GSM Network and Services

Cellular networks

The name of the game

- The number one priority for mobile/cellular networks is to implement full-duplex voice services with wide area coverage.
- Regulations decide what radio spectrum that can be used and this becomes the most valuable resource.
- Give me four reasons why this resource must be divided; who/what is competing for the resource?

Dividing the resources

- Among operators
  - Always (sofar) done by dividing the spectrum.
- Duplex communication
  - unless it's your mother on the other end
- Multiple access
  - we are not alone
- Cellular planning
  - neighbouring cells can not use the same resources

Duplex communication

- Frequency division duplex (FDD)
  - one carrier is used in the down link, another in the up-link
- Time division duplex (TDD)
  - Use the same carrier but take turn using it.
  - Requires that we can make a pause in the transmission to wait for the other party.

FDD is most often used

- GSM, as most mobile networks, uses Frequency Division Duplex.
- What is the advantage of FDD?
- What is the advantage of TDD?
- What systems uses TDD?

Multiple access

- FDMA – frequency division
  - Each user is allocated one (or two for duplex) frequencies. This was the method used in the analog mobile networks. Each carrier will need its own transceiver. A carrier becomes narrow in bandwidth.
- TDMA – time division
  - Make the carrier a little bit wider and divide it into time slots. Problem, how do we keep mobiles synchronized?
- CDMA – code division
  - Allocate a unique code for each connection.
- SDMA – spatial division
  - Use active antennas and track each user.

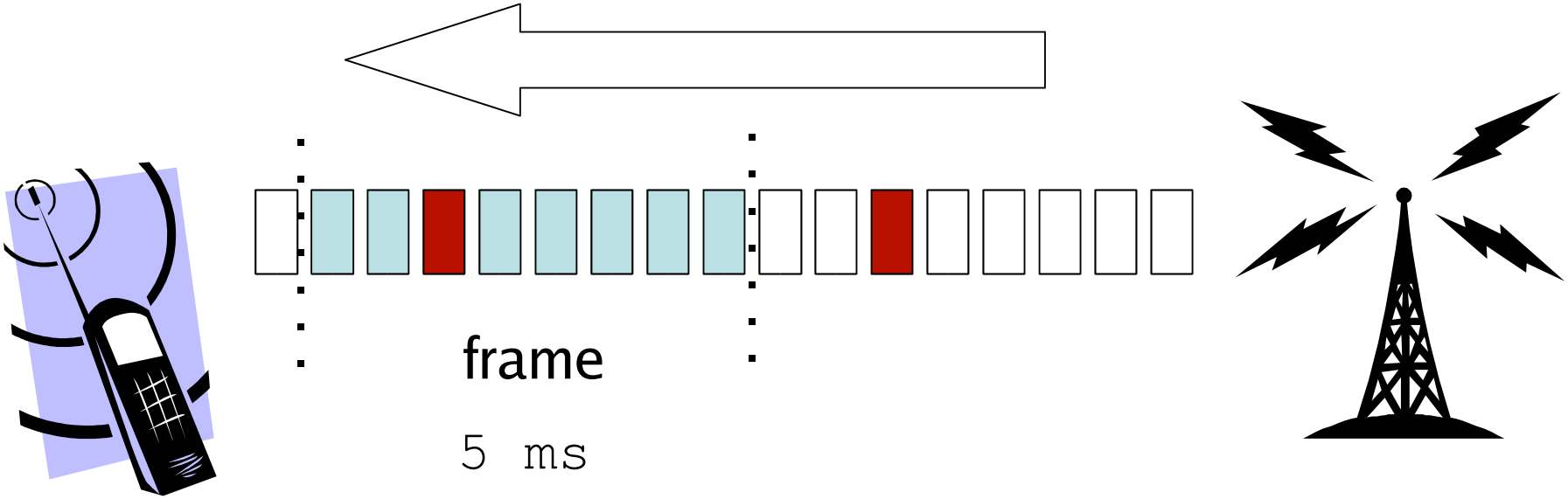
TDMA rules but CDMA is the future

- GSM and many other mobile systems uses TDMA.
- If we have a broad carrier then we need to divide it into shorter time slots.
- Shorter time slots require better synchronization.
- All 3G standards uses CDMA.
- CDMA terminals need not be as tight synchronized but has other problems.

GSM multiple access

- Transmission in a carrier is divided into time slots of 0.6 ms.
- Eight time slots make up a frame so one frame last aprx for 5 ms.
- A physical channel is made up of one of the slots in each frame.
- Logical channels are then defined that uses a whole, parts of, or several physical channels.

The GSM time slot



Cellular network

- Frequency planning
  - Each cell will use a different set of frequencies.
- Code planning
  - Each cell will have different set of codes.
- Time planning
  - Never heard of?

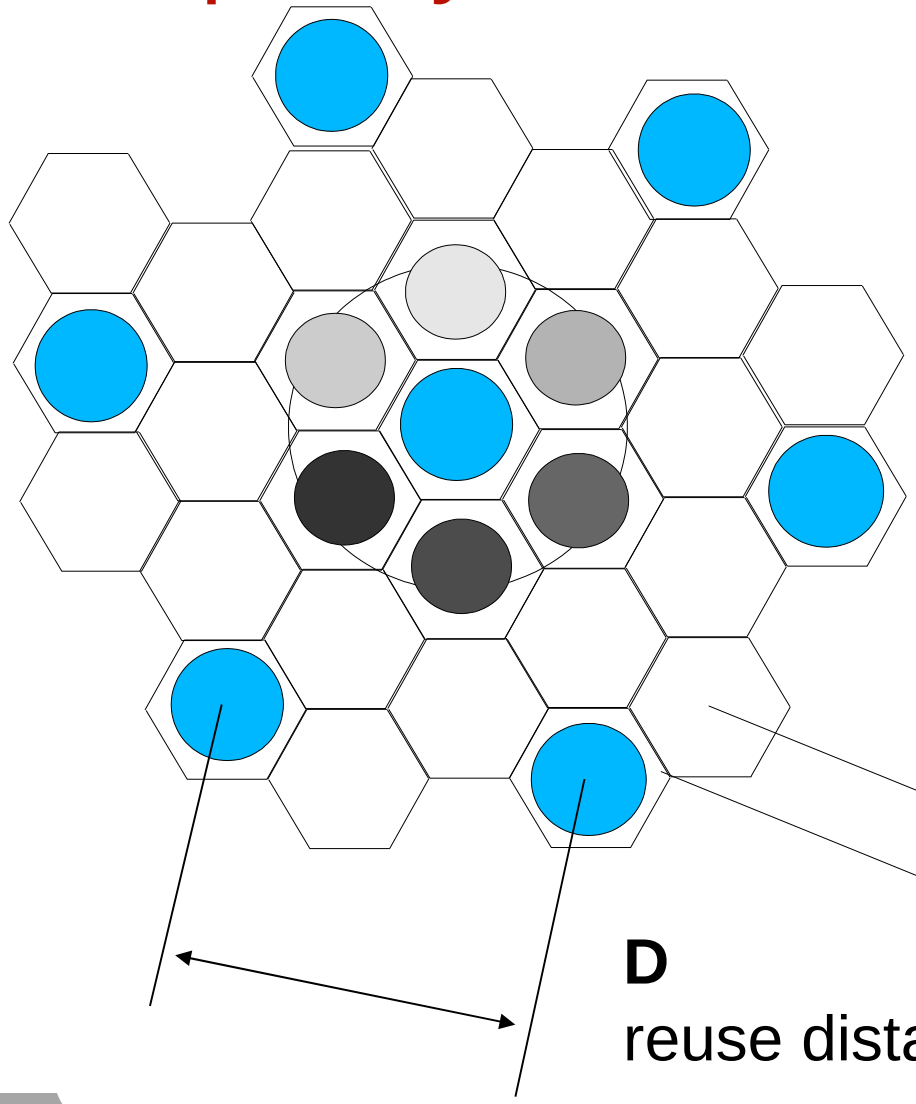
GSM

- GSM
  - Frequency division for cell planning.
  - Frequency division for duplex communication.
  - Time division for multiple access.
- WCDMA
  - Code division for cell planning.
  - Frequency division for duplex communication.
  - Code division for multiple access.

Frequency planning

- Since cells are more or less close to each other there is not perfect solution.
- Cells will always interfere with each other even if they are not immediate neighbors.
- How many cells must we consider when we do our planning?
- How many closest neighbors do we have?

frequency reuse

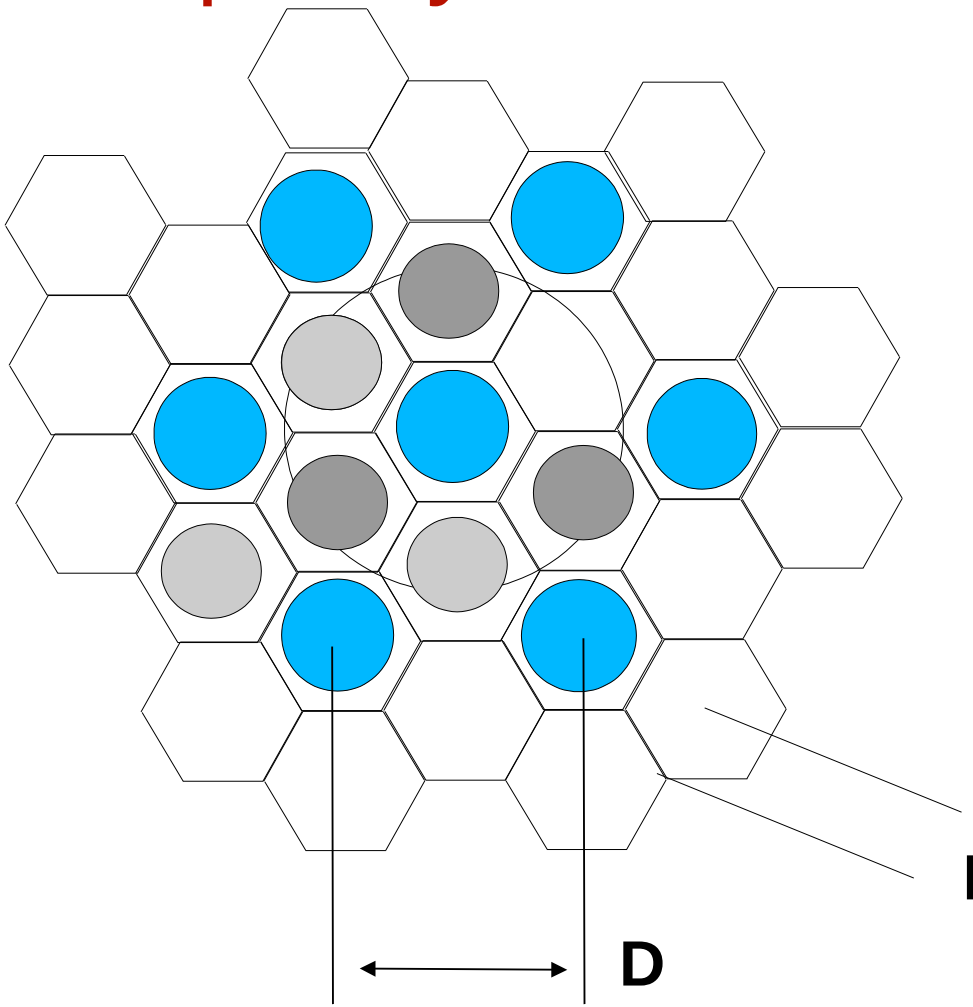


k = 6
number of cells in pattern

R radius of cell

D
reuse distance

frequency reuse



D = R sqr(3k) aprx.

k = 3
number of cells in pattern

R radius of cell

D
reuse distance

Interference from neighbors

- The only (almost) noise we have to consider comes from interfering base stations.
- If we want to reduce interference from neighbors we need to increase the D/R ratio.
- If D = R sqr(3k) then sqr(3k) should be big, that is increase k!
- If we need a C/I ratio of 18dB then we need k > 6.

GSM frequency reuse

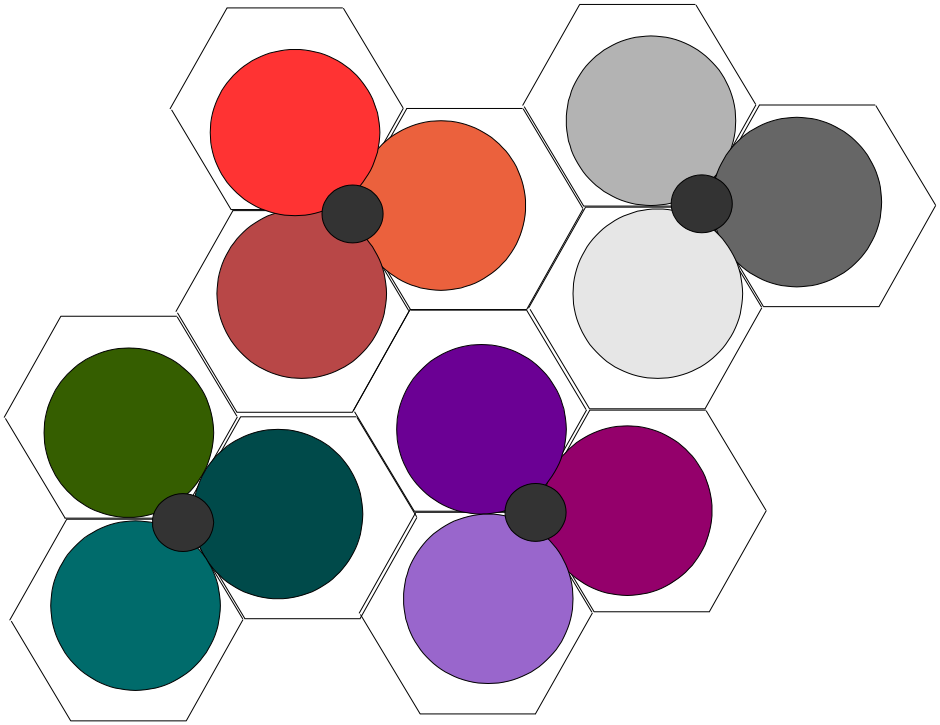
- In GSM networks a frequency reuse pattern with k = 3, 7 or 12.
- In the 900-band, which is 2x25MHz wide, we can have 124 carriers. If these are divided into groups of 12 frequencies we can have 10 groups.
- One cell can thus be covered by 10 carriers.
- Each carrier can have 8 connections thus a maximum of 80 calls in an area covered by a cell.

More consequences

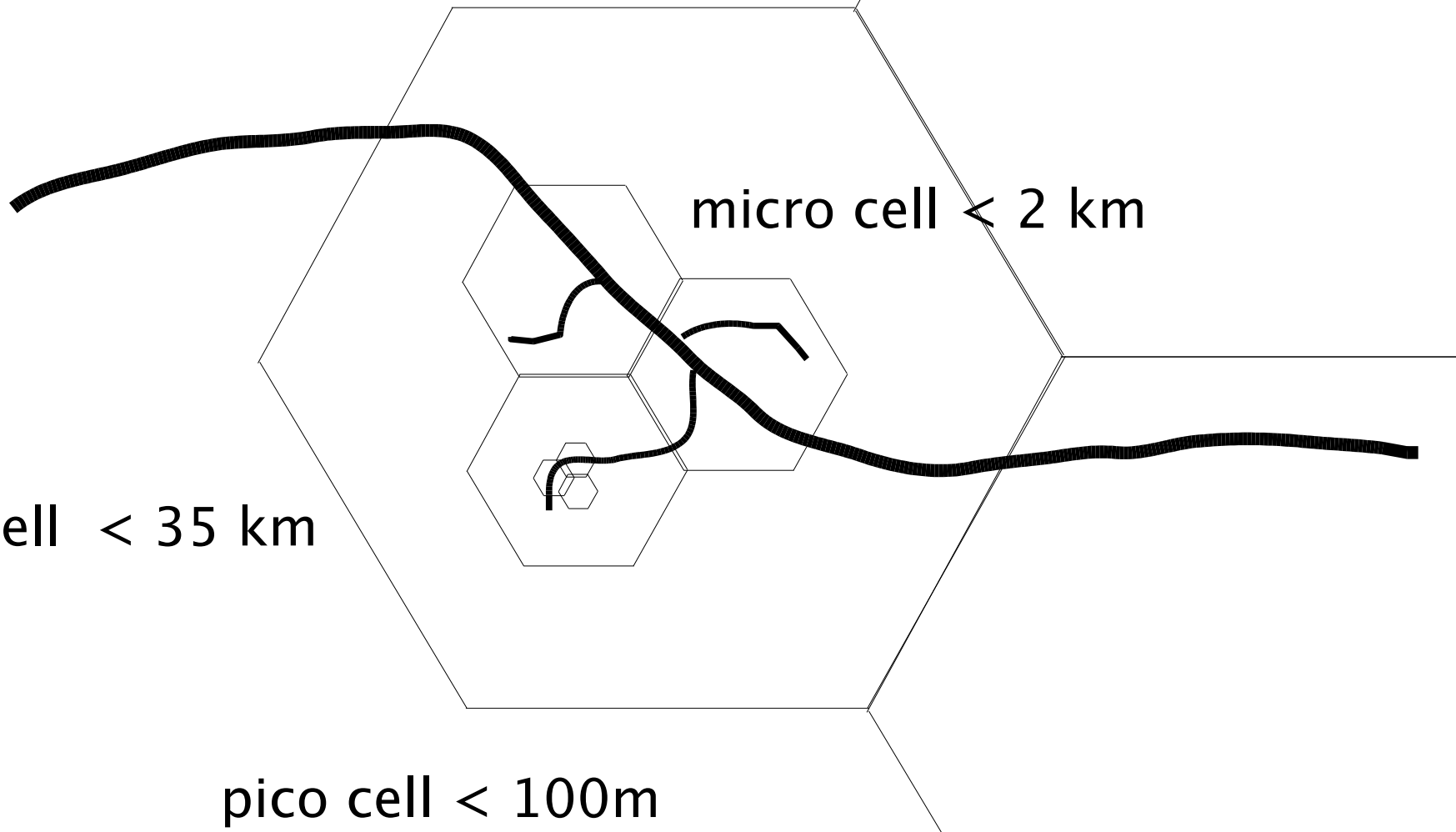
- If we only have 10 groups and we have three operators each operator will have three groups.
- We can have a maximum of ten operators but then no operator would be able to cover any are with more than one carrier.
- To increase the overall capacity we need to make cells small. We still have a maximum number of carriers in a cell but if the cell is small the total capacity increase.

4/12 resuse pattern

- Four base stations.
- Each base station has three antennas and serve three cells.
- In total 12 frequencies.
- Note: the base station is located in the intersection of three hexagons.



Macro, micro, pico ...



Who should use what

- Fast moving mobiles such as cars, trains etc should avoid using micro cells since they would have to change cell more often.
- Slow moving mobiles should use micro or pico cells to leave room in the macro cell for faster mobiles.

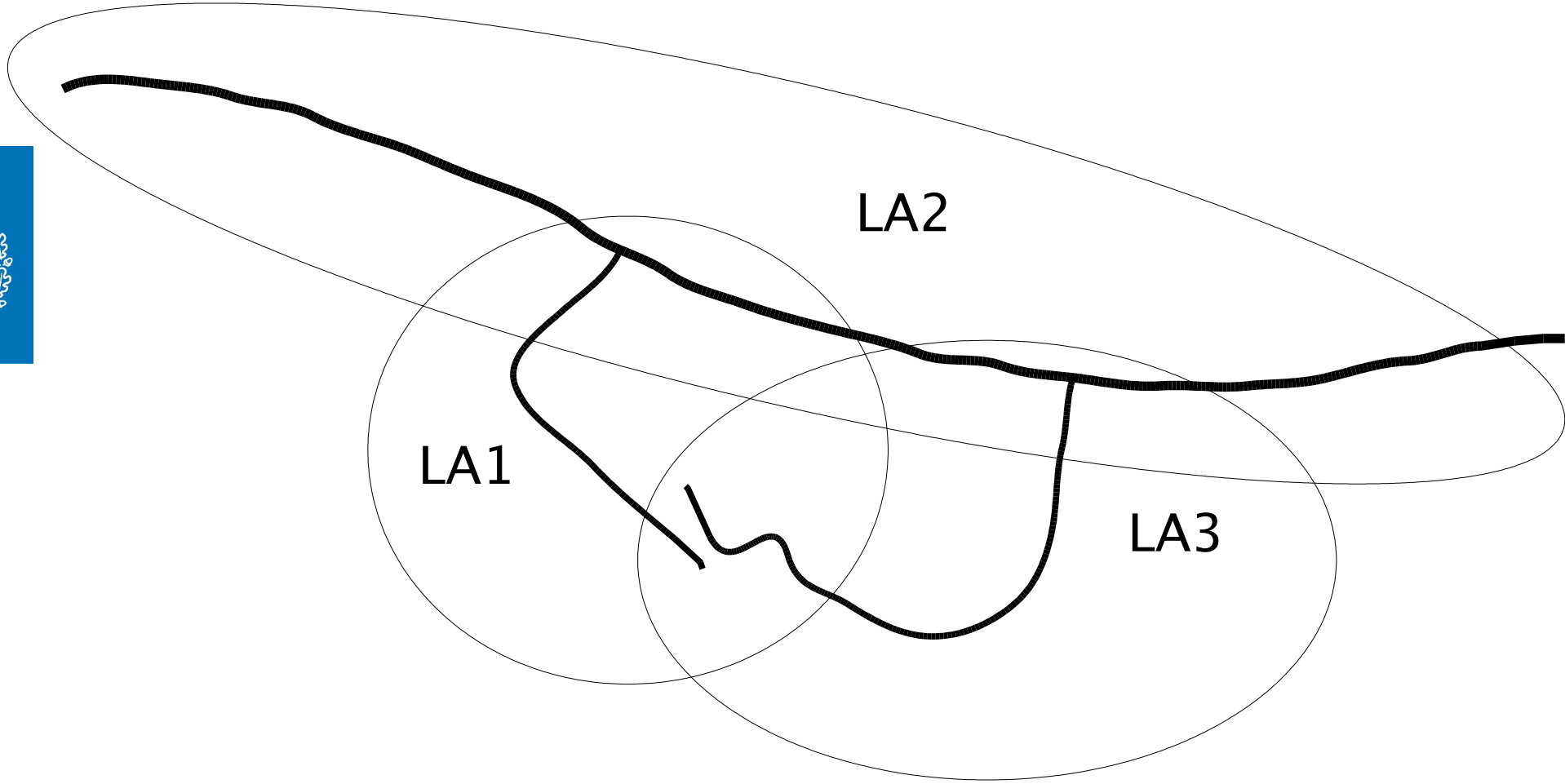
Remember the frequency group

- If you only have one frequency group you can not build a macro and micro layer.
- One size fits all – not.
  - Large cells: total capacity will be low.
  - Small cells: fast moving mobiles would have to do frequent handovers.

How do we find a mobile

- Solution one: let the mobile report to the network as soon as it enters a new cell.
- Solution two: let the network *page* the mobile if it needs to know its location.
- The compromise: divide the network into *location areas* consisting of a set of cells.
- As a mobile enters a location area it will update the network. If the network needs to know the exact location it will page in all cells in the location are.

Location Areas



Think about

- How would we implement a mobile network with a 802.11b radio access network?
- Can we divide the radio resources between operators?
- How would we do frequency planing?
- Can we have macro and micro layers?
- How should we do location updates?
- How do we perform paging?