Mobile Communications
Problem Set 4

Prof. Dr.-Ing. Markus Fidler
M.Sc. Felix Langenbruch

13.05.2016

1. Are MAC protocols from wired networks suitable for wireless networks? Explain your answer

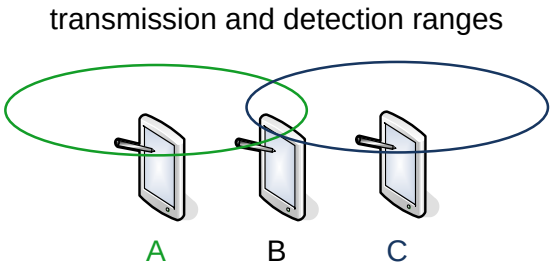
   Solution:

   Wired networks use 1 persistent CSMA/CD, i.e., carrier sense multiple access with collision detection. The sender senses if the medium is free and start sending as soon as it becomes free. While sending the sender listens to the medium to detect other senders. In case of a collision the sender immediately stops sending and waits for a random amount of time. In the context of wireless networks the signal strength decays with the distance d at least as $1/d^2$. There the following difficulties arise:

   - the sender can generally not detect a collision while sending. It would need a second antenna and moreover it would mainly hear its own signal
   - A detected collision by the sender does not imply that there is also a collision at the receiver
   - A collision at the receiver does not imply a collision at other locations, e.g. at the sender

2. Explain the hidden terminal problem and provide a possible solution to it.

   Solution:

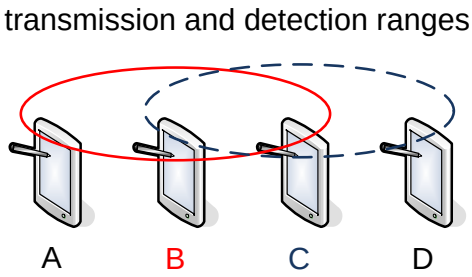


   At B a collision occurs because A is hidden from C and C is hidden from A. A senses free medium and starts sending to B. In the same time C cannot hear A. Then C senses free medium and starts sending to B. Since A cannot hear C both are sending at the same time to B. A collision occurs at B.

   One solution to the hidden terminal problem makes use of the fact that both A and C are in the transmission range of B. Thus when B starts receiving it sends a busy tone on a second channel indicating that it is busy. If C wants to send to B it listens to the medium first and hears the busy tone. This prevents C from sending.

3. Explain the exposed terminal problem.

   Solution:



   C is exposed to the transmission of B, i.e., C cannot send to D as long as B is sending to A. This happens because B and C both want to send data and both can detect the transmission of each other. So B starts sending to A before C starts sending. C listens to the medium and detects that it is busy and does not start sending to D. However, since D is outside the transmission range of B it would have been able to correctly detect the signal from C without any collisions.

4. We revisit the CDMA decoding example from the lecture with two senders A and B. Assume a third station that is called C is tapping the channel. However, C does not have the codes for A and B. Station C uses the random code "$-\,-\,+\,-\,-+$" and tries to decode any of the transmitted bit streams from A or B. What does C decode? Is it possible for C to correctly decode the signals for A and B?

Solution:

From the lecture:

A sends the bits 0110 and B sends the bits 1010. The code for A is "$-+--++$" and for B is "$++-+-+$". The chirp signals for senders A and B and sum of the two signals are given in the following (with $+,-$ is $+2,-2$)

A	$+-++--$	$-+---++$	$-+---++$	$+-++--$
B	$++-+-+$	$--+-+-$	$++-+-+$	$--+-+-$
Σ	$+0\ 0+-0$	$-0\ 0-+0$	$0+-0\ 0+$	$0-+0\ 0-$

Receiver A

Σ	$+0\ 0+-0$	$-0\ 0-+0$	$0+-0\ 0+$	$0-+0\ 0-$
A	$-+---++$	$-+---++$	$-+---++$	$-+---++$
Π	-6	6	6	-6

Receiver B

Σ	$+0\ 0+-0$	$-0\ 0-+0$	$0+-0\ 0+$	$0-+0\ 0-$
B	$++-+-+$	$++-+-+$	$++-+-+$	$++-+-+$
Π	6	-6	6	-6

C uses the (wrong) code "$--+--+$" and decodes he following

Σ	$+0\ 0+-0$	$-0\ 0-+0$	$0+-0\ 0+$	$0-+0\ 0-$
C	$--+--+$	$--+--+$	$--+--+$	$--+--+$
Π	-2	+2	-2	+2

C decodes the bit stream "0101". The summation after each bit period still gives a 0 or a 1, however, the signal rather resembles noise. The sum over noise results in values close to zero as can be seen from the results "-2" and "+2". This example shows that CDMA protects transmitted signals from tapping. The used chirp codes are at the same time encryption keys. Station C requires the codes from A or B to be able to detect their bit streams.