



Schweizerische Eidgenossenschaft
Confédération suisse
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Federal office of communications (OFCOM)
Frequency Management Division



20th WGRA (Gdynia, Poland)
Workshop on Cognitive Radios

Cognitive Radios (CR)

Potential Regulatory Issues

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What Is the Object of Our Curiosity ?

Cognition

→ *No unique definition*

- Great functions of the mind
- Mental processes of acquisition of knowledge

« Cognitive » radio !

→ *No unique definition*

- “Aware”
- “Adapting”
- “Learning”
- In a single word: “Intelligent”...

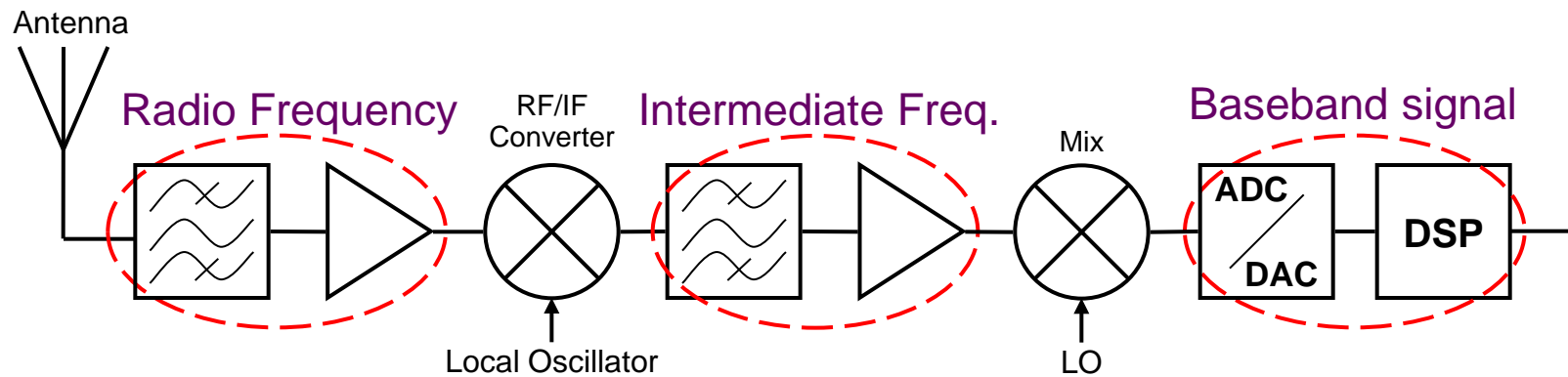




Device-related Aspects

Importance of Software-defined Radio (SDR)

- **Very likely Cognitive Radio will be based on SDR**
 - But: a SDR is not necessarily a CR [criteria: "intelligence"]
- SDR : Radios whose operating parameters are **generated by software** (e.g. frequency range, modulation type)

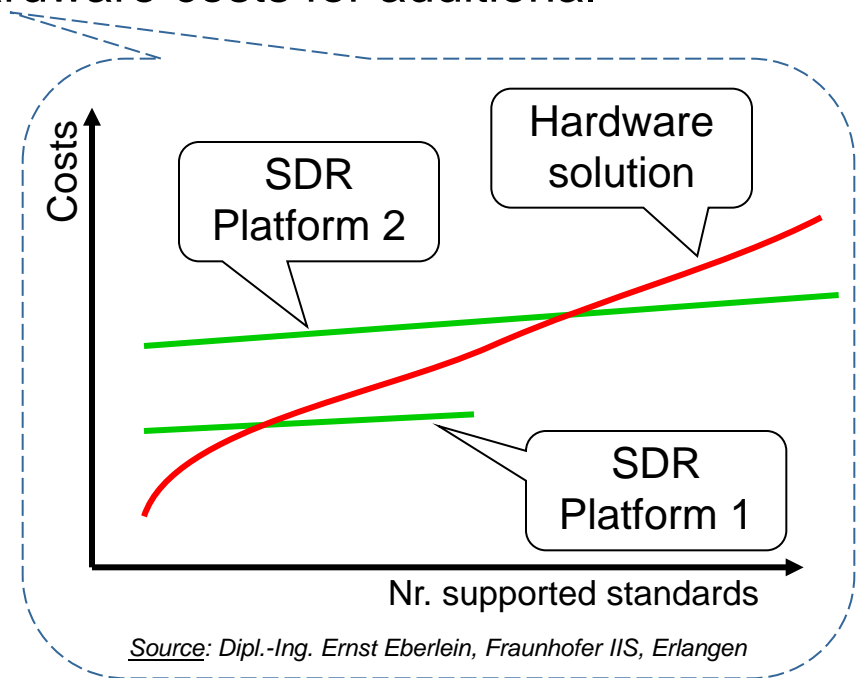


Progress of software definition



Advantage: Reconfigurability

- **Flexible implementation of heterogeneous "standards"**
 - Several standards operate on same components (RAM, interfaces,)
 - No or small increase of hardware costs for additional standards
- **Preparedness for future "standards"**
 - Software for new standard downloadable
 - Easy migration to modified/extended standards

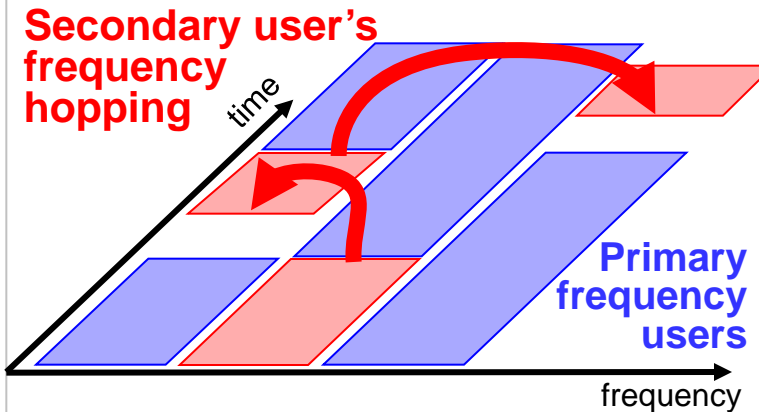




“Cognitive” Spectrum Access As Presently Envisaged

• Secondary, Underlay Use

Heterogeneous systems use the same spectrum as primary systems on a non-interference/non-protection basis



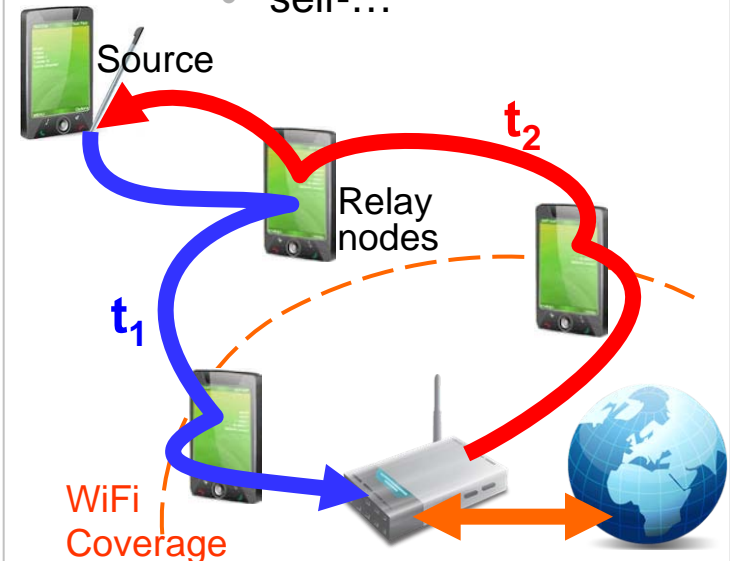
or **U**ltra **W**ide **B**and

• Mesh / Ad Hoc Networks

Cooperative relaying

- self-organising
- self-healing
- self-...

not
necess.
for free !



C o m b i n a b l e

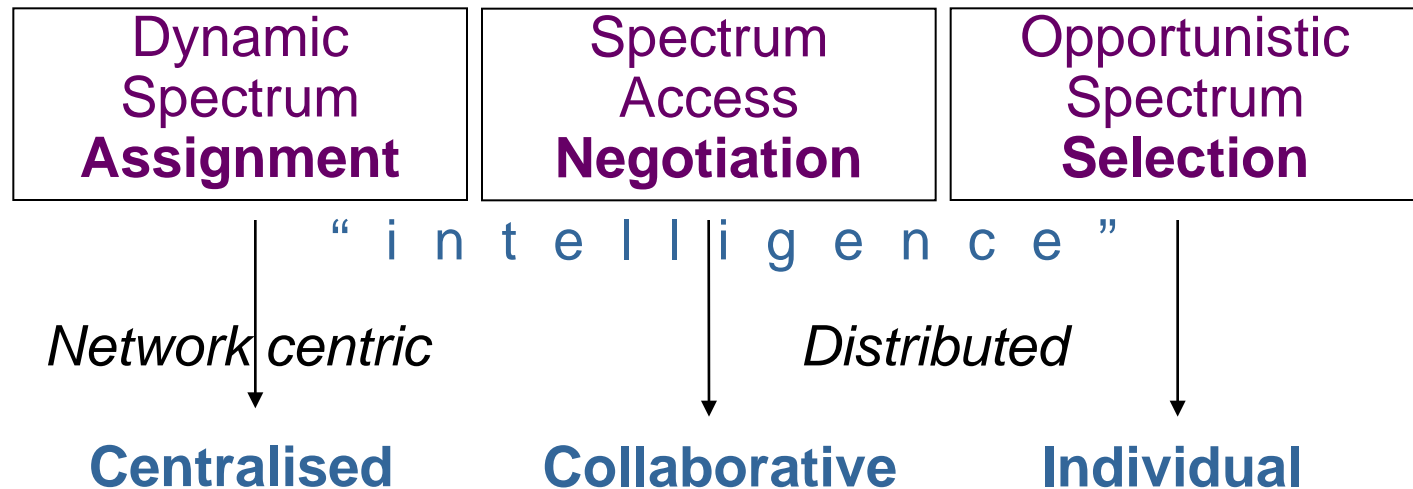


Cognitive Radios and Networks

Radio Resource Management

Varying locations of "intelligence" in relation with

- **Information gathering** (discovery)
- **Identification** (available access schemes, spectrum resources)
- **Decision-making** concerning spectrum usage





Information Gathering & Identification

Sensors, "Beacons", Databases, ...

- **Autonomous sensing and deciding very delicate**
 - Amongst others: "Hidden node" problem
- **Assistance: Cognitive Pilot Channel (CPC) or equivalent**
 - Lowers noticeably risks of interference
 - Centralisation of sensing, mapping, deciding, ...
 - Reins in costs of terminals
 - Limited sensing capabilities sufficient in terminals
 - Saves time and battery energy
 - Curtails consuming spectrum scanning procedures (search of other users, access technologies,...)
 - Facilitates terminal reconfiguration in heterogeneous wireless environments
 - Over-the-air download of updated software possible
- **Occurrence of substantial signaling overhead**



CR in Comparison with SDR

SDR Is Key in Order to Develop CR

Software-defined Radio

- Dynamic support of multiple variable systems, protocols and interfaces
- Interface with diverse systems
- Wide range of services with varying QoS
- Many upgrade mechanisms
 - External and centralised (e.g. firmware over-the-air)
 - Individual (e.g. OSS)

Cognitive radio

- *Autonomous* discovery and development of new radio access technologies
- *Autonomous* negotiation with available networks and selection of most appropriate access technology
- Adjusting operations to meet QoS required by application
- Further upgrade mechanisms
 - Internal (*autonomous*)
 - Collaborative





Key Points

From My Perspective

- **SDR: Presently mainly niche products**
 - Today potentially attractive only for long life time radios
 - Military at vanguard of SDR usage
 - ETSI and IEEE established groups addressing reconfigurable radio systems (RRS)
- **CR: Presently at the stage of models, concepts**
 - Wider potential than just “white space devices” (WSD)
 - Vast efforts in Europe at the level of research
 - COST IC0902 and IC0905, FP7, E³, ARAGORN, & *many more...*
 - Phobia of incumbent users vs. CR concepts [*secondary use*]
 - Dubiety on potential commercial mass applications
 - Goodwill from spectrum management authorities



Potential Regulatory Issues

Overview

- **Devices' conformity & Market access (R&TTE)**
 - Conditions for conformity
 - Interoperability
 - Standardisation
 - Market surveillance
 - Liability, responsibility
- **Spectrum access**
 - Radio interface specifications
 - Spectrum Trading
- **Privacy of telecommunication & data protection**
- **Lawful interception & data retention**



Market Access of SDR/CR in Europe

Analogy Possible With Cars?

- Use intended by manufacturer when originally placed on the market
- “**Reconfigured**” version with modified software (and hardware)



No → “Pre-market” control by car authorities: **Type Approval**

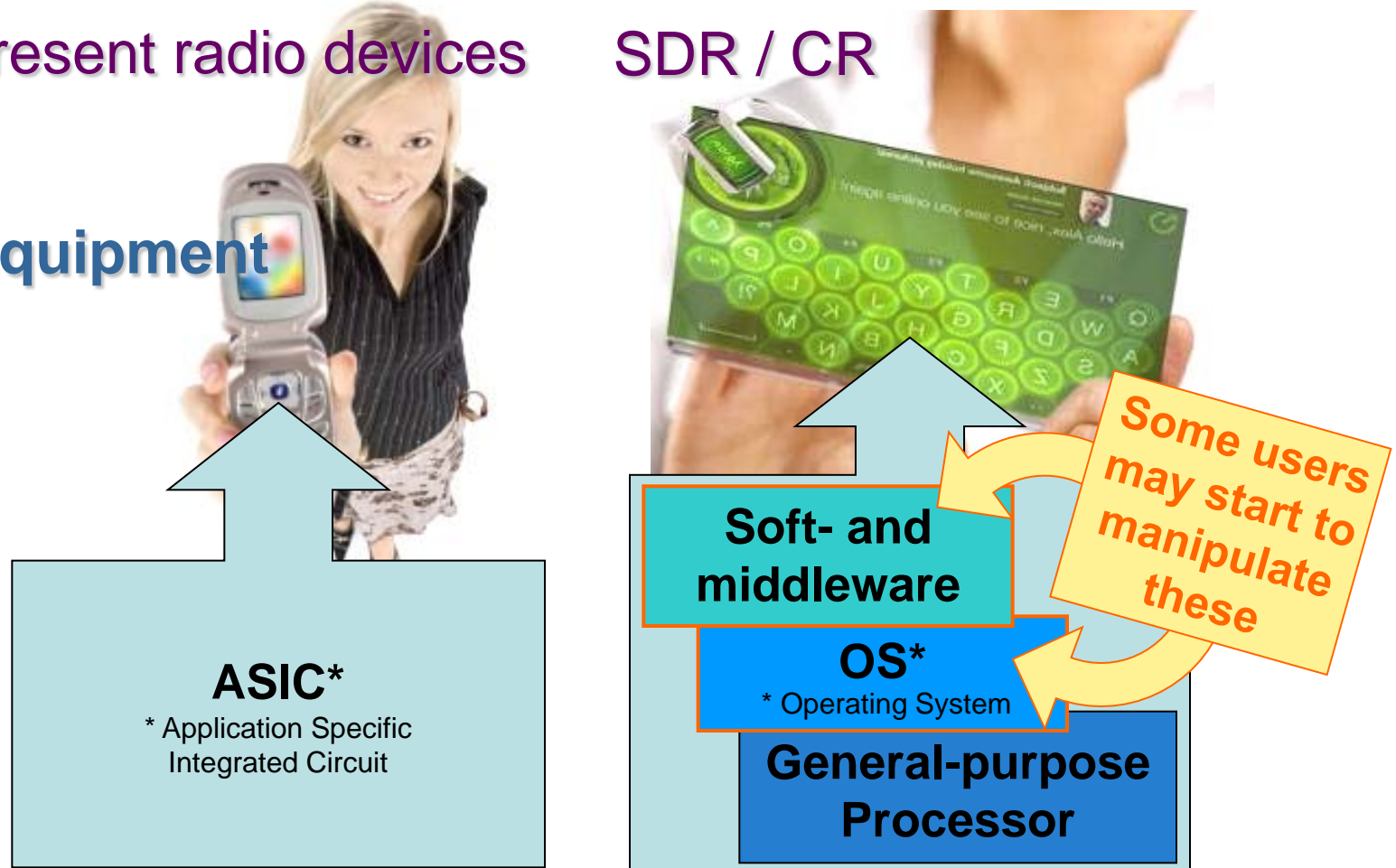


Potential Regulatory Issues Resulting from Reconfigurability

Present radio devices

SDR / CR

Equipment





R&TTE Directive

Material, Essential Requirements

- EMC
- Electric safety
- Efficient use of spectrum

- **Additional requirements needed for reconfigurable equipments ?**



Formal, Administrative Requirements

- Application of conformity assessment procedure
- Markings (CE, class identifier, etc.)
- Inscriptions (type, serial number, etc.)
- Notification
- User information (intended use, declaration of conformity, etc.)
- **Application to software products workable?**



Additional Essential Requirements? For Reconfigurable Radio Equipment

- **Interoperability?**

- Esp. when hard- and software marketed by separate entities
- Standards for software architecture
 - Open platforms
 - Published APIs

- **Network, equipment integrity?**

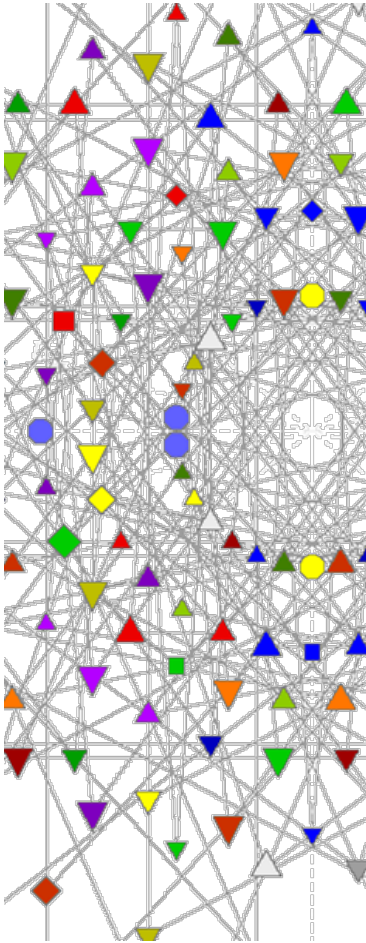
- Protection against unauthorised programming (e.g. hacking)
- Recording of configuration history (“Reconfiguration Controller”)
- Autonomous downloading of updated software

- **Others?**



Interoperability

„Standardisability“ of Interfaces of CR/SDR ?



- Decision of the Commission required for interoperability to be essential requirement
Article 3, para. 3, lit. a), R&TTE Directive 1999/5/EC
 - Justification for such a decision ?
- *Effectiveness* ?
References to standards in RIS only informative
 - Merits of making some references mandatory ?
- Which interfaces of SDR/CR should be covered ?
 - *Vertical interoperability*
user equip. ↔ network
 - *Horizontal interoperability*
user equip. ↔ user equip.



Software with User-modifiable Code & Open-Source Software (OSS)

FCC «Cognitive Radio Report & Order» of 11 March 2008

- No hindrance on OSS developers not affiliated with device manufacturers to work on their software
- CR devices using OSS-based software platforms could also pass FCC certification

OSS makes difficult to:

- Identify “author” of non-conform product (software)
- Establish when modifications of software leading to irregular situation were made

→ Vain to enact regulation fixing responsibilities in case of non-compliance of SDR/CR equipment ?



Key Points

From My Perspective

- For SDR or CR, return to type-approval not an option
- Additional, different **essential, material requirements?**
- Additional, different **administrative, formal requirements?**
 - Less stringent provisions for SDR/CR devices “notably modified” (updated) by manufacturer or network operator?
- **Review of repartition of responsibilities between actors?**
(Relevant only if reconfiguration using third party software is permitted)
 - Responsibilities of equipment, hardware manufacturers established relatively clearly
 - What about radio software developers (IT industry)?
 - Acceptance of responsibilities for their products similar to manufacturers?
 - Enforceability by market surveillance authorities?



Spectrum Access by Cognitive Radios

“It’s all about getting a grip on interference”

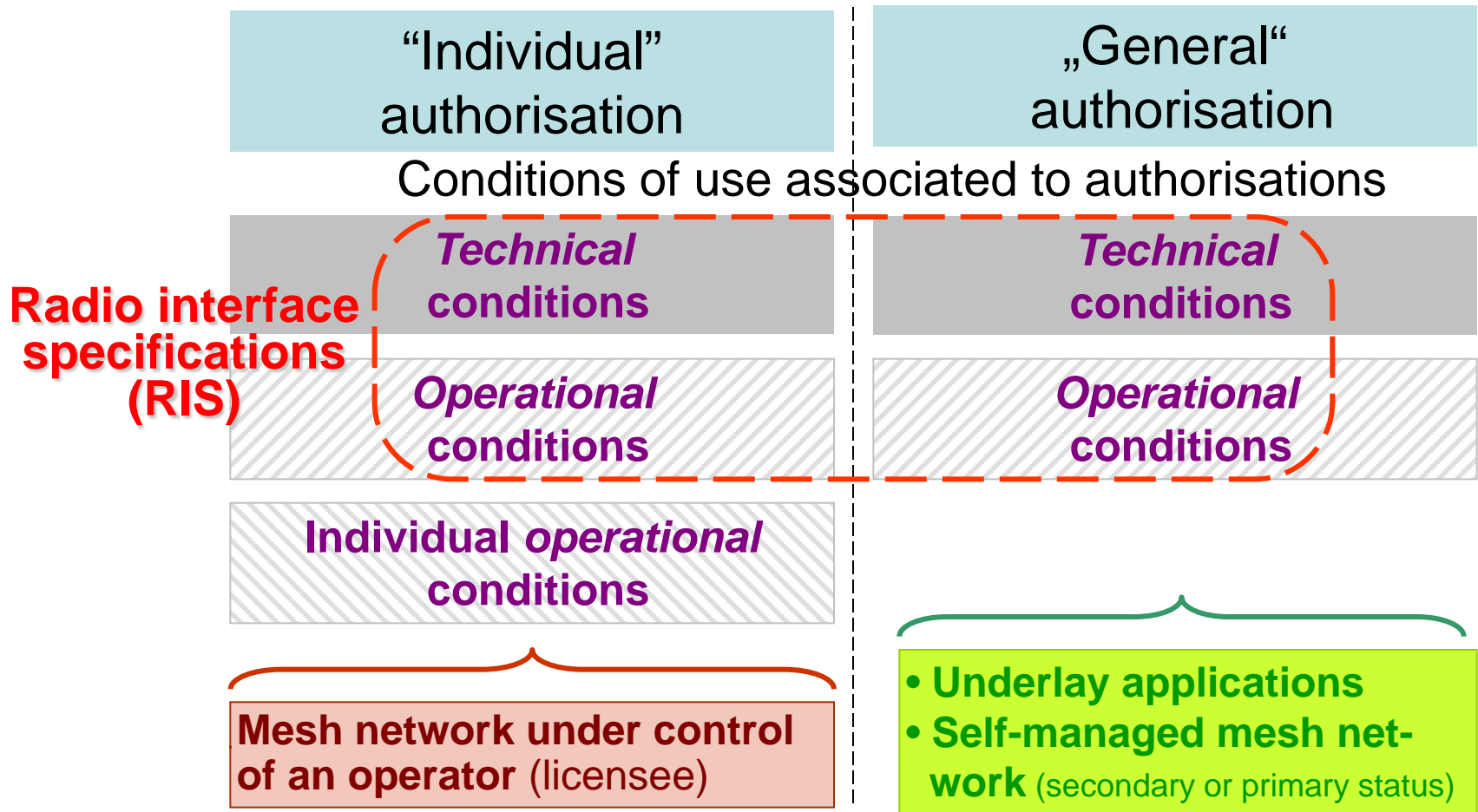


Again a shaky
analogy of
mine?



Spectrum Access

Authorisation Regimes for Radio Spectrum Use





Technical and Operational Conditions

Detailed Implementation Rules Needed

- "Dirk's Conjecture":

The regulatory **principles** of present-day radio-regulatory framework can accommodate agile radio systems

NB₁: Requires **specific rules** on spectrum access conditions
→ **Radio Interface Specifications (RIS)**

NB₂: Maybe even too supple...
→ "Technology neutrality" paradigm

- Secondary Spectrum Use

- "Detection"

→ Criteria ensuring protection of existing services

- Without imposing too constraining conditions on industry of agile radio systems

- "Aggregation": cap-levels?

- Mesh / Ad hoc Networks

- "Dialogue mechanisms"

→ Control and signalisation in co-operative systems

→ Co-operation between systems

Interoperability prescriptions?



Market-based Spectrum Access

Spectrum Trading



- **Spectrum leasing for underlay usage**
 - Primary spectrum users lease usage rights to secondary users
 - Minimal regulatory constraints, maximal flexibility (both for primary and secondary users)
 - Users as free as possible in designing rights to be traded
- Negotiations may result in *willingness to share* by primary user in favour of secondary user
 - Primary user → Appreciation of amount of “interference” that can be tolerated at which location, time, and in which frequency channels (etc.)
 - Secondary user → Definition of wanted QoS (etc.)
 - Existing overlap? Agreement on price?



Market-based Spectrum Access

Capacity Renting, Brokering

- **Renting capacity of other users' devices for relaying in mesh/ad hoc networks**
 - Not spectrum trading *stricto sensu*
 - Spectrum trading non-sense in license-exempt bands
 - Countless modalities imaginable for implementing capacity renting in mesh networks
 - Any need for regulation of negotiations for relaying?
- **Establishing brokerage agents or institutions?**
 - Primary users also bid in order to access spectrum?
 - Third party spectrum manager maximises usage (= revenue?) of entrusted resource
 - = most efficient balance between CR users' rights and legacy users' rights?



Key Points

From My Perspective

- Competition of “standards” unavoidable
- In short/medium term: Services with higher regulatory status not unquestionably protected by sensing alone
- Alleviation by CPC, databases, ...
 - One core aspect: quality of data (actuality, precision, etc.)
 - If incompatible technologies: any co-ordination?
 - Mandatory harmonised standard ensuring interoperability?
- Spectrum trading *might* be a major facilitator for SDR/CR
 - What are pre-requisites for instant & short-term trading?
 - Will payment lead primary users to moderate their protection claims?
 - Special design of spectrum pricing or auctions in order to play complementary role?



Technological Requirements

Important Technical Progresses Still Required

With a view to mass-market

- **Processors** (CPU: *Central Processing Unit*)
Replacing nowadays ASIC
- **Algorithms**
 - For handhelds' CPUs for dynamic and opportunistic access to spectrum
 - For auto-organising networks (*signaling architectures, etc.*)
 - Energetic efficiency of algorithms
- **Electric Accumulators** (batteries)
 - Power consumption
- **Miniaturisation**

Last but not least

- **Develop a viable business model...**



Fig.: Enhanced AN/GRC-245
High Capacity LOS radio



Concerns of Interested Parties

Relating to the Introduction of CR

	Regulators	Users	Mesh Netw. Operat.
Network	<ul style="list-style-type: none"> • Not critical if network controls equipment • Telecommunications' Privacy & data protection • Efficiency of spectrum use due to signaling & addressing overhead 	<ul style="list-style-type: none"> • Interoperability • Telecommunications' Privacy & data protection • Battery life 	<ul style="list-style-type: none"> • Network integrity and security • Number of users impacts on required bandwidth • Business model
Underlay	<ul style="list-style-type: none"> • Establishing conditions guaranteeing minimised risks of interference • Difficult future refarming • Consistency with international obligations 	<p>[Primary users]</p> <ul style="list-style-type: none"> • Aggregate interference • Shadowing, Hidden node • Sensing may not recognise new systems 	



Implications for Administrations

Market Surveillance & Radio Monitoring

- **Substantial challenge for radio monitoring**
 - Difficulty to observe identify, and determine in a timely manner a source of unlawful interference
- **Considering placing more responsibility on spectrum users?**
 - In case of
 - *absence of conformity* (essential requirements)
 - *non conform use* of SDR/CR equipments (access to spectrum)





Fields of Investigation for WG RA

Speaker's Selection



- SDR/CR-preparedness of
 - Equipment conformance regulation?
 - RIS model?
 - Responsibility ascription regulation?
 - Increased facility and lower cost of manipulating equipment reduces manufacturers' or network operator's control
- Elaborate regulatory measures applicable to SDR/CR
 - Facilitating location of source of interference?
 - Facilitating in due course refarming? (esp. license-exempt)
 - Mandating upgrading faculty to future standards, spectrum rules, etc.?
 - Correcting deficiencies in relation with spectrum trading?
- Always: Regulation should be enabler for new technologies



Thank You for Your Attention



“Could you explain that again
in real words?”