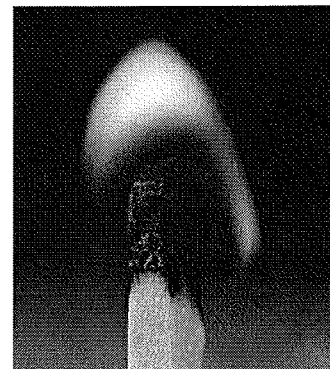


HOT RADIO TECHNOLOGY TOPICS

COGNITIVE RADIO
SPECTRUM SHARING
WHITE SPACE
GEO-LOCATION DATABASES

Tim Irnich
Broadband for all Seminar 2012 – Technology Briefing
Ericsson Studio, 26 June 2012



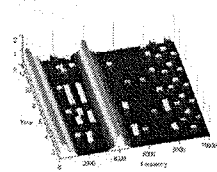
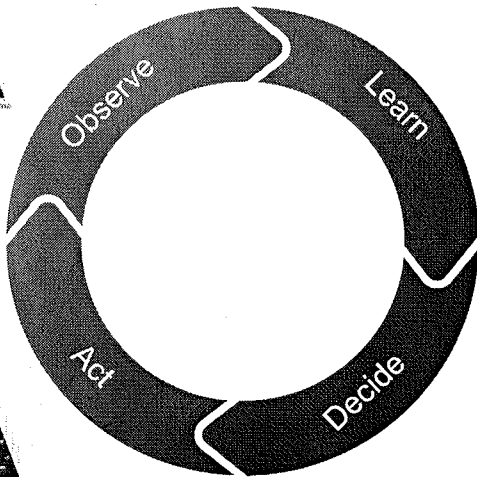
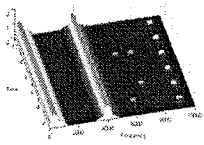
OUTLINE



- › Cognitive radio – theory and practice
- › TV white space for cellular networks?
- › Success factors for spectrum sharing in cellular networks
- › Summary



COGNITIVE RADIO



› Original concept described by Mitola in 1998 [1]

- › Generic
 - Power control
 - Link Adaptation
 - Hybrid ARQ

› Application to spectrum: radios coordinate themselves

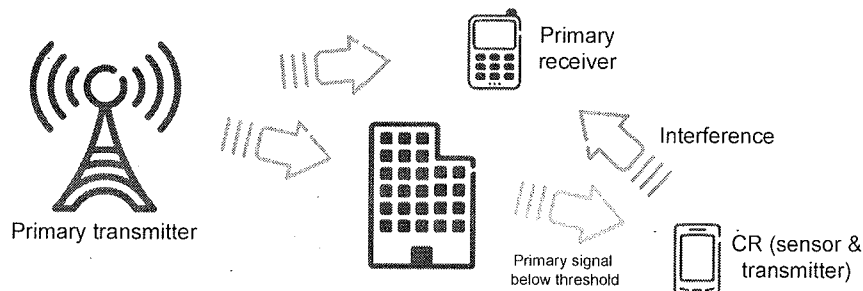
Fundamental problem: imperfect knowledge

[1] Joseph Mitola III, Cognitive Radio: An Integrated Agent Architecture for Software Defined Radio, Royal Institute of Technology (KTH) Stockholm, Sweden, 8 May 2000, ISSN 1403 - 5286.
Ericsson Internal | 2012-06-14 | Page 3

HIDDEN NODE PROBLEM



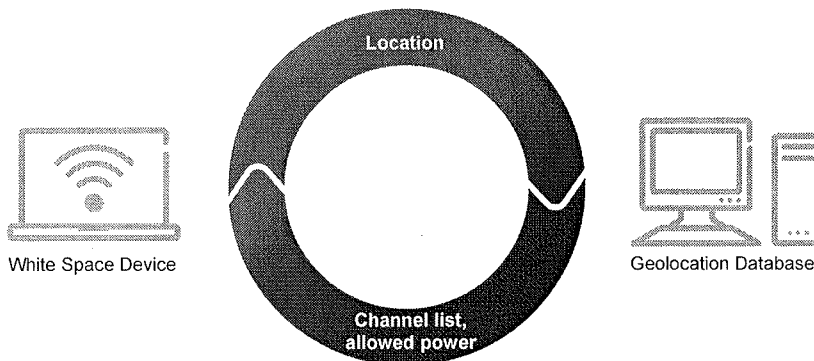
- › CR may fail to detect primary signal due to shadowing/fading
- › Possible solutions:
 - Lower sensing thresholds
 - › Infeasible sensing thresholds & large loss of opportunity
 - Cooperative sensing: gains depend on number and location of sensors
 - › Lower bound of detection performance = single sensor performance



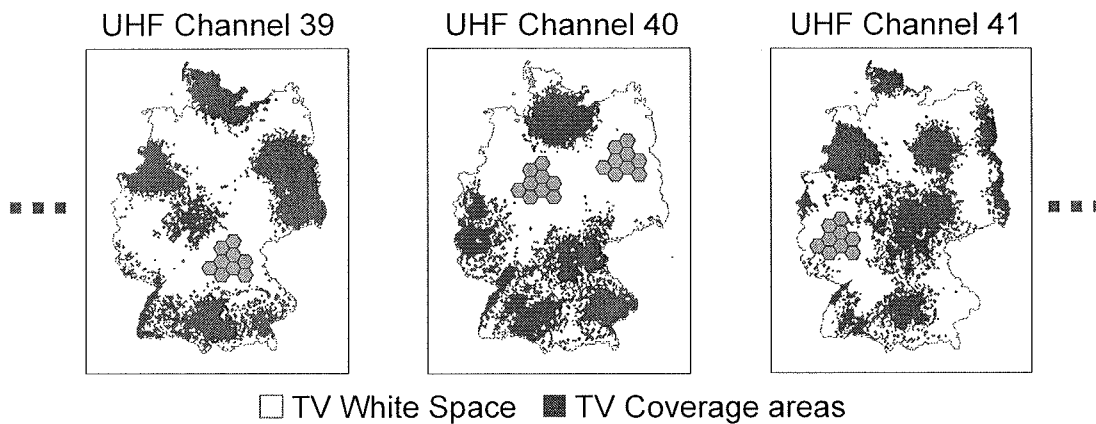
GEO-LOCATION DATABASE



- › White Space Devices (WSD) provide their location in database query
- › Database tells them which channels they may use at given location, and under what conditions
- › Mainly applicable where spectrum opportunities exist in spatial domain
- › Can be enhanced with cognitive capabilities → feedback loop
- › **Provides flexibility for later enhancements & updates**



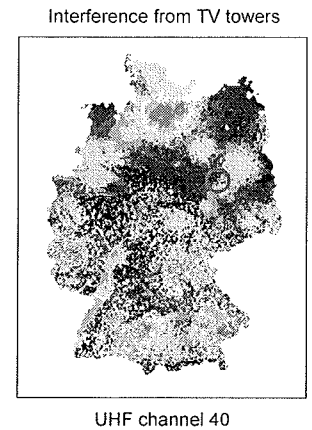
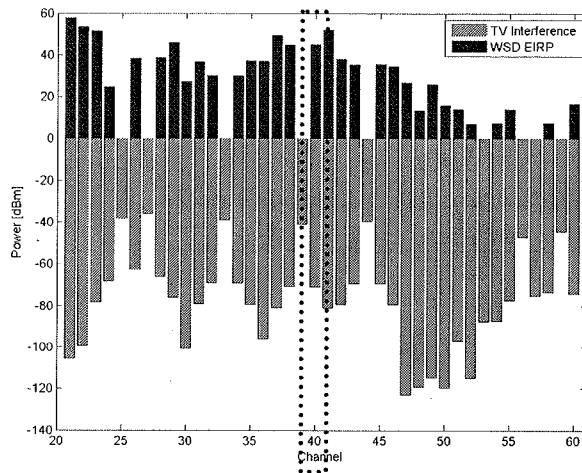
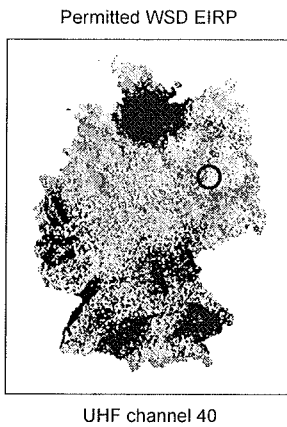
TV WHITE SPACE



- › Exists in locations where successful TV reception is not possible* and thus secondary usage by White Space Devices (WSDs) can be permitted

*according to a certain (regulatory) threshold definition (in practice, TV coverage is not a binary phenomenon)

NOT ALL TV WHITE SPACE IS EQUAL



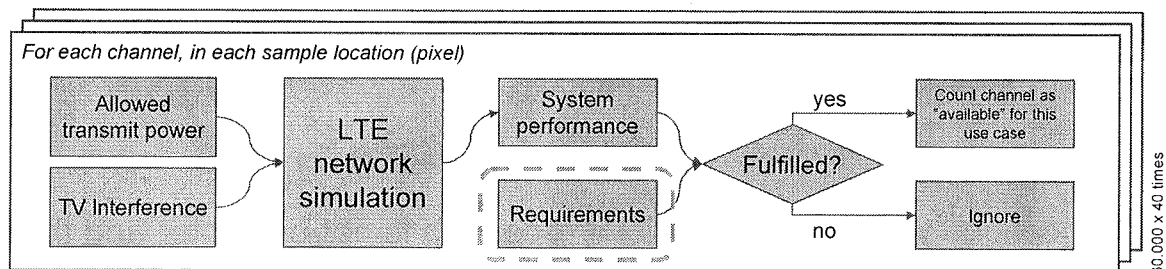
Allowed transmit power & TV interference vary strongly over available channels → How to select?

- CEPT TVWS rules
- TV transmitter database from German regulator
- Terrain-based propagation model, SRTM terrain data
- WSD at 1.5m height

HOW MUCH FOR A GIVEN USE CASE?



- › At a given location, permitted TX power and interference vary strongly
 - Which channels to select?
 - Use-case dependent criteria needed!
- › How many channels fulfill these criteria?



USE-CASES CONSIDERED



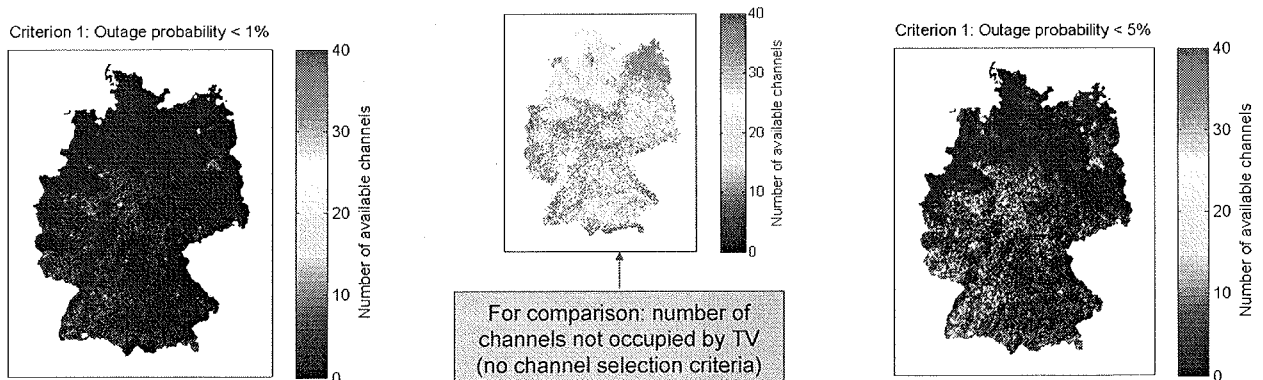
› Use case 1: Standalone network

- Newly built network in TVWS spectrum only
- **Requirement: contiguous coverage for typical site density**
 - › Metric: outage probability

› Use case 2: Cellular network offloading

- Network operating in dedicated spectrum opportunistically expands into TVWS spectrum for traffic offloading
- **Requirement: sufficient “value for money”**
 - › Metric: average cell spectral efficiency

AVAILABLE TVWS CHANNELS STAND-ALONE NETWORK CASE

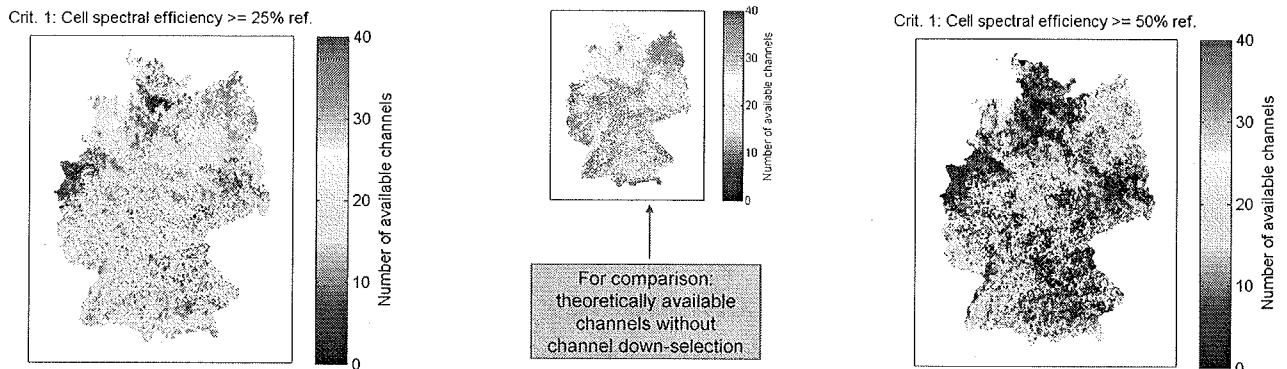


- › **72%** of Germany: zero channels
- › Only 10% of Germany has at least **3** or more channels

- › **32%** of Germany: zero channels
- › Only 10 % of Germany has at least **9** or more channels

If coverage is required, little TVWS remains...

AVAILABLE TVWS CHANNELS OFFLOADING CASE



- › At least one channel everywhere
- › 50 % of Germany has at least 21 channels

- › Zero channels only 2% of area
- › 50 % of Germany has at least 11 channels

For offloading reasonable opportunity exists...

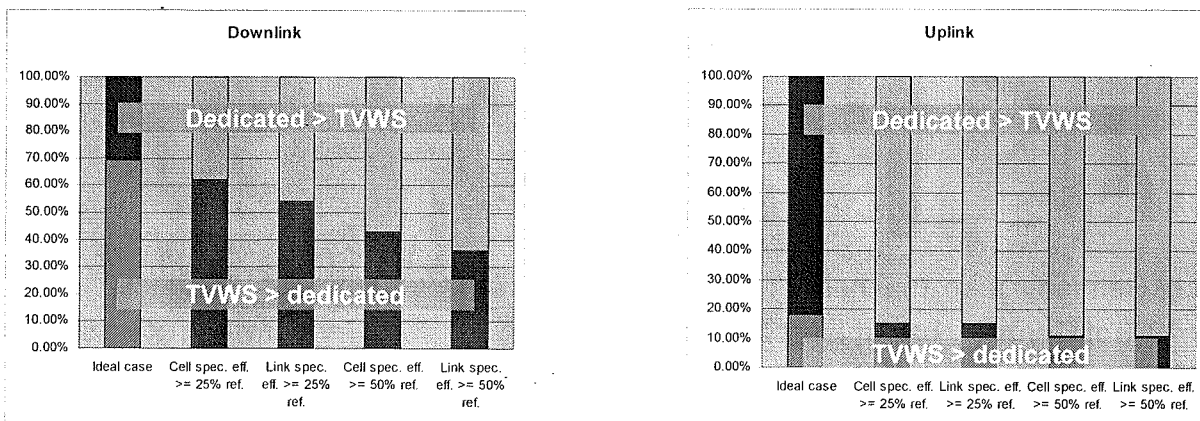
- TV transmitter database from German regulator
- Terrain-based propagation model, SRTM terrain data
- WSD at 1.5m height
- 20% fractional load

BETTER THAN DEDICATED SPECTRUM? OFFLOADING CASE



- › Percentage of locations in Germany* where all TVWS channels together deliver **higher** capacity than 100 MHz dedicated spectrum

*Locations with zero channel availability excluded



- CEPT TVWS rules
- TV transmitter database from German regulator
- Terrain-based propagation model, SRTM terrain data
- WSD at 1.5m height
- 20% fractional load

OBSERVATIONS ON TV WHITE SPACE



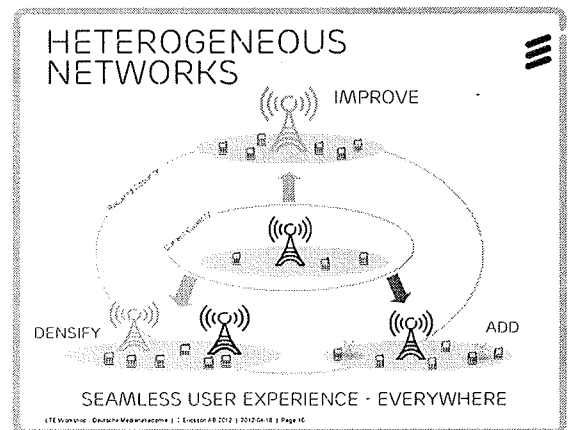
- › TVWS are a very noisy environment → achieving contiguous coverage is difficult
- › Sweet spot for TVWS usage is low power short range scenarios
- › Downlink works better than uplink (BS receiver more exposed to TV interference)
- › Re-purposing 100 MHz → higher capacity in 50-80% of Germany's area
- › **TV white space is not “white”, and transmit power often strongly limited**
→ range advantage of low frequencies is lost
- › **Is TVWS the right way of using beachfront spectrum?**
 - For offloading higher frequencies could be equally well suited
- › **Geo-location databases interesting to unlock other frequency bands**

However, TV white space is just the beginning...

SCOPE FOR SPECTRUM SHARING IN CELLULAR NETWORKS INCREASES



- › Technical network evolution to address capacity challenges...
 - Densification → smaller cells, lower power
 - Below-rooftop, indoor cells
 - Higher frequencies
- › ... **facilitates sharing spectrum for parts of a heterogeneous multi-RAT multi-band network**
- › Many different flavors of spectrum sharing exist, and all of them have merit **in certain situations**
- › **Important to understand how the different sharing options map to deployment scenarios**



The future is a mixture of different dedicated and shared spectrum

SUCCESS FACTORS FOR SPECTRUM SHARING



Dedicated and shared spectrum complement each other...

Dedicated spectrum → high reliability, mobility support and basis for increasing spectral efficiency

Shared Spectrum → peak demands, high QoE in limited areas

Crucial to understand for which parts of a network which type of spectrum is best

Number of parties involved in sharing should be limited → "Licensed sharing"

Licensed Shared Access (LSA) unlocks underutilized spectrum

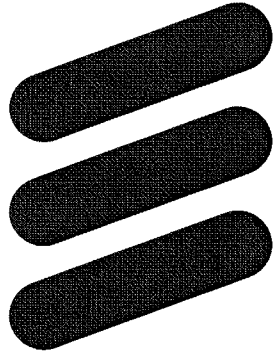
In most cases by means of geo-location databases

Detailed information on incumbent usage is key

SUMMARY



- › Cognitive Radio is a generic but also elusive concept
 - For vertical sharing, sensing not reliable enough → databases required
- › TV white space is difficult to use for cellular networks
 - Range advantage of low frequencies is lost due to transmit power limitations and TV interference
- › Dedicated spectrum continues to be the basis for mobile broadband
 - But scope for spectrum sharing in cellular networks increases
- › Dedicated and shared spectrum together stronger than each one alone
 - Find the right balance, get shared spectrum right



ERICSSON

