

Agentschap Telecom  
*Ministerie van Economische Zaken*

## Cognitive radio and conscious behavior

CWTe 2014 Research  
Retreat

22 oct 2014, Eindhoven

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## Agentschap Telecom

- Part of Ministry of Economic Affairs (Ministerie van EZ)
- 240 employees, founded in 1927 (being part from the dutch PTT organisation)
- Location Groningen/Amersfoort
- >98.000 licenses and registrations yearly
- Our mission: To secure the availability of a reliable and modern telecommunication in and for the Netherlands
- Our tasks:
  - Arrange and negotiate frequencies internationally
  - Divide frequencies nationally (licences, and licenses exempt)
  - Monitor the efficient and safe use of frequencies and electrical equipments, including enforcement





# Our scope of work





# Stakeholders and policy

For BV Nederland, we care for...

*More room for innovation and economic growth*

*Flexibility*

*License exempt wherever possible*



Citizens, consumers and (end-)users



Decision bodies



Operators, (public) sectors, research institutes





## Frequencies

- Frequencies are a natural resource
- Electromagnetic fields are one of the four fundamental powers of nature
- Frequencies are not scarce
  
- *It is always there*
- *After using it's as clean as before*
- *It is everywhere available, and in the complete bandwidth*
- *The more cellular the network is, 'the more is spectrum available' without harmful interference*
  
- Scarcity is man-made





# Men and technology

E=M



E: Cosmos, higher energy, the all, etc



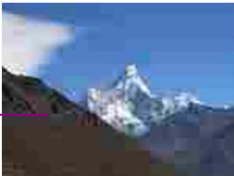
People



Animals



Plants



M: Materials, earth,

Conscious behavior

Knowing why you are doing what you are doing



Technology

Anything invented and created by men, to make things easier, nicer, faster, efficient,...



## Theme 1: Society

- People want more safety and objective information, at the same time people do want have less regulations.



Seemingly conflicting standpoints: more safety  
but less government





## Theme 2: Shared use

There is an increasing interest for shared spectrum usage, but today's regulations and traditional actors (the incumbents) are holding up.



### Shared usage?

Most: Yes we should start immediately, let us share.

Incumbents: we have paid for spectrum, so.. Even if we would be positive, should one expect us just to just write off assets?

How to create win/win?

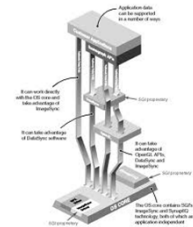




## Theme 3: Decentralization

Now the current is decentralization , we have moved from 'point to point' to 'many to many' and in extreme rapid manner !

1. Electronic equipment everywhere
2. New nomadic infrastructures
3. Mobile use and M2M rapidly growing
4. Software defines the machine, and can "change" locally



But also : Internet en freedom, demonstration and liberation

Arab spring ?

Maidan / Ukraine ?

Yellow umbrella's /Hongkong ?

....



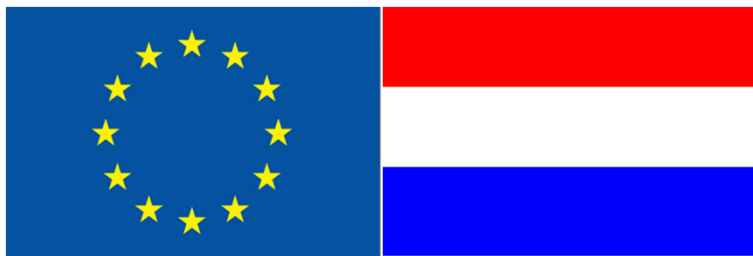


## Theme 4: Globalisation

Telecom is becoming a global business

Devices need to have global harmonized standards

EU law and regulations becoming much more important



ECC/CEPT

ETSI

CIE

ITU, IEEE

Playing on two chessboards: The Hague and Brussels

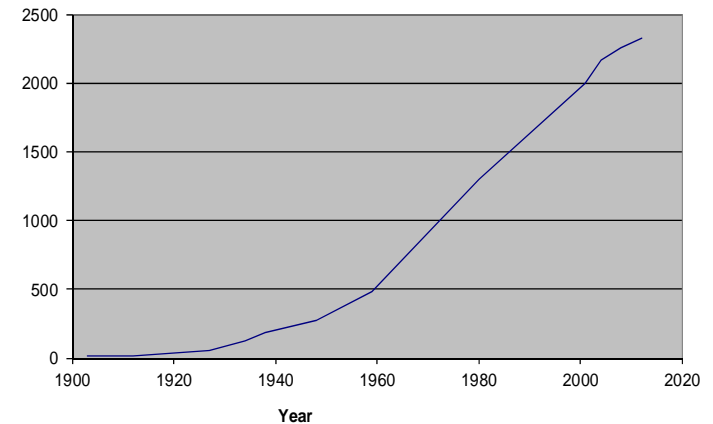
Digital agenda EU



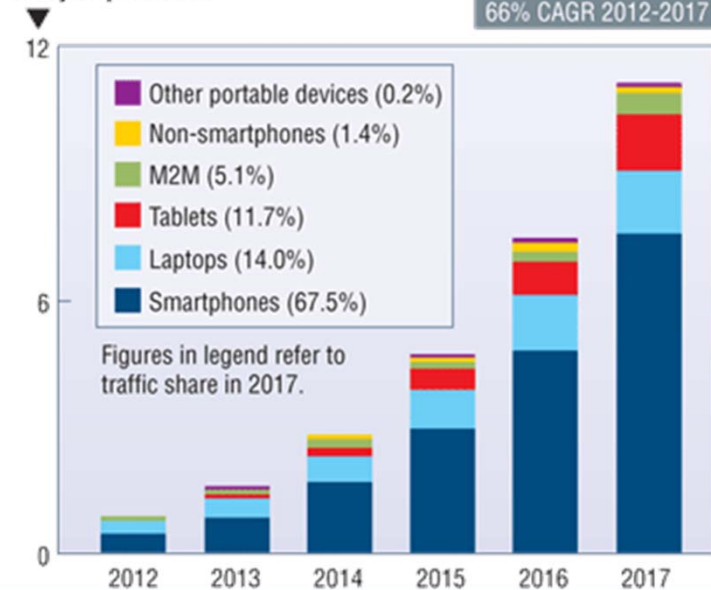
# What's happening in spectrum

- Increasing demand spectrum
- Economy is more and more depending on telecom
- Fast technological developments
- Harmonisation and "refarming" slow

Number of pages of the Radio Regulations

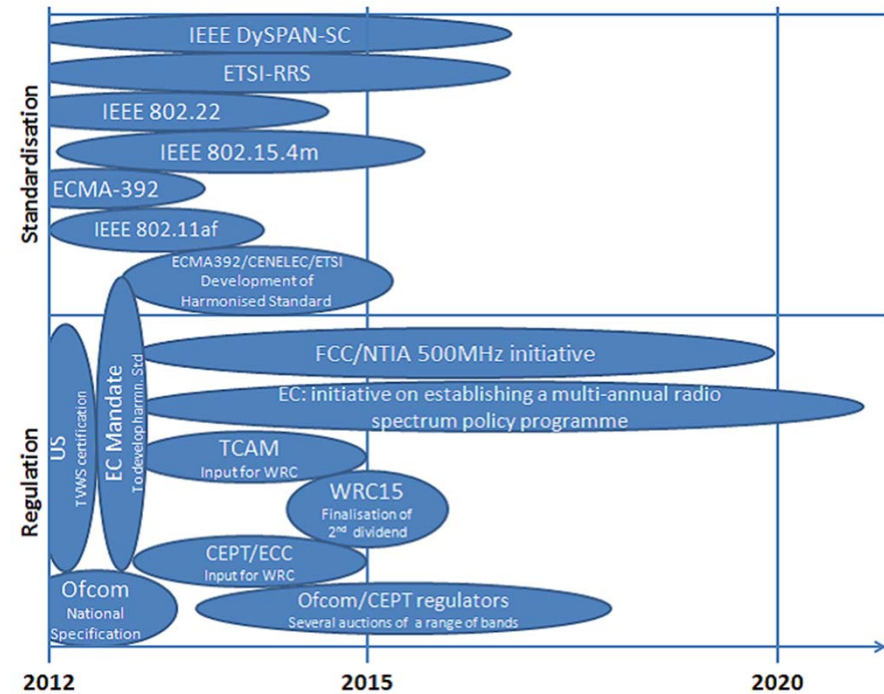
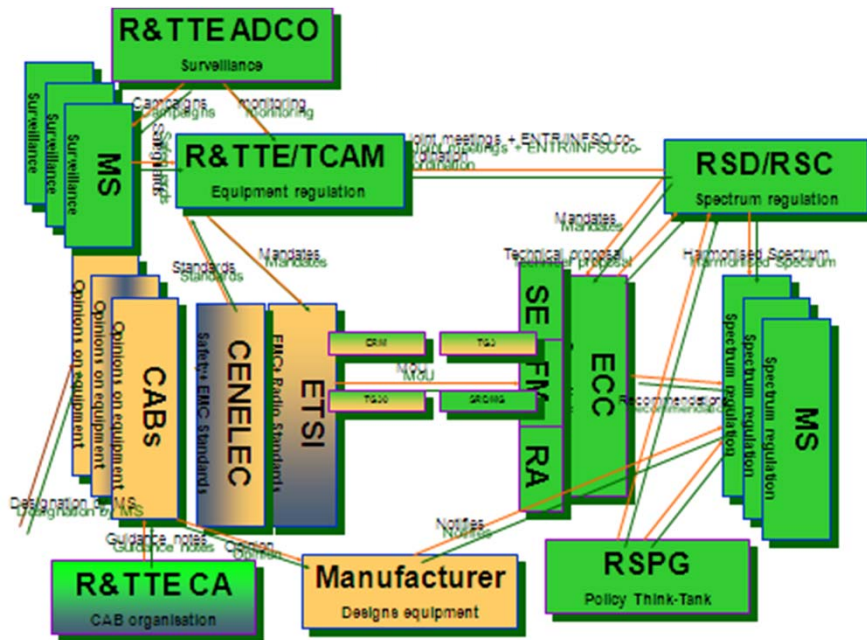


Exabytes per month





# Law and regulation getting complex





## Ostrom and Williamson

- Nobel prize winners Ostrom and Williamson (Delft, 2010, Conference on the Economics of infrastructure,)
- A system will grow, until the transactions costs keeping the system intact, are higher than the benefits the people will receive from the system.
- The best way of organizing sustainable and lasting maintenance of a system to be done by the ones who have the strongest ownership, i.e. the locals users.





## For the regulators a challenge

- Higher complexity in regulations means..
  - More time-consuming work, more international meetings
  - Higher costsAnd likely.. still too slow for industry ?
- Innovation necessary
  - License exempt (already ongoing)
  - Small cells techniques
  - Shared use / LSA
  - Self sensing technology
  - Dynamic frequency issuing (incl database)
  - Mobilizing the creative and social conscious human behavior



<https://www.youtube.com/watch?v=M1Q-EbX6dso>



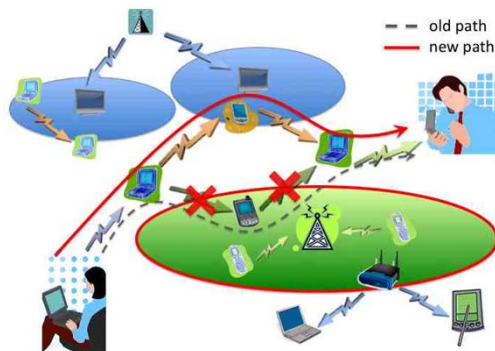
## Why is cognitive radio important

- CR contributes to an efficient spectrum management:
  - Unused parts of spectrum can be (re-) utilized (when primary user is not using them temporary)
  - Bandwidth can be assigned dynamically
  - Economical and societal benefits can be increased
- It fits the way society and technology changes: decentralization
- It 'rocks' the classical pattern which is leading to an increasing complexity in regulating and enforcement
- It is new and innovative

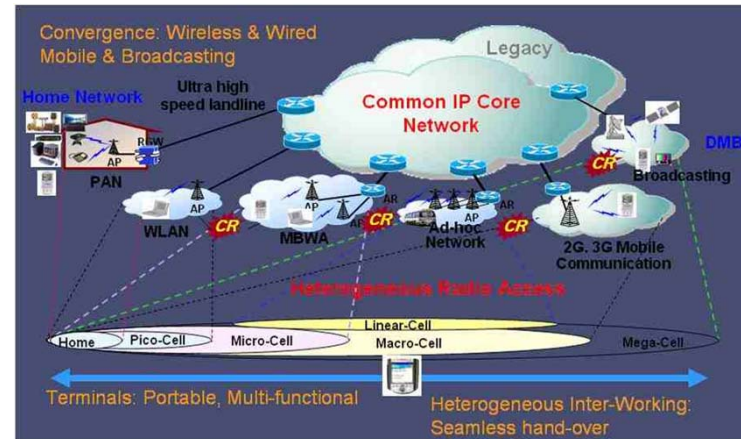


# Cognitive radio = Smart radio

## Dynamic use of the spectrum



A wireless transceiver which adjust it's radio spec's automatically to its network, the environment and the user's need, based on interaction with it's surrounding.



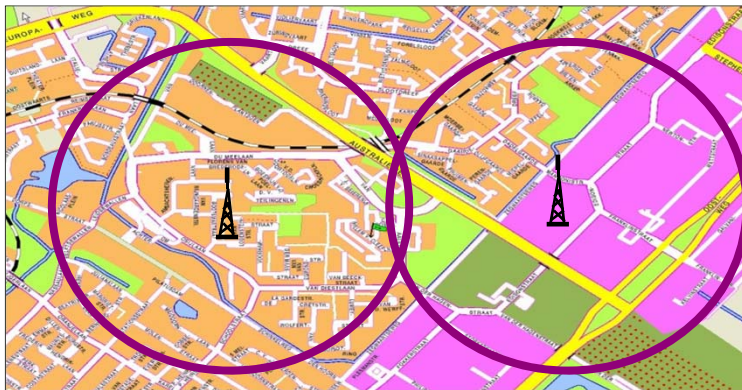
## Three CR types

- Database (central)
- Beacons (local support)
- Self-sensing (decentralized)





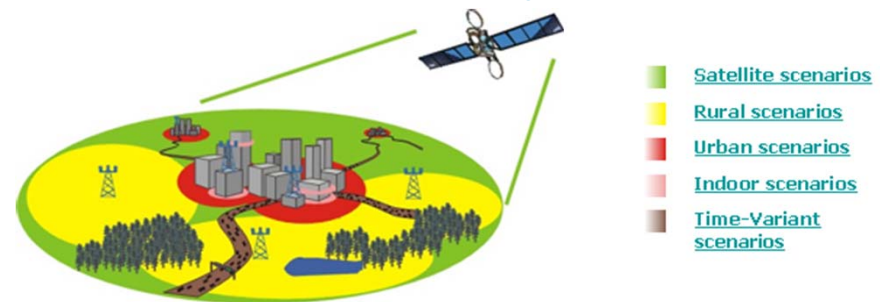
## Classical pattern is missing conscious behavior



- Classical pattern of network thinking is top down and central.
- When the QOS degrades more of the same (i.e. antennas and capacity) will be added
- It doesn't start with the smallest level of intelligence
- Doesn't take into account (social) intelligence of the users and their devices



Network scenarios is already an improvement:





## What to do next?

- The Netherlands is (soon) amongst the countries with;
  - Highest coverage 3G and 4G
  - Highest degree of fixed cable to the home
  - Highest penetration of devices (apparatuur as e.g. smartphones) in society
  - Highest internet acceptance
  - Highest (general) level of educated people

### Fixed

100% of the Dutch households and industry has access to basis internet

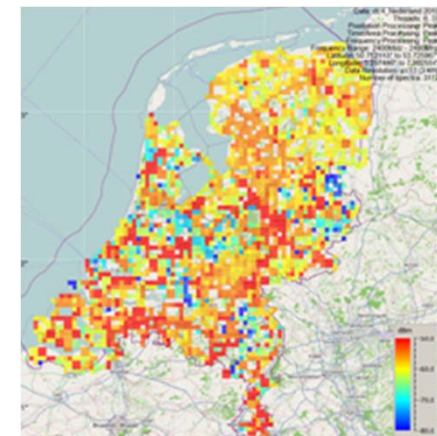
95% has access via fixed networks to so called superfast internet (>100 Mbps)

Comparison EU: average has 97% access to basisinternet and circa 62% access to superfast internet

### Mobile

NL has 3G coverage of 99%, and LTE > 90%

Comparison EU: EU-average is 3G 97% and LTE 59%



wlan 2,4 GHz



## Developments are awaiting new (smart) applications

- From big antennas to small antennas
- Point to point; Fixed
- Point to many; FM, GPS, GSM, LTE, Wifi fixed
- Many to point; M2M, GSM, LTE,
- Many to many; Mesh, nomadic, crowd network  
Wifi in the devices



CR, Database, Self sensing



## New network philosophy?

- Start small
  - Individuals, and conscious behavior
  - Devices (with CR)
  - Work up from scratch /zero power
  - De-tune/re-route asap when interference with neighbors
  - Use network scenarios for the mainframe (as on slide 17)
  
- Include social behavior of people in business model (see 'ziggo')
- Make visible what happens, including (societal) benefits e.g.:
  - less 'spilling' of spectrum, of energy, less radiation, lower costs, less disturbances, better coverage, more free spectrum usage
- Combine people's knowledge with the right usage of technology



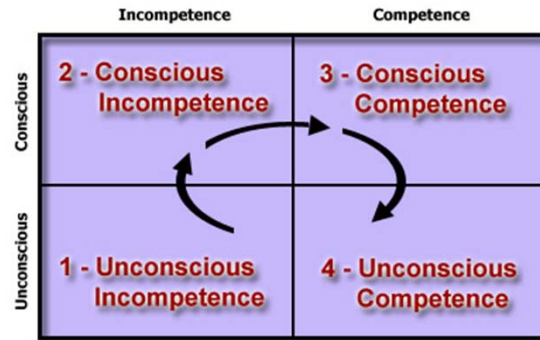


## 5 G the 'service & device'-network?

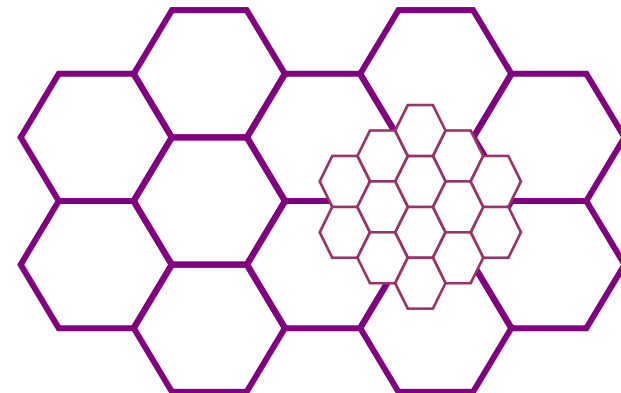
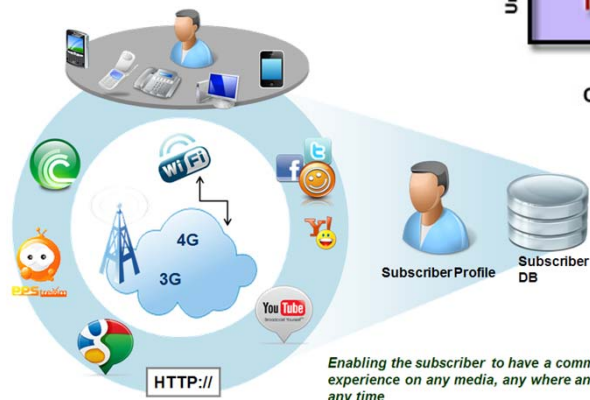
Pre-designed for known places



Mesh network for unknown spots



Conscious Competence Learning Matrix



Cognitive radio as the base technology on devices



## CR & Responsibility to manage spectrum yourself

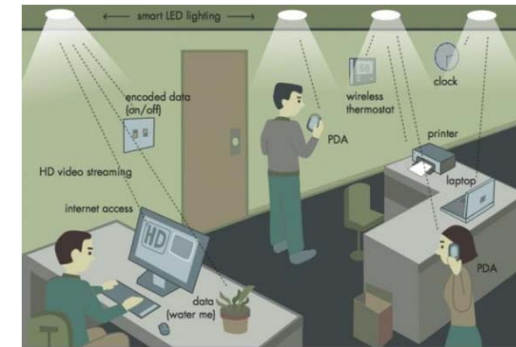
Technology within the context of conscious and responsible behavior

- Switch on/off the CR part of the device, ie on only when really needed
  - Define the transmission service you need (data, voice, video, latency allowed..)
  - Sense 'free' spectrum
  - Do not disturb others (re-route/switch off)
  - Take always the 'nearest' offload for the right transmission
- 
- Safeguarded crucial public services (e.g police, ambulance) being backboned (redundancy) by exclusive licenses and/or networks



## CR & The future small cell ?

- Will we soon reach the smallest data offload
- I.e. the office or house room
- Visual light communication (VLC)
  - Nearby light spectrum
  - Spectrum at Terahertz
  - No interference next-door
  - You are self in direct control
  - License exempt spectrum
  - Li-fi





## Will NL be the first testing and marketing real CR?

- Agentschap Telecom has a generous experiment policy.
- Experts who are willing to support.
- Knowledge about international developments.

*'We can not innovate frequencies, but we can innovate the way we use them.'*

- Don't hesitate to contact us!

[info@agentschaptelecom.nl](mailto:info@agentschaptelecom.nl)





Thanks for your attention

Questions ?