Issues of Spectrum Management in the Broadband Era

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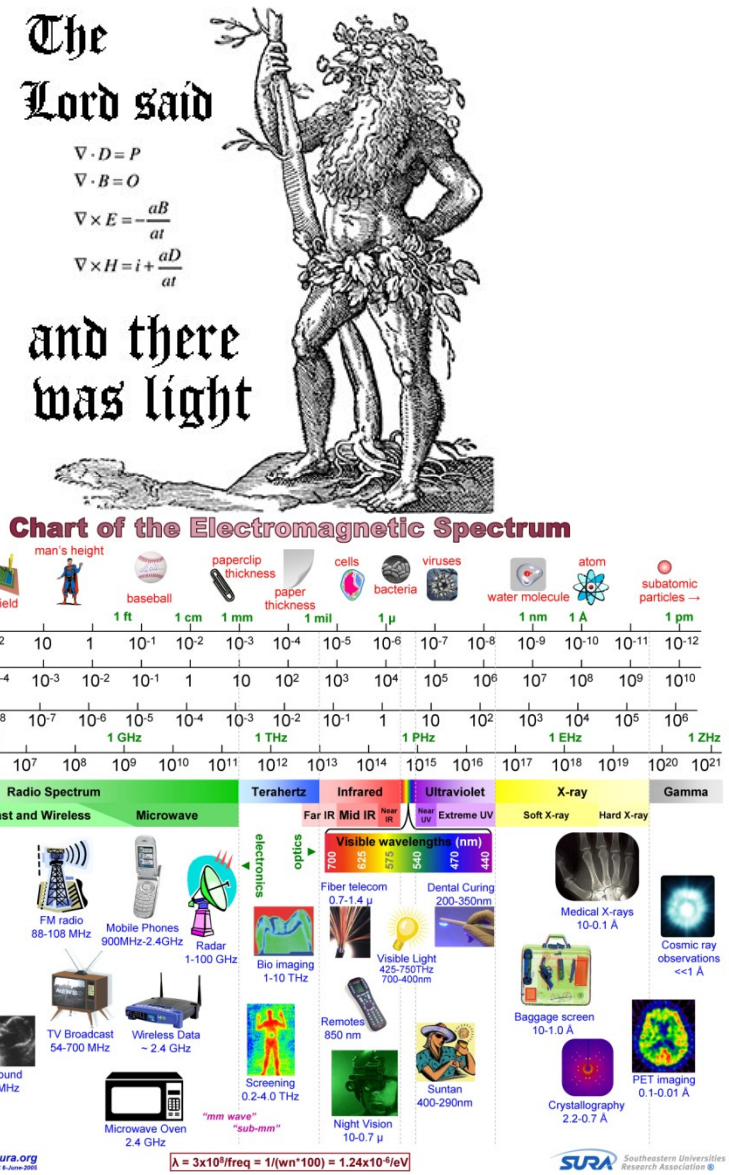
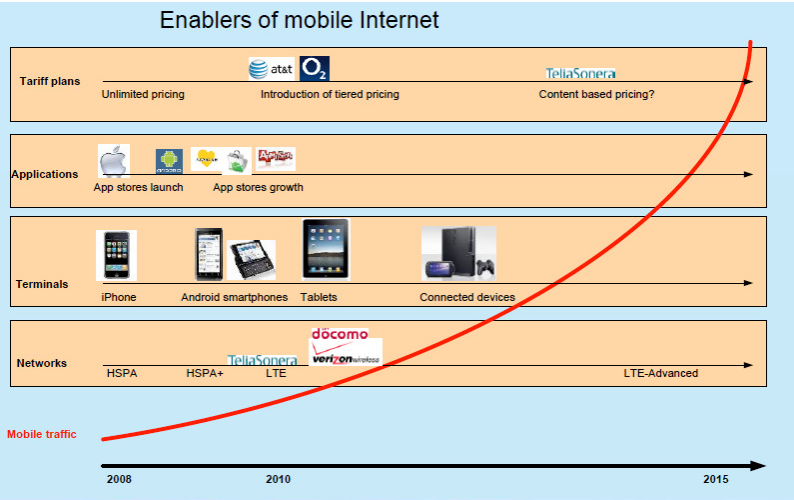
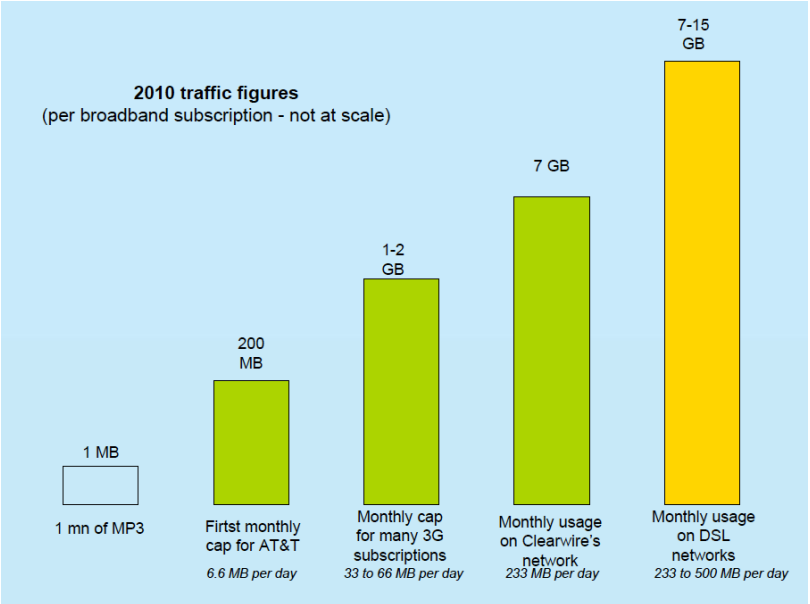
Brief Intro to Electro Magnetic Spectrum

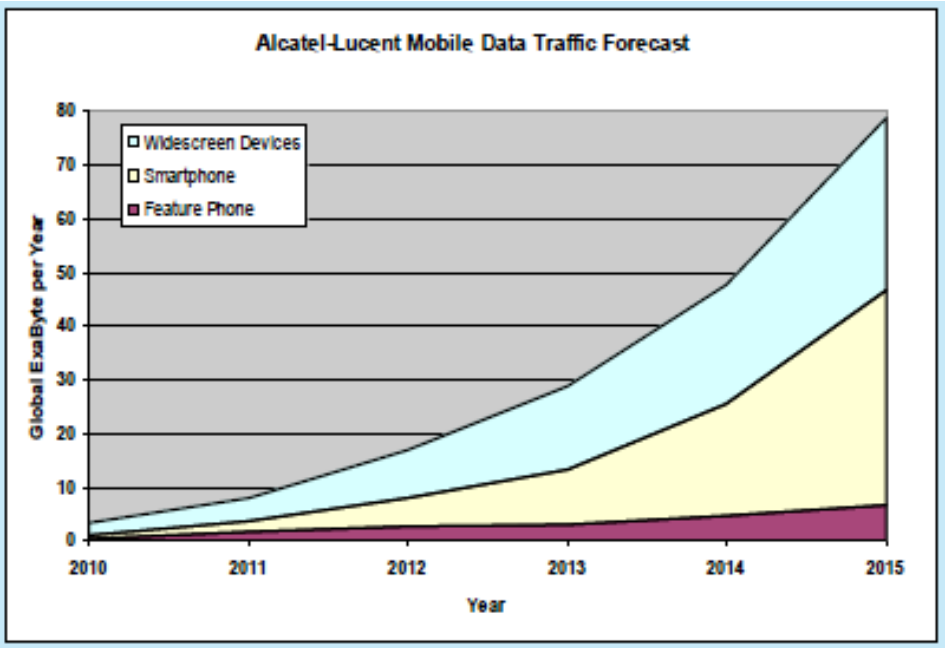
- *What is electro magnetic spectrum*
- *What is band*
- *Maxwell's formula describes it Shanon's formula governs it, it doesn't adhere to manmade jurisdictions*
- *Invention of wireless communication made it into a valuable resource*
- *However, agreements and laws make it possible to be used*

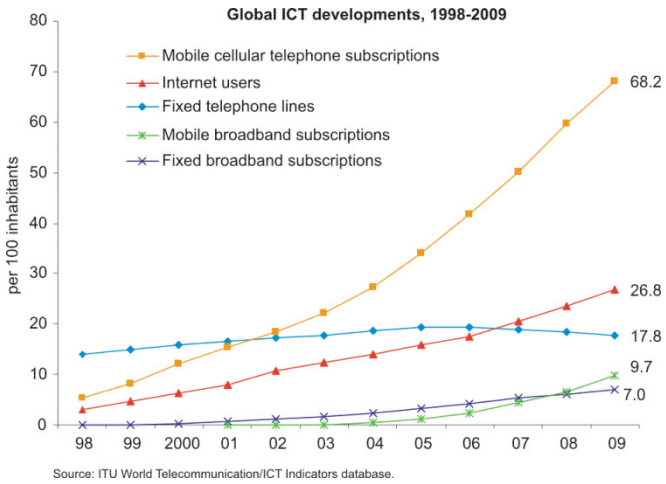


Global Mobile Phone Scenario









Early history of spectrum management

- *Titanic*
  - *The California was 20 miles away, not listening.*
  - *A tanker was rescued at the same time. People on shore thought people from Titanic were being rescued.*
- *US had its first Radio Act in 1912*
  - *License required*
  - *Spectrum allocated among uses and users*
  - *Prioritization*
    - *Distress signals, military users, etc*
- *US history of Spectrum Management (Initiative of Sec.of State Harbert Hoover)*
  - *All applicants must be licensed, but no authority to reject*
  - *Hoover sets process for deciding who gets licenses*

Spectrum management in Broadband Era

- ***Spectrum is a scarce resource***
- ***Advent of Internet has made increased the demand of spectrum use***
- ***Government entrusted with this resource should make sure the resource's best use***
- ***Spectrum management has technical, economic and regulatory aspects***
- ***Concept of Broadband- definition***

[Fig: table defining how much time needed to download]

[Fig use of spectrum, need for spectrum,]

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Technical aspects of Spectrum management

- ***Spectrum management deals with***
  - *Different bands have different characteristics*
  - *Issues of interference, attenuation etc.*
  - *Impossible to set policies to prevent without understanding "interference"*

[Fig characteristics of different bands, attenuation, interference] [Fig use of spectrum, need for spectrum,]

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- ***Impact of Regulatory decisions on Spectrum Management***
  - *Policy makers take decisions, regulatory bodies enforce them*
  - *The agencies that manage spectrum take decisions on use of technology, use of band and the methods of awarding spectrum*
  - *All these decisions impact the trajectory of diffusion of the technology*

Characteristics of various bands

All bands are not the same :Coverage vs.Throughput

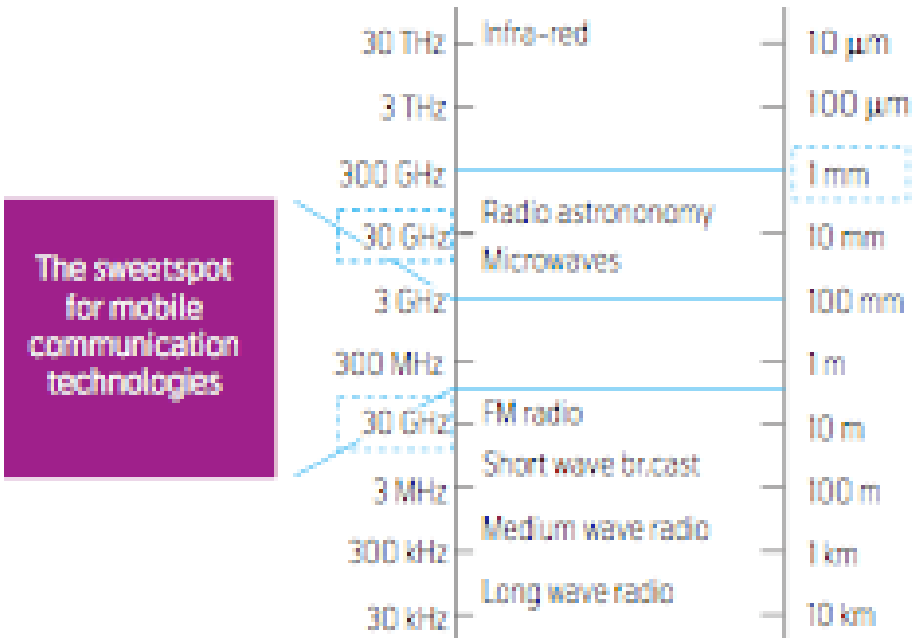

Figure 1: The electromagnetic spectrum and the preferred spot for mobile communication technologies [7]

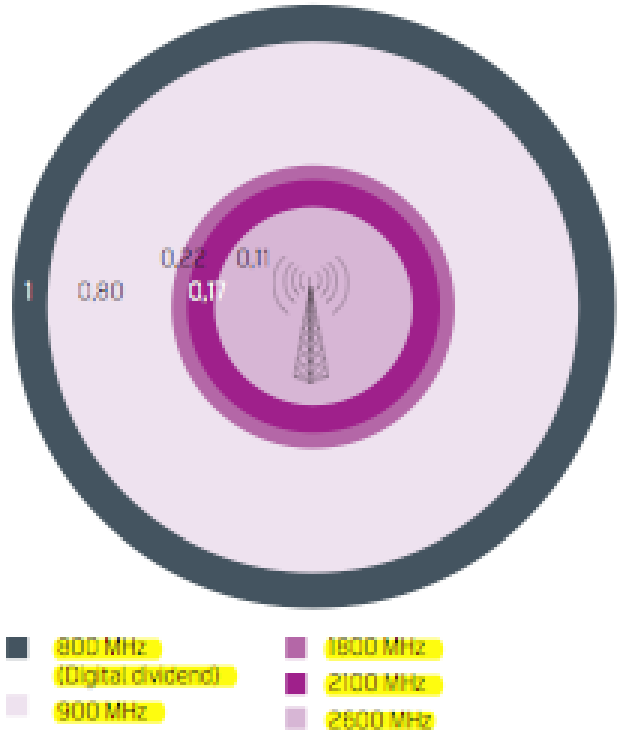

Figure 2: Relative cell size of different frequency bands, given same technical conditions[7]

Allocating Spectrum

- ***Regulators determines***
  - *Allowable use(s) for a block of spectrum*
  - *channelization of the block for licensing*
- ***Band plan***
  - *Specific rules for the license*
- ***Geographic limits***
- ***Power limits***
- ***Modulation scheme***
  - *Initial Assignment: Who gets a license*
  - *Rules for transfer and renewal*
  - *Obligations of the licensee*

Channelization or Band Plan

- ***Suppose we decide to allocate 120 MHz to land mobile***
- ***How should this spectrum be divided up***
  - *How much spectrum to one licensee?*
  - *120 MHz?*
  - *4x30 MHz?*
  - *12x10 MHz?*
- ***Broadcast spectrum***
  - *How many kHz per AM radio station?*
  - *9 kHz*
  - *10kHz*
  - *20 kHz*

Allowable use

- ***International Rules***
  - *Can address*
    - *Cross-border interference*
    - *International standards*
  - *WRC sets broad guidelines for categories like*
- ***Fixed satellite***
- ***Land Mobile***
- ***Broadcasting***
  - *Latitude within regions*
  - *Primary and secondary uses*
- ***Most bands have multiple allowed uses***
  - *If there is no primary user*
  - *If secondary would not harm primary*

Determining Best Use

- ***How does the Commission decide if a band should be used for UHF broadcasting or Land Mobile?***
  - *What determines the "best use" for a band?*
  - *Public interest?*
  - *Willingness to pay?*
  - *Technical characteristics?*
- ***Impediments to innovation***
  - *Existing users are well funded and established;*
  - *Potential new users are not*

Resistance to Creating Bands for New Uses

- ***In USA***
  - *AM broadcasters fought the allocation of spectrum for FM*
  - *AM and FM broadcasters fought creation of Digital Audio Radio Service*
  - *National Association of Broadcasters fought reassignment of spectrum from UHF TV to land mobile*

Band Plan Issues

- ***Number of Licenses***
- ***Number of licenses determines industry structure***
  - *E.g. 2 analog cellular licenses means a duopoly*
  - *efficiency vs. competition*
- ***How much spectrum is needed for a viable business?***
  - *More spectrum means fewer base stations required, lower infrastructure costs*
  - *More channels per base station means less blocking for a*
    - *given ratio of calls to channels*
- ***Area (US) [Change it to India]***
  - *• Geographic extent of a license*
  - *– Basic trading area (493)*
  - *– major trading area (51)*
  - *– metropolitan statistical area (734)*

Spectrum Management- Regulatory regime

- ***International spectrum management***
  - *How does ITU system work*
- ***International Radio Regualtion***
- ***Each country has the soverign right to regulate its telecommunication and to interpret the international RR [4spectr_Mngmngt]***
- ***Regulatory practice of command and control- how C&C works***
- ***Neo- Liberal economists belive that market mechanism is better than the present 'administrative' spectrum management***
  - *Band/ Portions of spectrum are to be treated as private property*
  - *Some limited amount of the spectrum reserved for public and governmental services*
- ***Spectrum Market place***
  - *GATS, WTO, Free market*
- ***Spectrum Commons***
- ***License-exempt spectrum***

[Fig : over grazing, spectrum commons]

Licensed vs. Unlicensed spectrum

- ***What part of Spectrum is regulated***

  [Fig from 4Spectr_mngnt+]
- ***What technologies use which part of spectrum***
- ***Regulatory decision on spectrum management***
- ***- Market structure and entry***
- ***- Licensing***
  - *License exempt equipment*
  - *Licensing models*
  - *Detaching spectrum from service license*
  - *Technology neutrality*
- ***How can the regulatory regime can facilitate market***
  - *Entry and exit regulation*
  - *Enhance competition*
  - *Infrastructure sharing*

Background on Spectrum award process

- **Auction or Hearing**
- **Regulators favor Auction.** [1]
  - Speed (comparative hearings or lotteries might take months or years!)
  - Transparency
  - High value use
  - Preserving public interest
- **Pit falls.**
  - Incumbents face greater pressure than new comers.
  - High debt
  - Tacit attempts by the government to provide state aid
  - Some believe it is unfair as those firms which already have a mobile license are obliged for a new generation
  - Late comer determines the price
  - Collusive bidding
  - [Fig : 3G Auction results]

Nextel Case

- ***Nextel used spectrum adjacent to public safety bands***
  - *Complaints of interference*
  - *Complex negotiation in which Nextel given more desirable spectrum at reduced price in return for moving out of contested band*

    – Many objections
- ***Technical aspects of Spectrum management***
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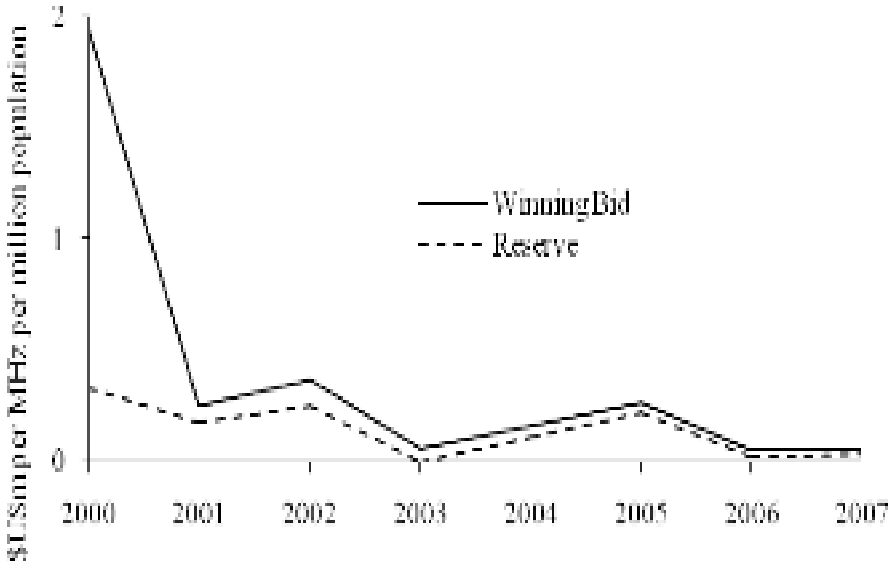
[Fig characteristics of different bands, attenuation, interference]

Lessons from past spectrum auctions

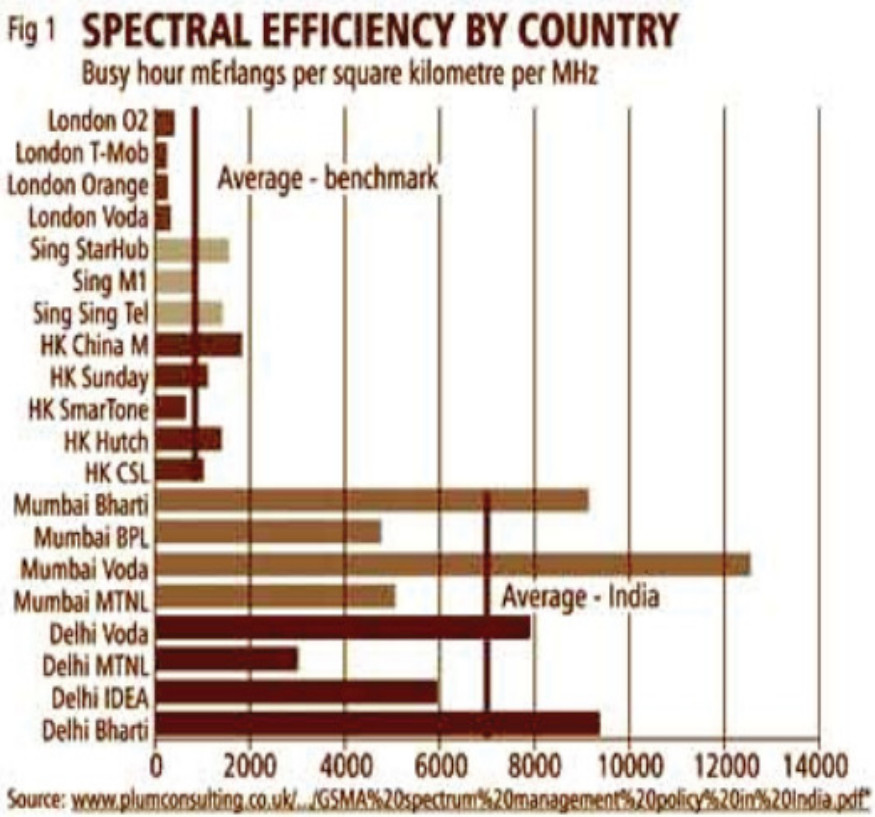
- UK -3G auction, 4G LTE auction
  - Price per MHz per population has gone down drastically
- India
  - Recent auction fell apart as the operators would not pay the reserve price
- Czech auction 2013
  - Regulator has suspended its own spectrum sale because cellcos were paying too much- they fear that, if the prices are too high, cellcos will pass on those costs to the customers, which would restrict uptake of 4G service
  - "Main motivation of the auction : quick availability of a 4G network for Czech citizens and possible entry of a new competitor-never about profit of the



Annual Mean 3G auction wining bid and Reserve mean value [5]

Spectrum Management in India

- Inefficient in terms of spectral Use



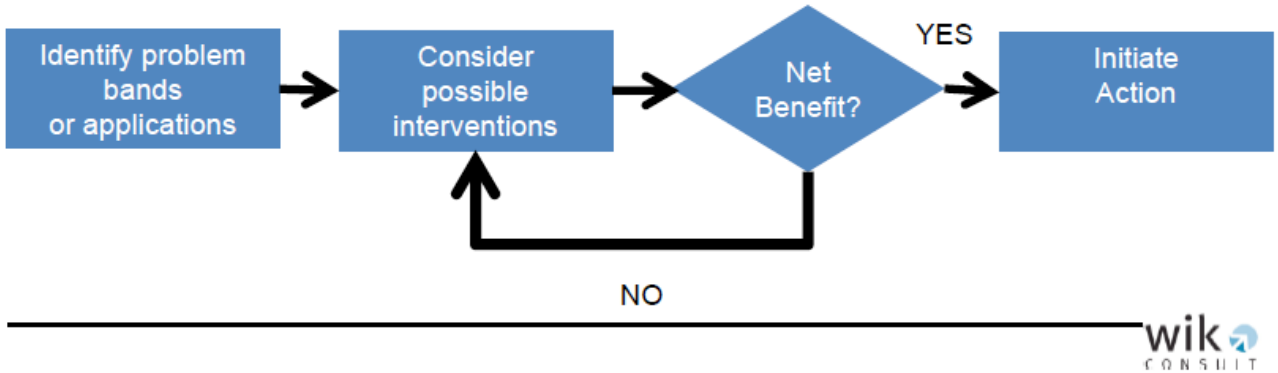
New technology and Open spectrum policy

- Inefficient in terms of spectral Use and reduced cost
- Spectrum Sharing
- Mesh Architecture
- Femto cells
- Open spectrum policy WiFi
- [Fig; from alcatel: efficient use of spectrum with new tech]

Future of regulatory regime

- ***Technology may relieve the regulators from most functions now they do in terms of spectrum management***
- ***New Technologies, new regulations – ultra wide band, nanotechnology, pico-satellites***
- ***Better spectrum optimization processes should be adopted***
  - *Should be customized to cater to the country's need*

A possible spectrum optimisation process



Source: WIK/Aegis/IDATE/Plum

Conclusion

- Take Away messages
  - New Technologies improve efficiency, they should be embraced as much as possible
  - High Spectrum price can be detrimental, regulatory authority is not the public exchequer rather an expert body for sector improvement
  - Open spectrum Policy should be embraced ultimately to cope up with the growing need of spectrum.

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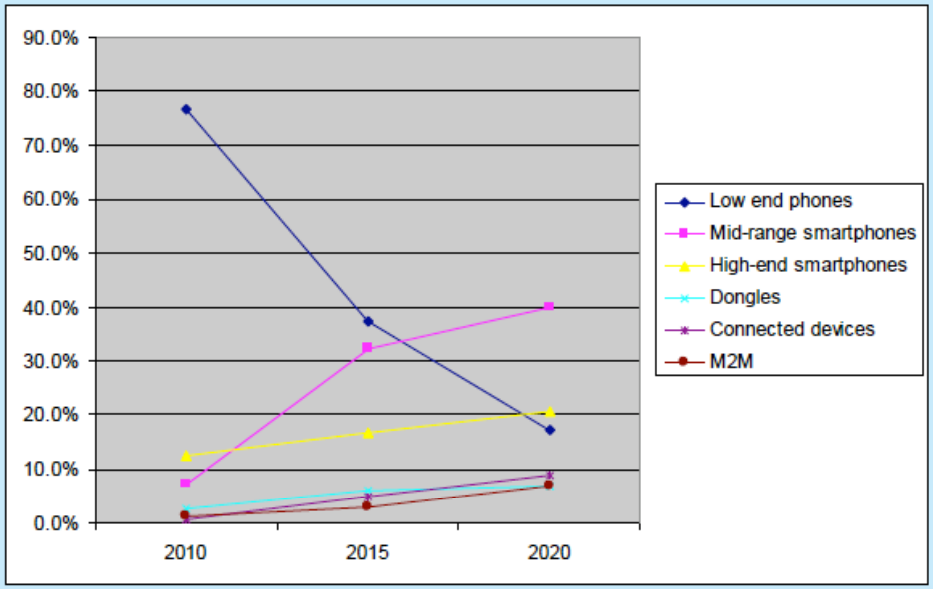
Extra



Network capacity units:

Kilobyte	**kB**	**10^3**
Megabyte	**MB**	**10^6**
Gigabyte	**GB**	**10^9**
Terabyte	**TB**	**10^{12}**
Petabyte	**PB**	**10^{15}**
Exabyte	**EB**	**10^{18}**

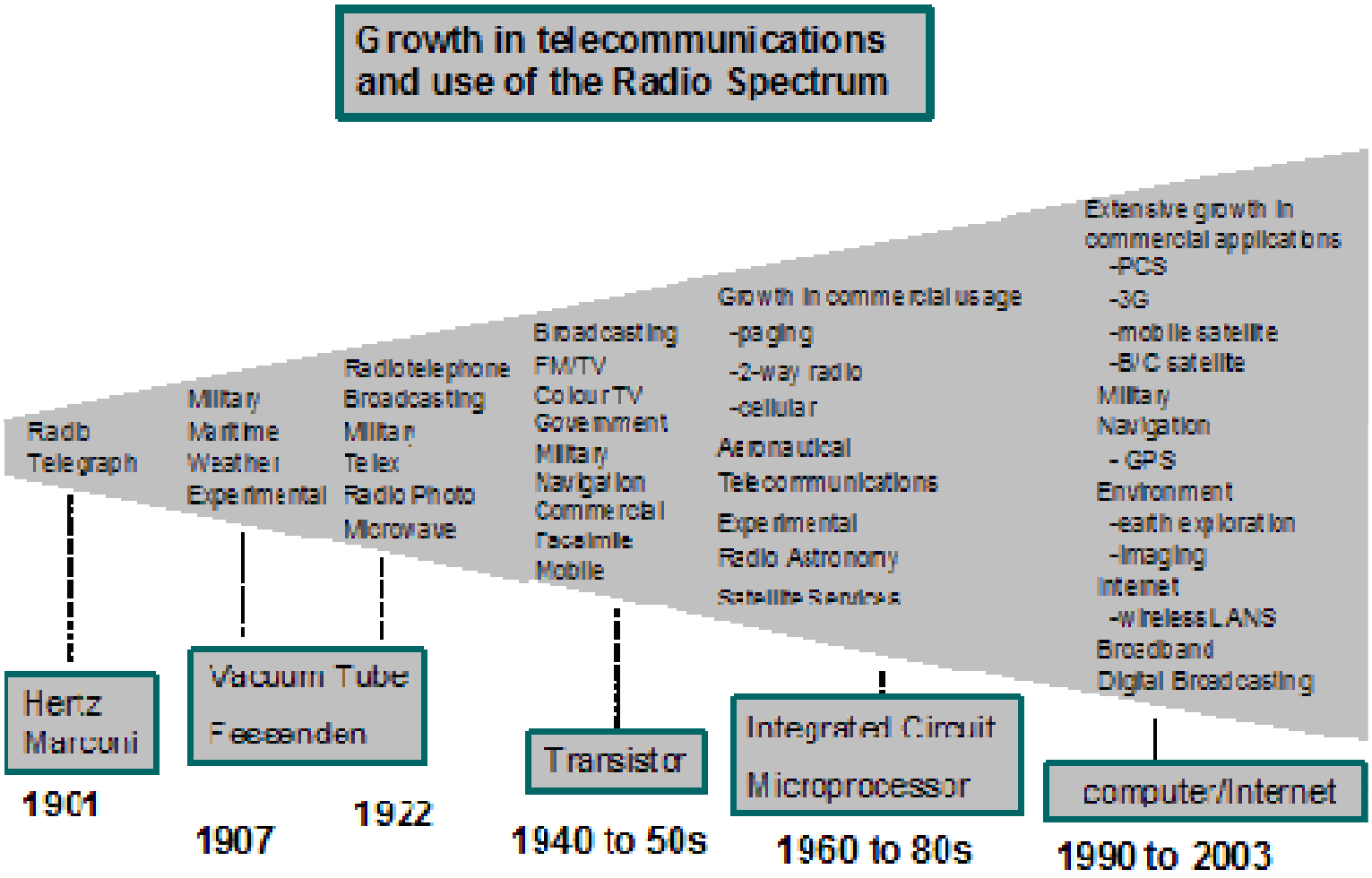
1 Gigabyte = 1,000 Megabytes
1 Terabyte = 1,000 Gigabytes
1 Petabyte = 1,000 Terabytes = 1,000,000 Gigabytes
1 Exabyte = 1,000 Petabytes = 1,000,000 Terabyte

UMTS Forum Report 44
Mobile traffic forecasts 2010-2020

Economic value of different bands

	400-600 MHz	600 MHz - 1 GHz	1-2.1 GHz	2.1-3 GHz	3-4 GHz	4-6 GHz
Cellular/BWA	0.01	1	0.5	0.1	0.01	0.001
Broadcasting (Terrestrial)	0.5	0.1	0.01	0.001	0	0
PMR/PAMR	0.1	0.1	0.01	0.01	0	0
Fixed links	0.1	0.1	0.005	0.001	0.001	0.001
PMSE[5]	0.1	0.1	0.01	0.001	0.001	0.001
Satellite (civil)	0.1	0	0.005	0.005	0.005	0.001
SRDs[6]	1	1	0.1	0.01	0.001	0.001
WTDS (WiFi)	1	1	1	1	0.1	0.1

Use of radio spectrum with advent of new technologies



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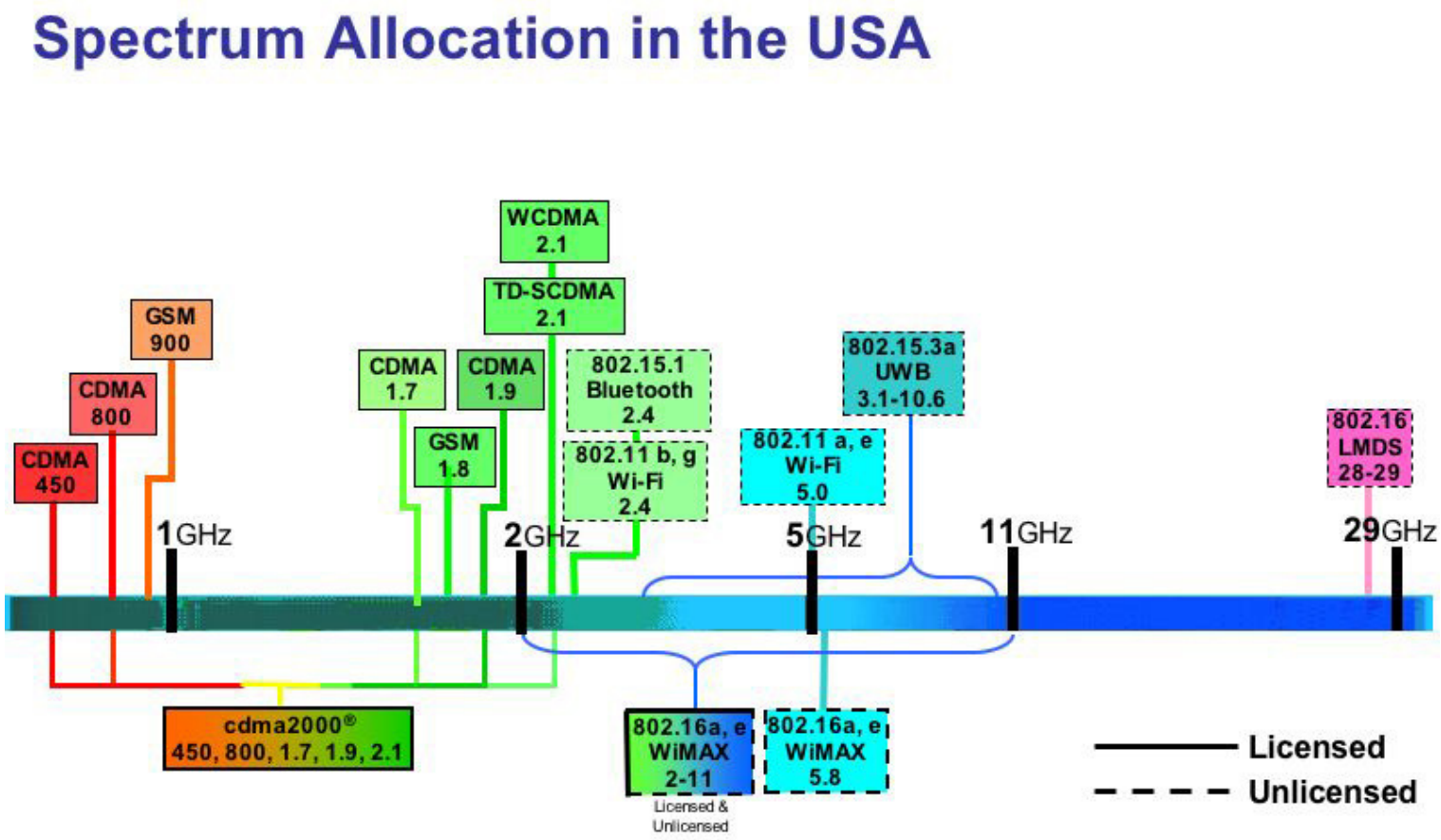

Licensed Spectrum vs Unlicensed Spectrum