC. Since the SCO bit rate is fixed at 64 kbit/s, HV3 allows maximum spacing between slots assigned to SCO. Knowing that the Bluetooth slot size is 625 us:

$$64000 = \frac{30 \times 8}{n \cdot 625 \times 10^{-6}} \Leftrightarrow n = 6$$

There will be 6 slots between the start of consecutive HV3 packets, considering one direction only. If both directions are considered, we must bear in mind that the SCO downlink slot (master to slave) is followed by the respective uplink slot (slave to master) and there will be two more slot pairs before SCO is transmitted again. The message sequence will be as follows:





3.

a) and b)

In UTRA-FDD, OVSF codes are orthogonal codes used to separate several streams from the same mobile station. The scrambling codes are quasi-orthogonal and will separate mobile stations located in the same area. Since there are only two mobile stations, we can assume that the background noise that is caused by each one of them in the other's signal reception is negligible. Consequently, each mobile station will be able to send the maximum possible total bitrate, which is 3.84 Mbit/s. This figure can be easily explained based on the following reasoning:

- With SF=4, each byte is coded into 4 chips: each stream has a bitrate of 3.84/4=0.96 Mbit/s.
- With SF=4 there are 4 orthogonal OVSF codes: (+1, +1, +1, +1); (+1, +1, -1, -1); (+1, -1, +1, -1); (+1, -1, -1, +1). Hence, a maximum of 4 streams can be transmitted at the same time.

If 4 streams are transmitted, the resulting bit rate is:

$4 \times \frac{3.84}{4} = 3.84$ Mbit/s

4.

a)

First we have to calculate *r*, based on which, *f* will be calculated. In order to calculate *r*, lets first calculate the distance to the surface of the Earth (*d*):

$$\boldsymbol{Footprint\ Diameter} = \boldsymbol{\theta_{div}} \times \boldsymbol{d} \Leftrightarrow 655 = \frac{2\pi \cdot 25}{360} \times d \Leftrightarrow d = 1501 \text{ km}$$

This corresponds indeed to a LEO orbit.

The distance to the center of the Earth, *r*, can now be easily calculated:

$$r = d + R = 7871 \text{ km}$$

We can now calculate ω, the angular speed:

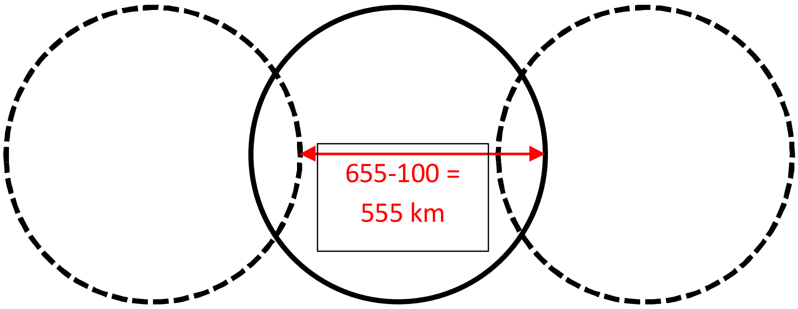
$$\boldsymbol{r} = \sqrt[3]{\frac{\boldsymbol{g \cdot R^2}}{\boldsymbol{\omega^2}}} \Leftrightarrow \boldsymbol{\omega} \approx 0.904 \text{ mrad/s}$$

And finally the rotational frequency:

$$f = \frac{\omega}{2\pi} \approx 0.144 \times 10^{-3} \text{ Hz}$$

b)

If we look at a footprint and its neighbor footprints (two) on the Earth's surface for a single satellite constellation plane, it should ideally look like this, all around the Earth, in case the minimum number of satellites is considered:



As such, we only have to calculate the ceiling of the ratio between the perimeter of the Earth and 555 km in order to obtain the number of satellites in the plane.

$$n = \left\lceil \frac{2\pi \cdot 6370}{555} \right\rceil = 73 \text{ satellites}$$

c)

The communication between the ground station and satellite is possible while the ground station stays within the footprint of the satellite. This corresponds to the time interval within which the projection of the satellite on the Earth's surface forms a line segment whose length corresponds to the diameter of its footprint. The fraction of the Earth's perimeter that corresponds to the diameter of the footprint is:

$$\varepsilon = \frac{655}{2\pi \cdot 6370} \approx 1.64\%$$

The period of the orbit is:

$$T = \frac{1}{f} \approx 6953s$$

The interval during which communication is possible in one cycle is then:

$$t = 1.4\% \times T \approx 114s$$