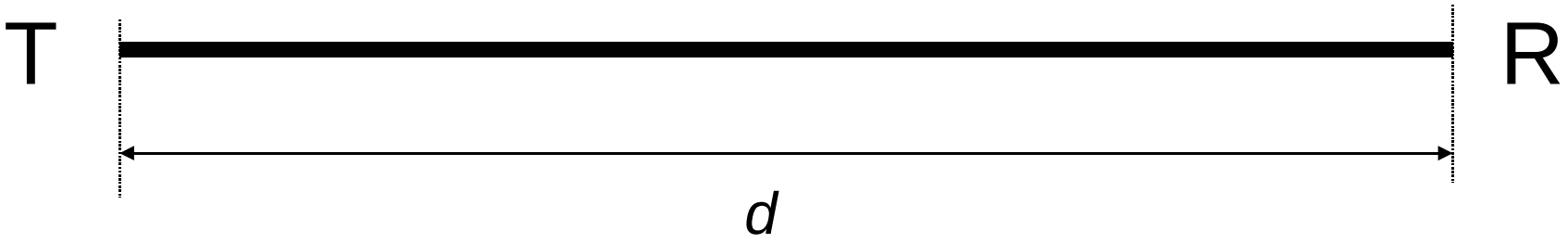
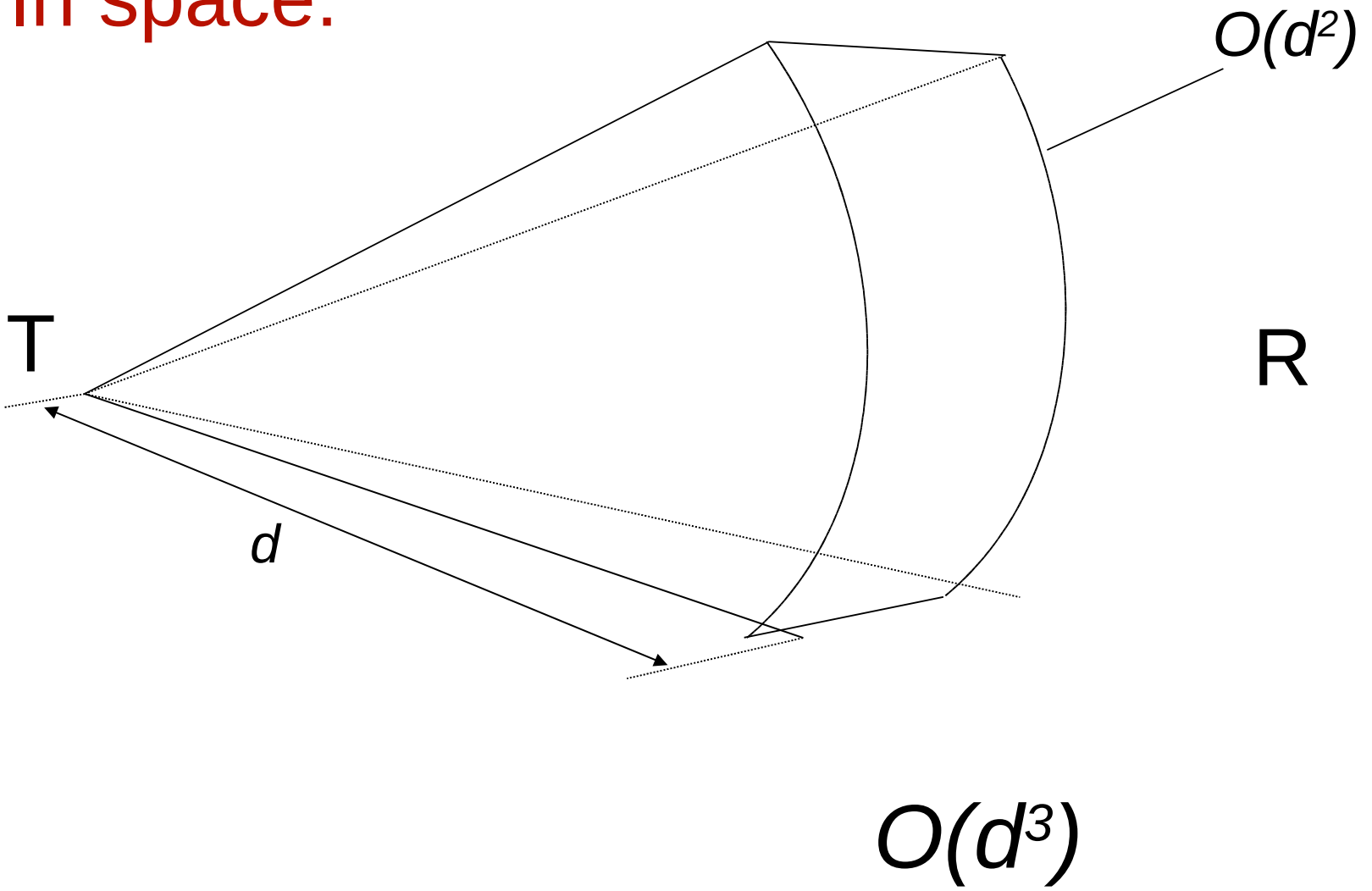
Wireless basics

In short, what you need to know about radio transmission

distance:



In space:



Data communication

- The normal way of communicate using a radio channel is to choose a carrier frequency and then modulate this frequency either in amplitude, frequency or phase (three sides of the same coin).
- We will look more carefully at how this is done but not now. The important ting is that we have a carrier that operates in specified spectrum. The bandwidth of the carrier is the difference between the allowed min and max frequencies.
- Historical note: we use carrier modulation partly because it has been very easy to design carrier transmitters and receivers.
- Take a look at what they do with UWB!

The most important thing:

$$C = B * \log_2(1 + S/N)$$

rules of thumb:

- high signal to noise ratio is good
- bandwidth is better
- mobile networks typically has a capacity of 1-2 bit per Hz bandwidth
- A regular GSM carrier is 200KHz wide and has a raw capacity of 271Kbps.

Signal attenuation

- Attenuation depends on distance, obstacles, weather, ...
- Attenuation is also frequency dependent. Higher frequency have generally higher attenuation.
- GSM in the 900-band provide better coverage compared to the 1800-band.
- Compare AM radio in the 500KHz band FM radio in 90MHz band.

Fading

- A moving terminal will observe increase and decrease in attenuation since obstacles get in the way of the signal. This is called slow fading.
- So what is fast fading?

Multipath interference

- Signals will arrive at the receiver
  - line of sight
  - reflected or deflected by larger objects
- If signals arrive out of phase the signals will interfere with each other
- At 900MHz the wave length is 30cm, if two paths differ in exactly 15 cm they will cancel each other out.
- A moving terminal will observe rapid fading in the signal as it moves since the difference between paths will go from 0 to 30 cm then back to 0. This is called fast fading.

Broad is better

- Fading is frequency dependent.
- If we use a very narrow carrier the whole carrier will be effected. In larger carrier only parts of the carrier would be effected.
- There is an advantage in using a broader carrier.
- If the carrier is broad then we must divide it in some way to allow more terminals to share it.

Symbol interference

- If the difference in length between two paths is very large different symbols that we try to encode will interfere with each other.
- In GSM we have a symbol rate of 271K symbols/s that is each symbol takes about $4*10^{-6}$ s to transmit, speed of light $300 *10^{6}$ m/s gives us a symbol length of 1200m.
- If the difference in paths is above 100 m we will have significant symbol interference.
- This is mainly a problem in rural areas.

Narrow is also good

- If we use a narrow carrier (and thus have room for more carriers) the signal speed will be low. If the signal speed is low then the signal length is long and the risk of symbol interference low (unlikely that two paths will differ in several kilometers).
- If we have a narrow carrier we will not have to divide it among as many users.
- But, ... if the carrier is narrow it will not have as high capacity :-(

Broad vs Narrow

- Improved methods of handling inter symbol interference, time and code division for resource sharing and demand of high capacity carriers has driven the evolution of broader carriers.
  - Analog systems: 20 – 30 Khz carrier
  - GSM: 200 Khz carrier
  - WCDMA: 5 Mhz carrier
  - 802.11: 20MHz
- Note, techniques such as OFDM (orthogonal frequency division multiplexing used in 802.11g) uses a set of narrow band carriers that are combined in one 20MHz carrier.

Important

- The bandwidth available to a radio network is the most important factor.
- Bandwidth must be shared.
- Radio technology is basically:
  - How to modulate radio carriers.
  - How to share resources.