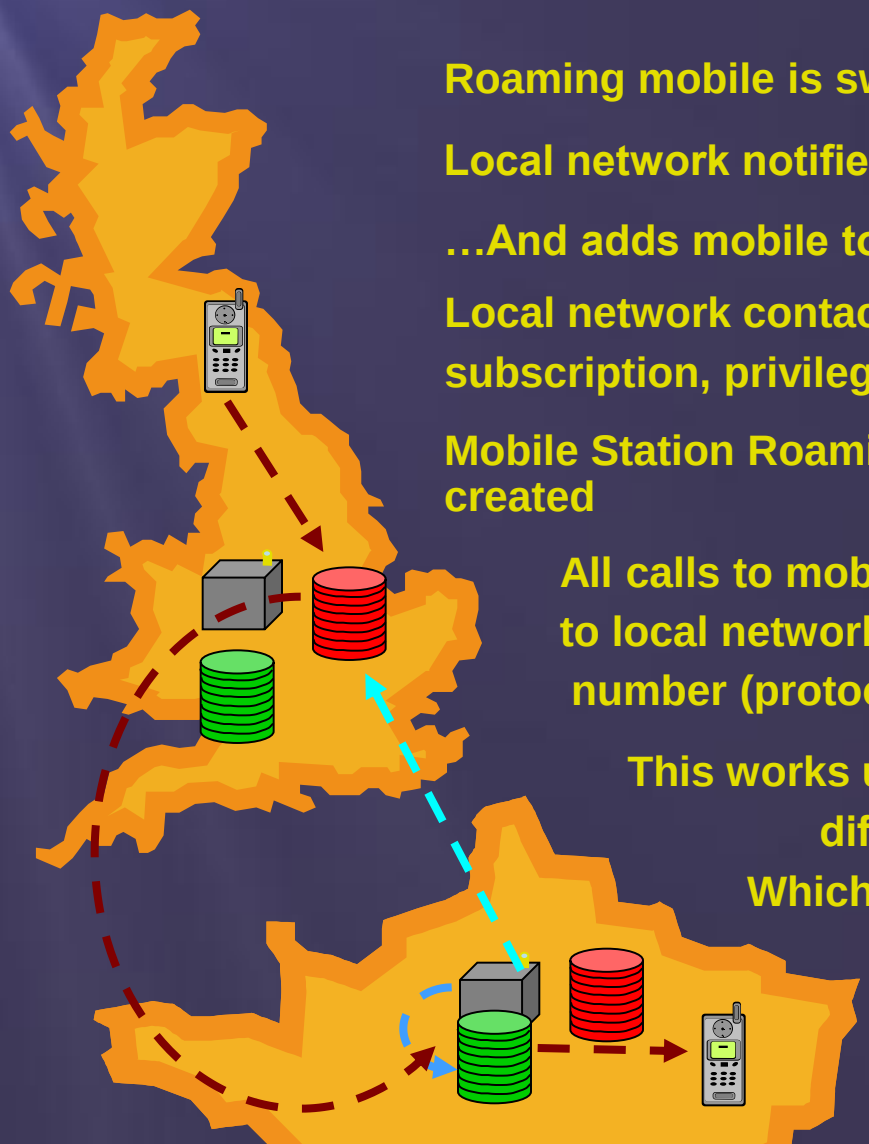
Wireless services, 3g and positioning

2G Services: Roaming



Roaming mobile is switched on in new country

Local network notifies HLR of home network…

…And adds mobile to it's own VLR

Local network contacts home network HLR to check subscription, privileges etc

Mobile Station Roaming Number (Virtual phone number) is created

All calls to mobile go to HLR and are then transferred to local network anywhere in the world via this virtual number (protocol SS7)

This works until you enter a country that uses different frequencies…

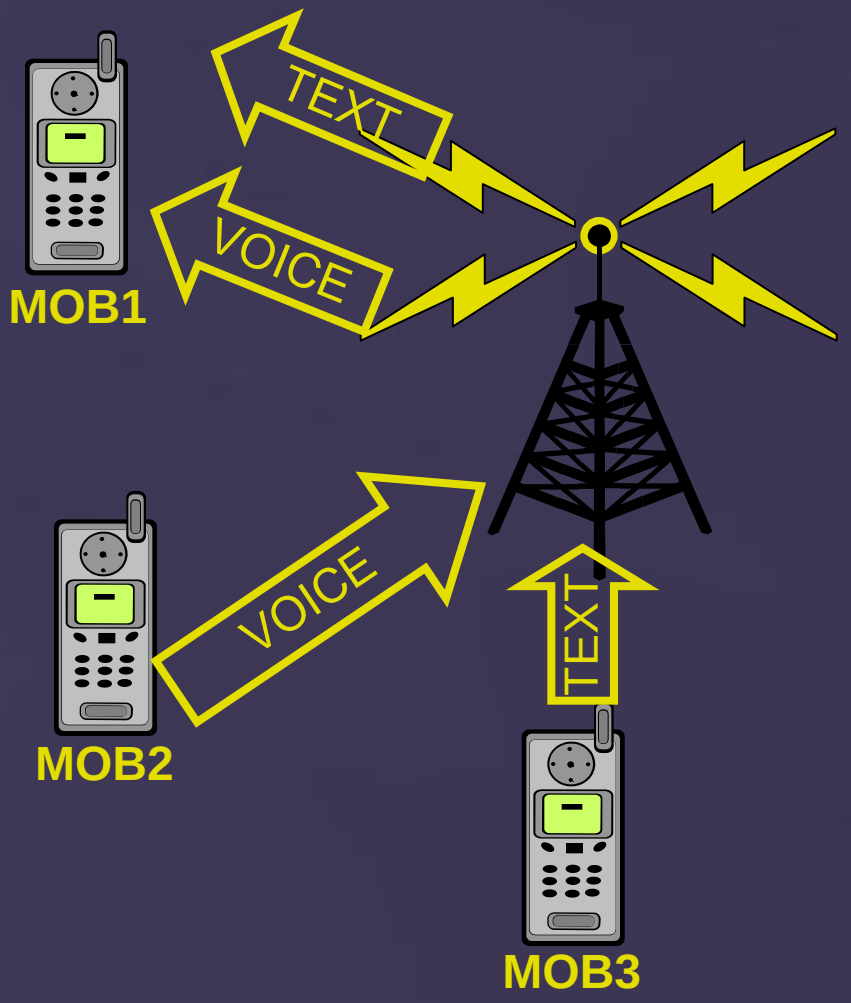
Which is where tri-band phones come in!

2G: SMS

- Short Messaging Service
- Intended to replace the pager
  - Problem with pager was that you had to reply via a phone call
- Supports ASCII and extra European characters and Unicode
- Accidental success! Never meant to be as popular as it became

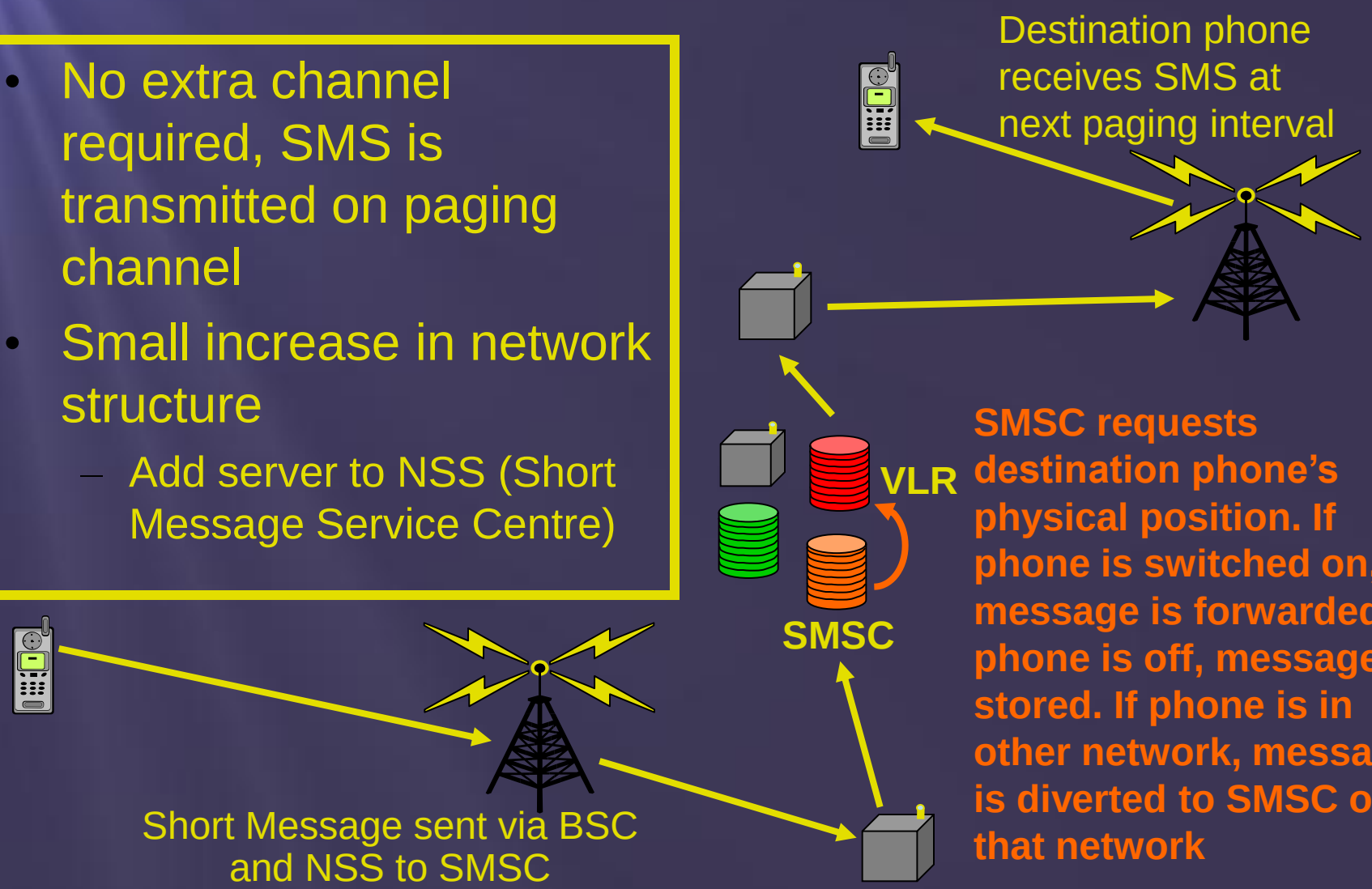
2G: SMS

- Mobile devices periodically ‘listen’ to Digital Control Channel Packet
  - DCCP indicates incoming call alert, pages to determine nearest BS etc…
- One packet format is SMS
- allowing messages to be delivered while calls are in progress



2G: SMS

- No extra channel required, SMS is transmitted on paging channel
- Small increase in network structure
  - Add server to NSS (Short Message Service Centre)



2.5G: MMS

- Multimedia Messaging System
  - Available only on packet switched networks
  - Backwards compatible
    - Un-enabled devices just receive a web-page address
    - Supports:
      - JPEG, GIF, PNG, SVG-Tiny (2D Vector Graphics)
      - MPEG-4
      - SP-MIDI
      - Adaptive Multi Rate (AMR) Audio

2.5G: MMS

- WML, XML and SMIL
- Synchronised Multimedia Integration Language (SMIL)
  - Allows for time dependent display of information eg. presentations
- Theoretically unlimited size
  - Makes use of multiple packet transmissions
  - Packets transferred with WAP
  - User notified only when whole message arrives

3G: Improvements over 2G

- Higher speed data access
  - 2048KBPS!!!...stationary environments
  - 384Kbps, pedestrian and urban environments
  - 144Kbps, in wide area mobile environments (vehicular etc)
  - Includes satellite standards, rates vary
- Anytime, Anyplace, Anywhere
  - This time the aim is a truly worldwide standard
  - No tri-band phones
  - No dual mode phones

The 3G Standard

Standards created by International Telecomms. Union (ITU)

- IMT-2000

2 Groups developing from different standards

- 3GPP (GSM)
- 3GPP2 (CDMA2000)

3 Implementations of the standards

- UMTS
- CDMA 2000
- TD-SCDMA

3G: The Reality

- One worldwide bandwidth
  - There's a reason we have tri-band phones…
- Problems with error control code specs
- Japanese standard, FOMA was not originally compatible
  - It is now!
- Back to old problems
  - commercial agreements for roaming (or lack of)
  - Huge increase in power consumption on devices
- Taken Ages to role out
  - But we're getting there

Universal Mobile Telecomms. System

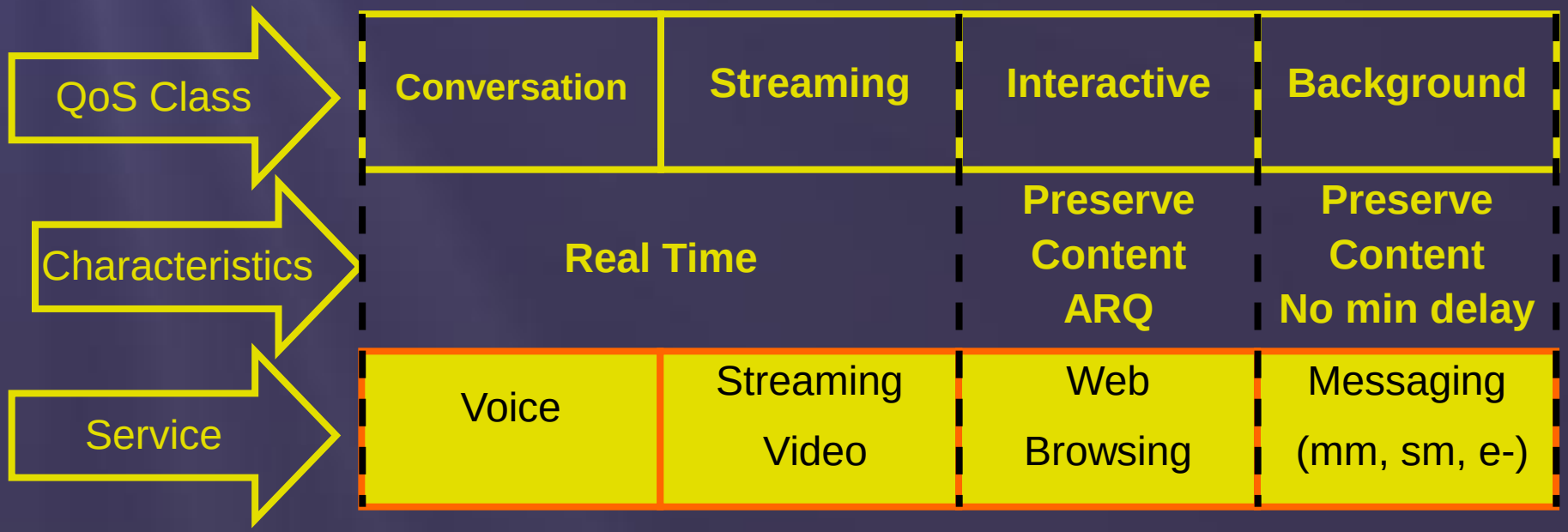
- Built on GSM technology
- Standardised by European Telecomms. Standards Institute (ETSI)
  - Incorporating GPRS and EDGE
- Core Networks
  - Asynchronous Transfer Method (ATM)
  - The core network
    - Allows circuit switched transfer of data using packets
    - High speed < 10Gbps
    - Guarantee of QoS for duration of transfer of packet
    - Small packets used to minimise effect on network

The Joys of Packet Switching

- UMTS is fully packet switched
- As discussed in last weeks lecture
  - Much better use of transmission medium
    - Silence during a call is not transmitted as it would be in circuit switching
    - Rather, the channel is used for other packets
  - GPRS and EDGE problems are not faced
    - As voice is also transmitted in packets, there is no possibility of underused data channels

Quality of Service

- Defines aspects of communications
  - Packet delay time
  - Sound quality etc.



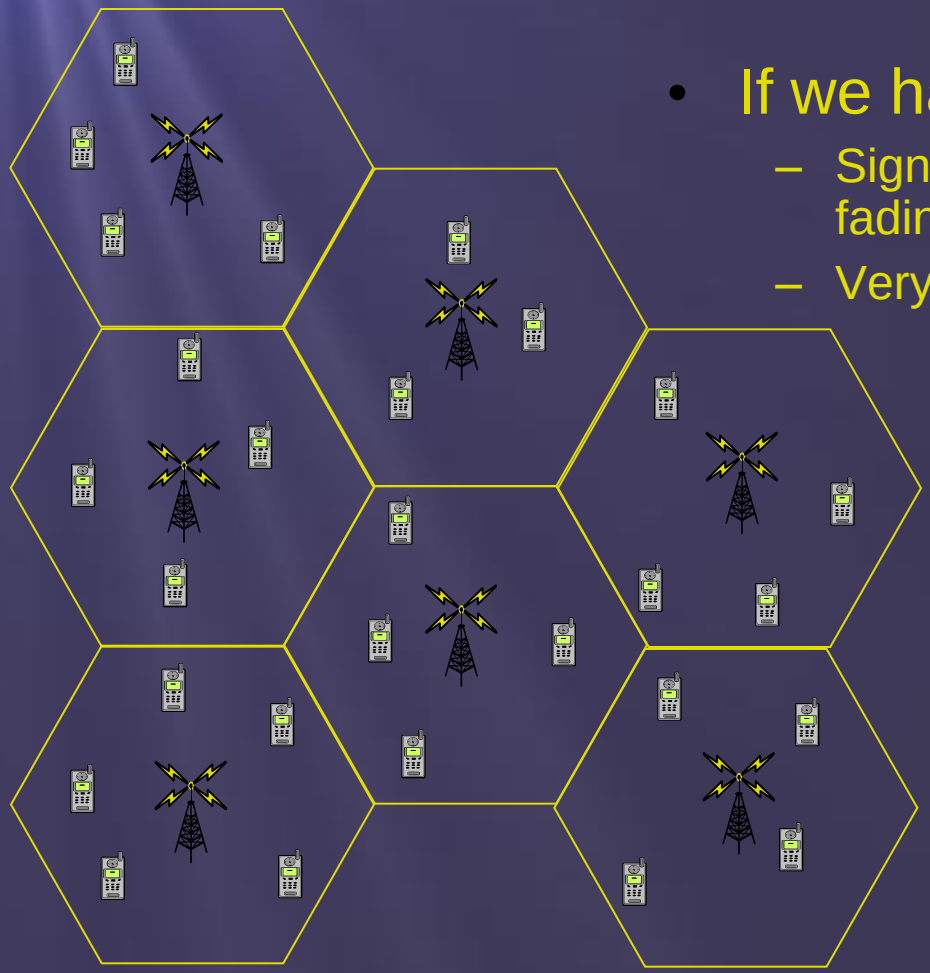
Quality of Service

To meet the different QoS Classes, requires that the network infrastructure alters modes of delivery

Higher information rate means larger number of packets which could impact on other users

Distance from nearest base station and speed of user require changes in error control techniques

Network Structure
(The Bigger Picture)



- If we have only one BS
  - Signal strengths will vary (attenuation, noise, fading)
  - Very small number of channels will be available
- So we introduce multiple BS (Cell structure)
  - Signal strengths will be more constant
  - More channels available
- But these introduce their own set of problems

Cell Structure

- Transmitter power can be reduced
  - Saves on battery power at handset
- Signal quality can be improved
- More calls can be handled
  - If designed properly!!
- Ignoring cost issues (base stations are expensive!), design means splitting available frequencies in a different way to FDMA…

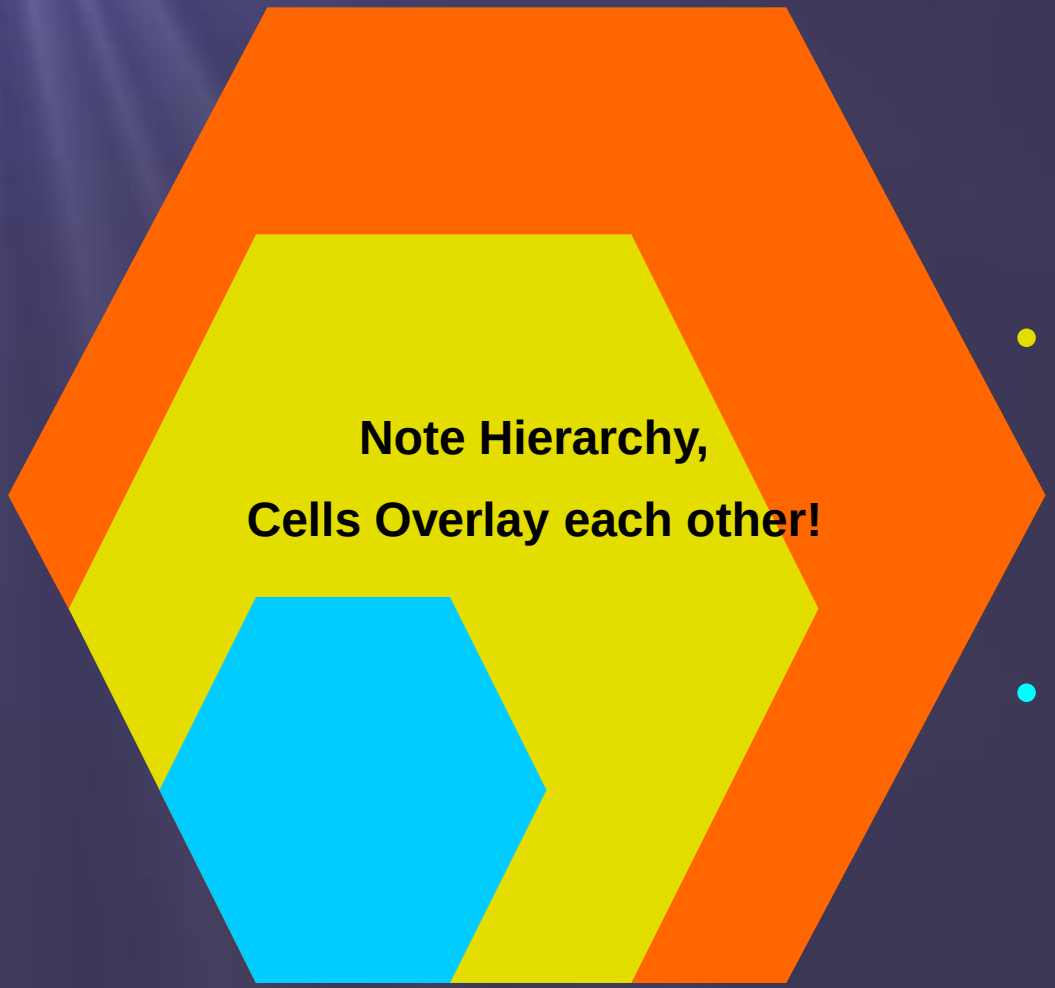
Cell Structure

- Splitting the available bandwidth
- If two adjacent cells are using the same frequencies, calls will interfere with one another
- Same effect as finding a nasty pirate radio station at 92FM instead of the Archers!
- Obviously cant split frequency endlessly
  - Transmitter power means that we can use the same frequencies in other cells, as long as they are far enough away

The ‘Minimum Frequency Reuse Factor’

- Carefully planned
  - Basically, all available bandwidth is split into three. No adjacent cells ever use the same frequency
- Then you have to deal with handover between cells

Cells in 3g



- Macro Cell
  - Large area, Suburban
  - 144Kbps
  - Superman, < 300mph
- Micro Cell
  - Medium area, urban
  - 384Kbps
  - Vehicular, < 70mph
- Pico Cell
  - < 100 metres
  - 2Mbps
  - Pedestrian, < 6mph

UMTS: Technologies

- Wideband-Code Division Multiple Access
  - W-CDMA for short
- We've seen how FDMA and TDMA work
- CDMA allows multiple users to work in one channel
- UMTS supports Time Division and Frequency Division Duplex
  - Duplex = 2 way comms at same time
  - Forward and back channels separated

The Biggest Benefit

- All use same frequencies.
- Which means that we can drop in cells wherever they are needed!
  - As long as channel ‘keys’ are unique

The Trickiest Bit

- Englishman, Irishman and Welshman…
  - Englishman starts talking louder than the rest
  - What do you hear?
  - All other voices are drowned out
- CDMA requires that just enough power is used to safely transfer the data
  - Side effect: Lower power consumption

Positioning in 3g

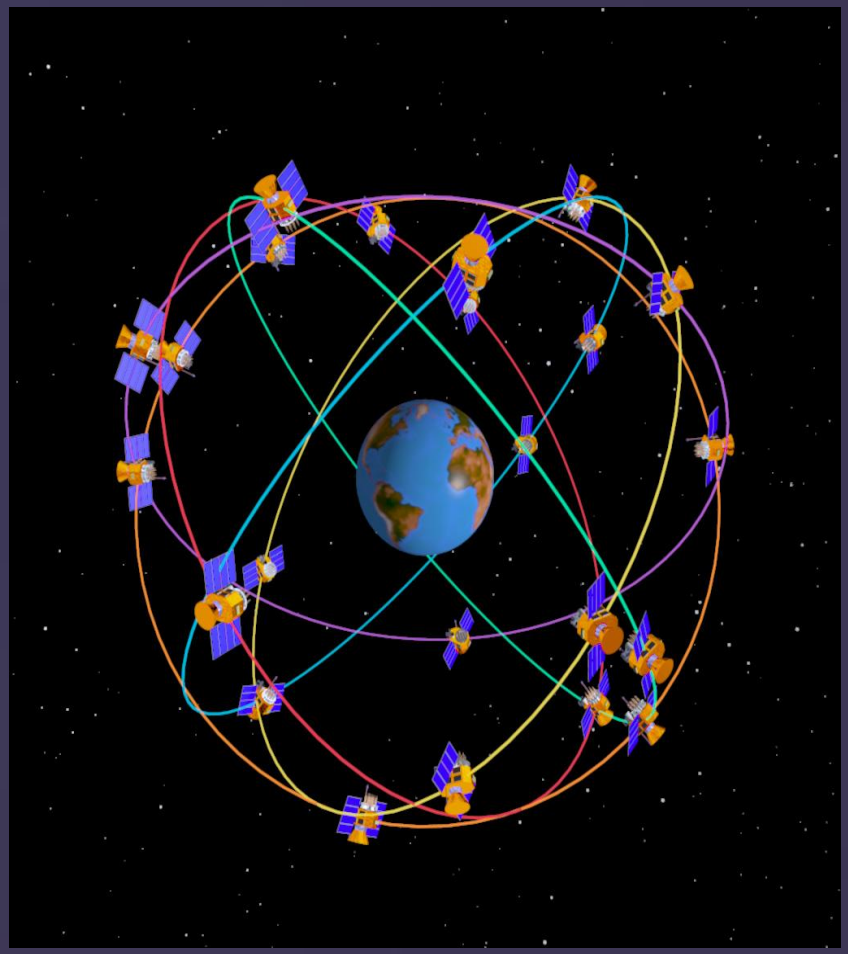
- Is based upon similar principles to GPS
- Although it works on signal strength
- We'll discuss GPS and all will become clear

GPS

The Global Positioning System (GPS)

24 earth-orbiting satellites used to define geographic positions, consisting of three segments:

User segment
Control segment
Space segment



GPS

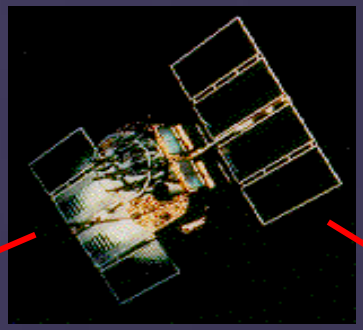
- Two services
- PPS – Precise Positioning Service - Encrypted
- SPS – Standard Positioning Service
- Until ~2000 the accuracy of SPS was deliberately reduced to stop enemies of US using it against them. Now SPS is roughly as accurate... but for how long?

GPS

- Space segment
- 24+ satellites (There are backups up there)
  - 6 planes with 55° inclination
  - Each plane has 4-5 satellites
  - Broadcasting position and time info on 2 frequencies
  - Constellation has spares

GPS

Control Segment - Maintenance



- ***Observe Ephemeris (position) and clock***
- ***Correct Orbit and clock errors***
- ***Create new navigation message***

(5) Monitor Stations

Falcon AFB

Upload Station

GPS

- It all hinges on signal time
- Think about how you measure the distance from lightning
  - See lightning
  - Count seconds until...
  - Hear thunder
- Distance = approximately number of seconds*speed of sound

GPS

- GPS works the same way.
- Satellite and receiver have synchronised clocks
- Satellite sends time
- Receiver compares that value with current time
- Multiply difference by speed of light
- Do this with multiple satellites and hey presto, you can triangulate position