

Radio Resource Management

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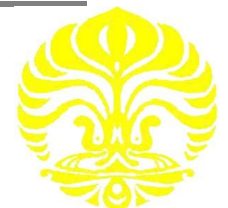
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Slide 1



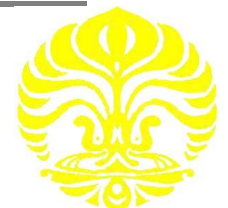
Information revolution

Value of information

Demand for bandwidth



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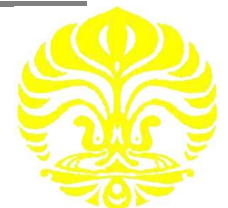


Need for mobility

**Information is only of value if it
can be delivered where it is
needed**

**Some mobility through intelligent
wired network**

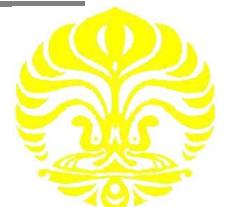
**More mobility through wireless
LAN technology, etc**



There is only one radio spectrum

Capability only expandable to a limited extent into the mm wavebands or by improving modulation and coding methods

MUST use it effectively to get best value, and to have potential for future expansion of services



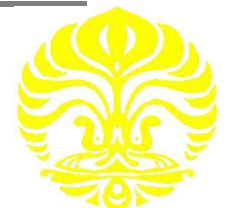
Need adequate quality of service

Assurance of protection against interference

REGULATE

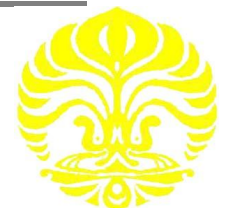


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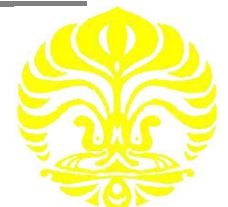
National Regulation

- Each country is sovereign – can authorise the use of radio transmissions
- Needs to plan and control the use of radio
- Licensing, etc



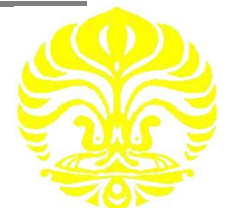
Regional

- Common objectives to coordinate the use of radio:
 - To avoid interference
 - Create common equipment specifications
 - Permit cross border use
- Example in Europe
 - European Communications Committee of CEPT
 - ETSI



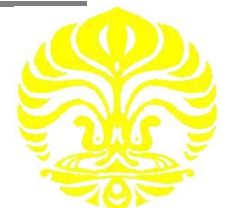
International

- International Telecommunication Union
 - International treaties to regulate the use of the radio spectrum and the satellite orbits



- **radio spectrum 3 kHz to 3 THz**

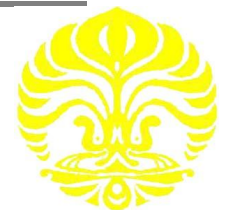
- **main use 9 kHz to 400 GHz:**
 - **range covered by ITU Radio Regulations.**



Band No	Symbol	Frequency Range	Wavelength	Corresponding metric sub-division of wavebands	Symbol
	ELF	< 300 Hz	> 1000 km		
3	ULF	300 Hz - 3 kHz	1000 - 100 km	Hectokilometric	B.hkm
4	VLF	3 kHz - 30 kHz	100 km - 10 km	Myriametric	B.Mam
5	LF	30 kHz - 300 kHz	10 km - 1 km	Kilometric	B.km
6	MF	300 kHz - 3 MHz	1 km - 100 m	Hectometric	B.hm
7	HF	3 MHz - 30 MHz	100 m - 10 m	Decametric	B.dam
8	VHF	30 MHz - 300 MHz	10 m - 1 m	Metric	B.m
9	UHF	300 MHz - 3 GHz	1 m - 100 mm	Decimetric	B.dm
10	SHF	3 GHz - 30 GHz	100 mm - 10 mm	Centimetric	B.cm
11	EHF	30 GHz - 300 GHz	10 mm - 1 mm	Millimetric	B.mm
12		300 GHz - 3 THz	1 mm - 100 μ m	Decimillimetric	B.dmm
13		3 - 30 THz	100 - 10 μ m	Centimillimetric	B.cmm
14		30 - 300 THz	10 - 1 μ m	Micrometric	B. μ m
		300 - 3000 THz	1 - 0.1 μ m	Decimicrometric	B.d μ m

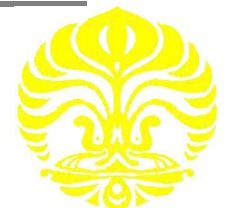


Letter symbol	Radar (GHz)		Space radiocommunications	
	Spectrum region GHz	Examples GHz	Nominal designations	Examples (GHz)
L	1 - 2	1.215 - 1.4	1.5 GHz band	1.525 - 1.710
S	2 - 4	2.3 - 2.5 2.7 - 3.4	2.5 GHz band	2.5 - 2.690
C	4 - 8	5.25 - 5.85	4/6 GHz band	3.4 - 4.2 4.5 - 4.8 5.85 - 7.075
X	8 - 12	8.5 - 10.5		
Ku	12 - 18	13.4 - 14.0 15.3 - 17.3	11/14 GHz band 12/14 GHz band	10.7 - 13.25 14.0 - 14.5
K ⁽¹⁾	18 - 27	24.05 - 24.25	20 GHz band	17.7 - 20.2
Ka ⁽¹⁾	27 - 40	33.4 - 36.0	30 GHz band	27.5 - 30.0
V			40 GHz bands	37.5 - 42.5 47.2 - 50.2



Spectrum Occupancy

Space:	service range coverage area interference range or area
Time:	continuous or intermittent transmission propagation variability
Bandwidth:	necessary bandwidth transmitter and receiver imperfections

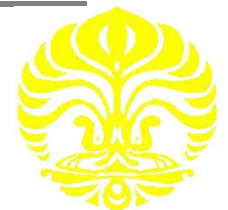


Spectrum Utilisation (U)

$$U=B \times S \times T$$

where **B** is the bandwidth
S is the geographic space or volume
occupied (desired or denied)
T is the time

Not a real equation!

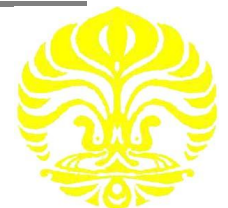


Geographic space

Area coverage systems such as broadcasting or mobile applications: - required space is defined as coverage area

Point-to-point communications – desired space is confined to the direct path between the terminals

Geostationary satellite networks:- just the orbit spacing around the geostationary arc and the direct links to earth stations



Bandwidth

for narrow band systems – related to information rate

complex modulation methods permit more bits/Hz but usually need a more perfect propagation channel

spread spectrum – consider a factor related to the power density across the bandwidth



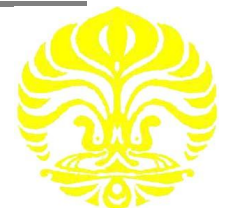
Time factor

Unity for broadcasting

Smaller for some other applications



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Efficient spectrum utilisation

Perfect technical efficiency would require:

Perfect transmitters – no unwanted emissions

Perfect receivers – no susceptibility to other signals

- perfect selectivity

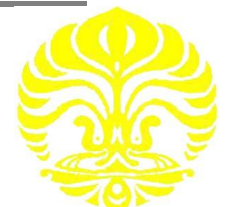
High gain antennas, accurately pointed

Emissions limited to the necessary bandwidth

Minimum power to provide sufficient signal

Maximise frequency reuse

etc



Effective spectrum use

Seek efficient use within practical constraints

Specifications for unwanted emissions

reasonable selectivity characteristics

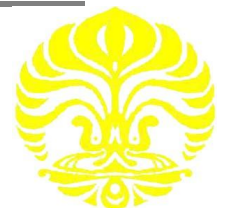
Design for acceptable cost

Rapid entry to market

Provide for future flexibility

etc.

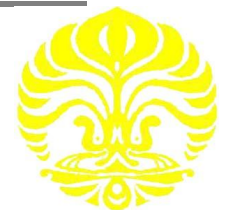
Effective usage is a more reasonable aim



ITU and the Radio Regulations



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Purposes of the ITU

ITU – concerned with the international regulation of telecommunications

Purposes include:

To extend international cooperation

To offer technical assistance

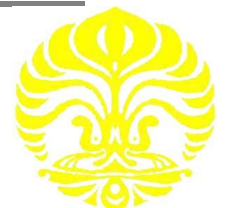
To promote the development of telecommunication facilities and their most efficient operation

To this end the ITU, amongst many other things

Undertakes studies

Adopts recommendations

~~Collects and publishes information~~



The ITU shall

Allocate frequency bands, register assignments and geostationary orbit positions to avoid harmful interference

Coordinate efforts to avoid harmful interference and improve use of spectrum and GSO

Facilitate international standardization

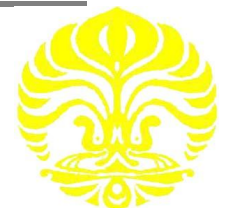
Foster international cooperation

Harmonise development of facilities

Establish rates as low as possible, consistent with efficiency

Ensure safety of life

Undertake studies

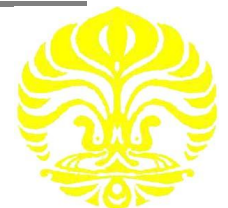


Membership of ITU

Member States (national administrations)

Registered operating agencies

Scientific and industrial organisations



f_C = carrier frequency
 δf = frequency tolerance (an allowance for Doppler shift would be included for a space station emission)
 F_A = assigned frequency
 F_C = characteristic frequency
 F_R = reference frequency

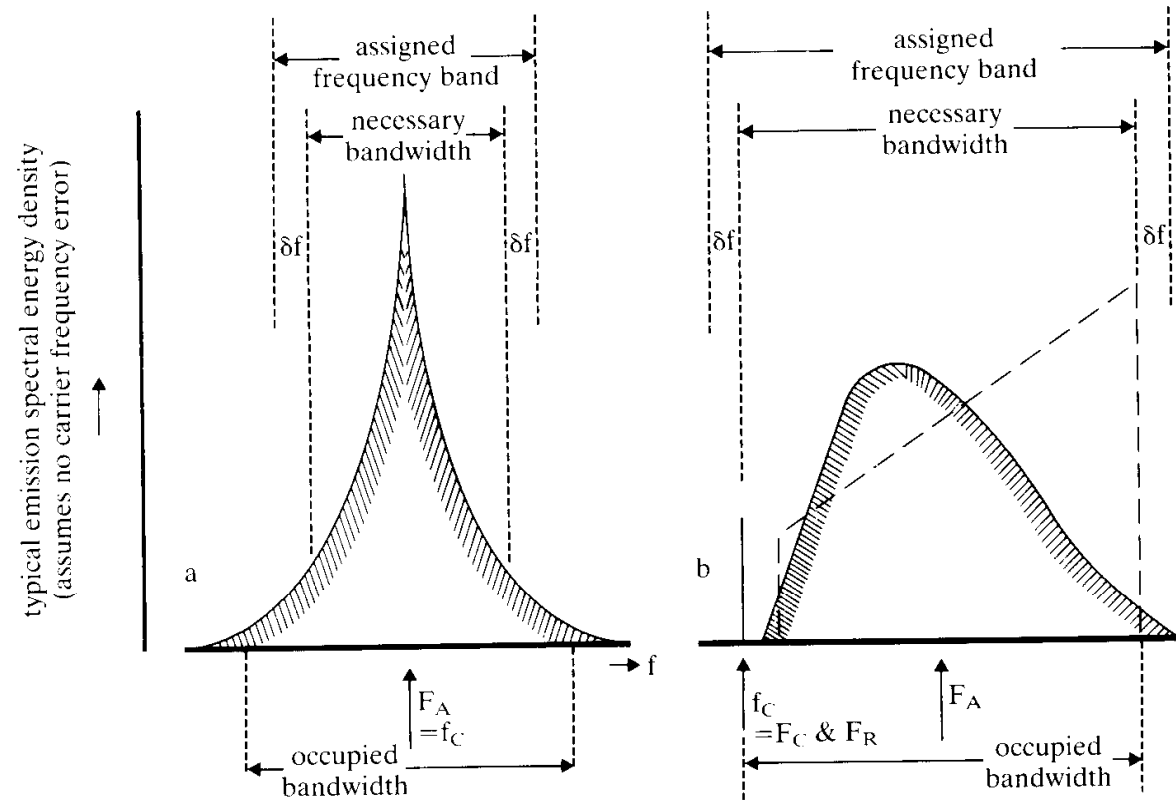
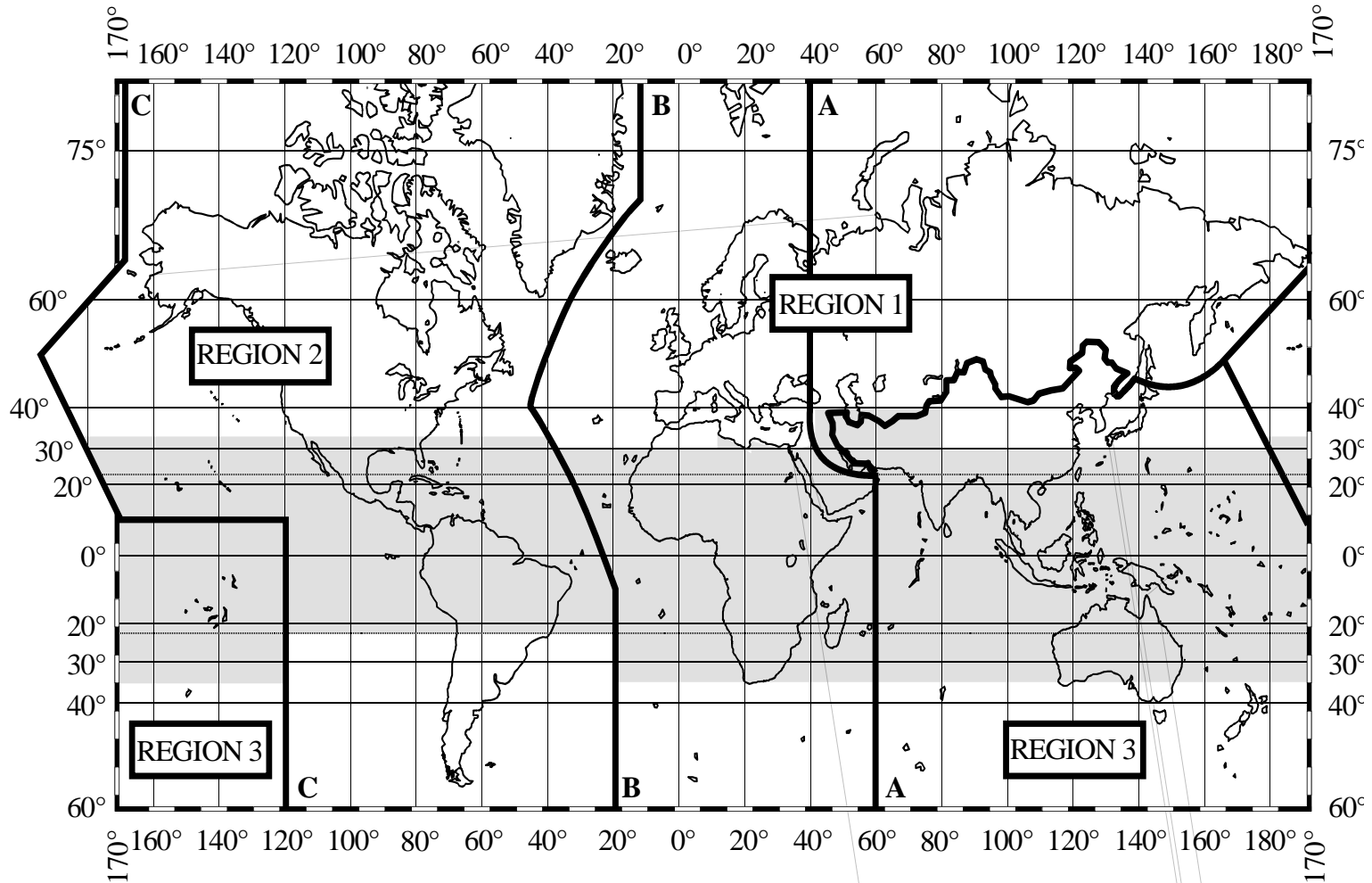


Fig. A.1 Sketches to illustrate terms used in describing features of the spectrum of emissions

a A carrier, keyed on-off by a telegraph signal
b An SSB telephony emission with a reduced-level carrier



ITU Regions



The shaded part represents the Tropical Zones as defined in Nos. 5.16 to 5.20 and 5.21.



Frequency Assignments

National frequency authorities assign specific carrier frequencies, within the frequency block allocations, for transmission at radio stations;

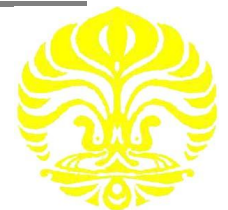
assignments are made for specified purposes, usually specifying emission parameters; receiving point, carrier power, bandwidth, antenna characteristics, etc.



*Regional and national
spectrum management*



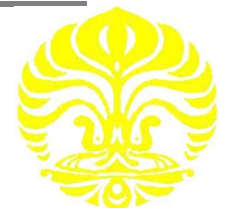
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Regional spectrum management

Regional groups are advantageous:

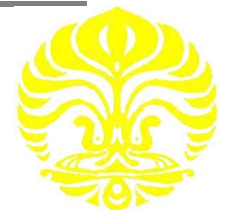
- **establishing common standards across a region**
- **provide a large market place**
- **remove barriers to trade**
- **permit cross-border operation**



Radio Resource Management for Cellular



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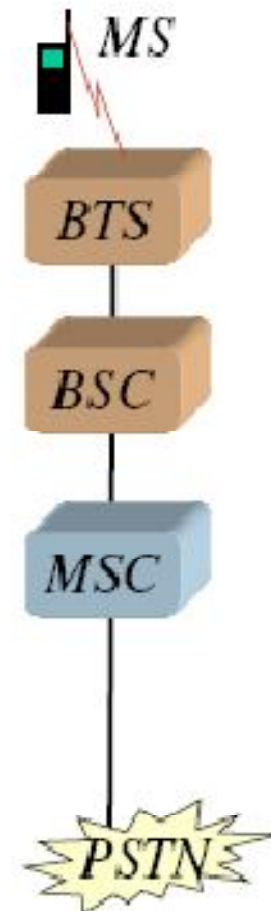


GSM Radio Resource Management

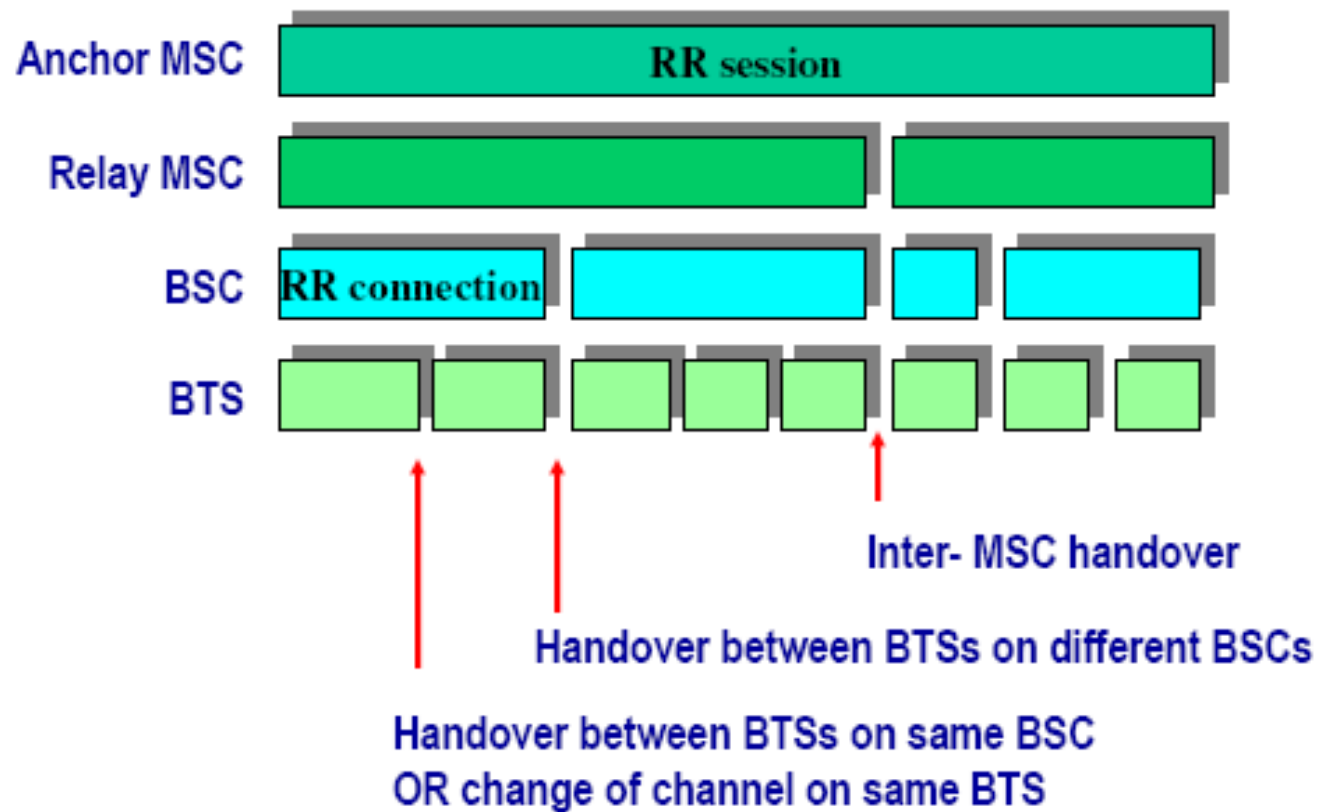


Radio Resource Management

- RR responsible for
 - allocating a channel
 - maintaining signal quality
 - handover
- RR involves
 - primarily the BSC and BTS
 - the MSC only when handover is between cells managed by different BSCs

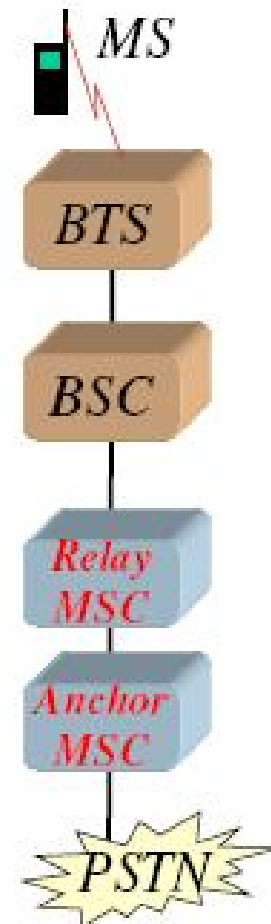


RR Session



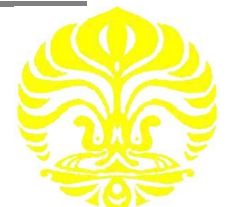
Anchor MSC and Relay MSC

- MSC is involved when inter-BSC handoff occurs
- But handoff to a cell controlled by a BSC in another MSC area can occur
- The original MSC is the **Anchor MSC**, and retains control of the connection
 - due to charging issues
- The new MSC is the **Relay MSC**
- To ease the terminology, a call is considered to have both an anchor and a relay MSC
 - even though in most cases this will be the same MSC



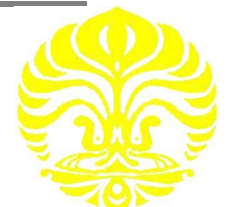
Channel Allocation Strategies

- **Very Early Assignment**
 - Allocate a TACH/F at initial assignment
- **Early Assignment**
 - Allocate a TACH/8 at initial assignment
 - then subsequently allocate a TCH/F as soon as it is known for certain that this type of channel is required
- **Off Air Call Set Up (OACSU)**
 - Allocate a TACH/8 at initial assignment
 - wait until called MS answers before attempting the subsequent assignment of a TACH/F
 - disadvantage: there may be a delay before a TACH/F is available



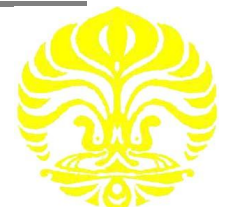
Handover Types

- **Rescue handover**
 - aims to avoid “disaster”, i.e. situation where there is a very high probability of call dropout
- **Confinement Handover**
 - aims to minimise overall interference levels, by connecting MS to the “best” BTS
- **Traffic Congestion Handover**
 - aims to offload traffic from congested cells into less congested surrounding cells
 - is in conflict with confinement handover

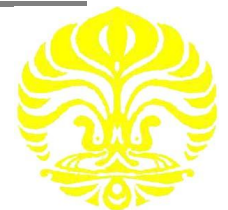
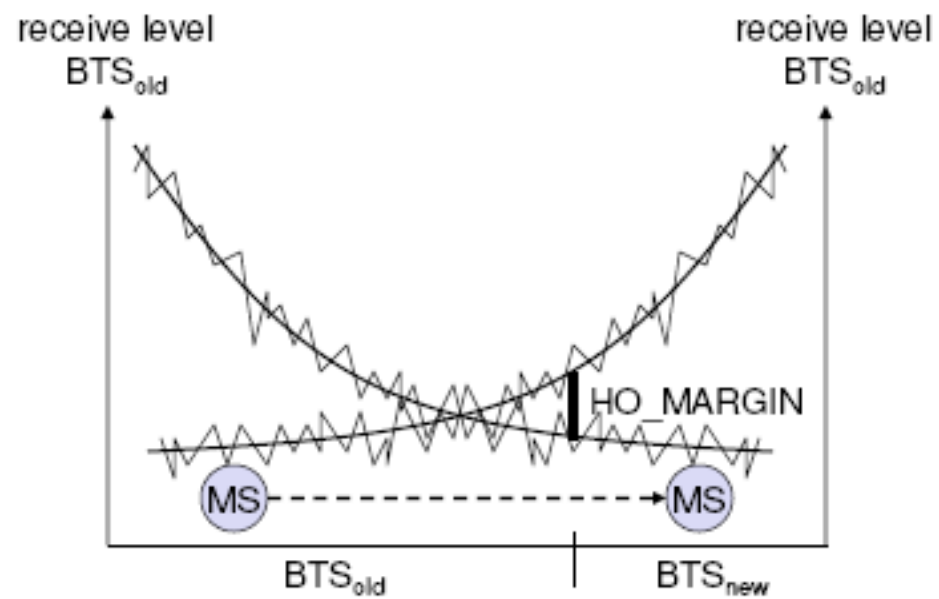


Handover Criteria

- Signal quality, both uplink and downlink, indicated by
 - transmission error rate
 - path loss to base station
 - propagation delay (for large cells)
 - path loss to neighbouring cells
 - only downlink values are measured, by the MS
- Load at each cell



Handover decision



Thank you.



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