



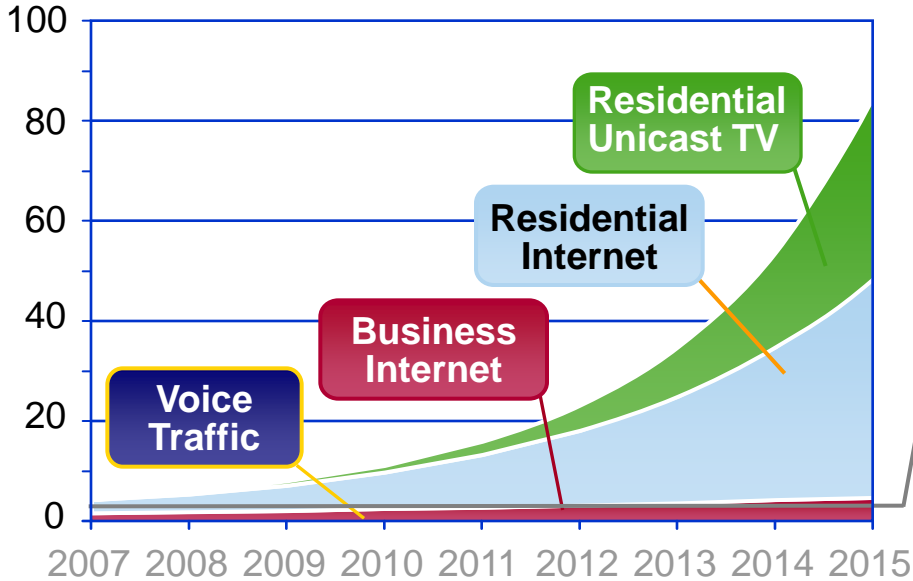
TVWS Is an Cognitive Radio Enabler with Challenges

TVWS Coexistence Workshop, July 16, 2010

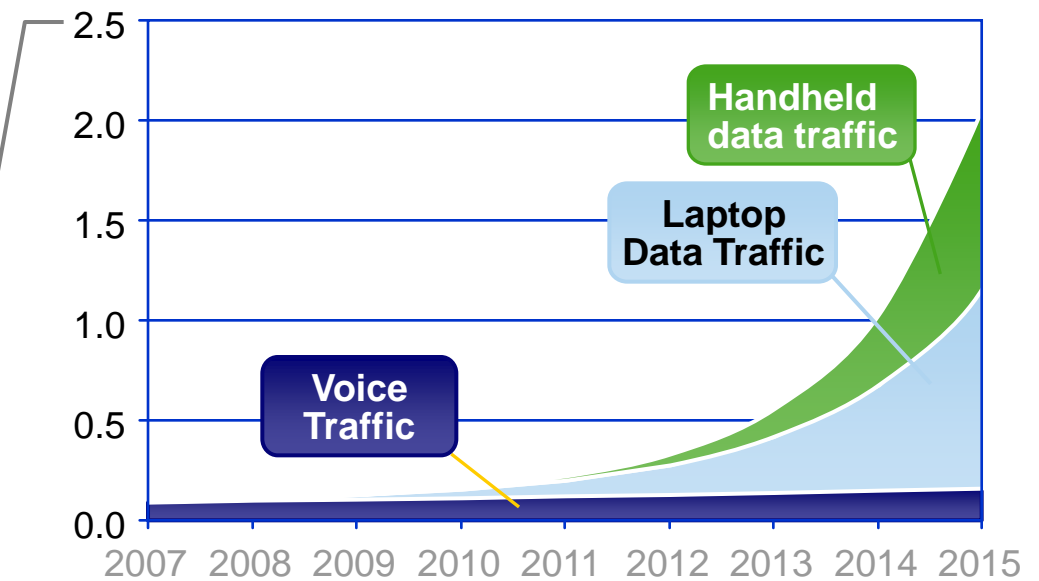
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Traffic forecast – x100

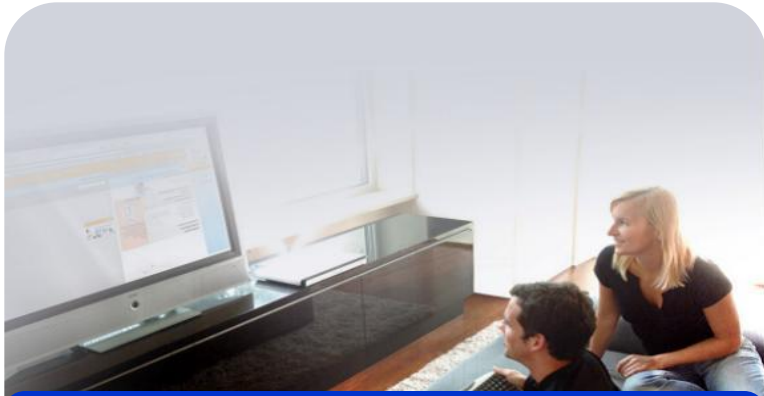
Global FIXED traffic (ExaByte/month)



Global MOBILE traffic (ExaByte/month)



Fixed broadband traffic is 40x mobile in 2015



I want only one TV channel - Mine!

Mobile data traffic grows 300 fold

Price per bit needs to decrease significantly!

Motivation

- Trend: Increasing growth of mobile traffic
 - More than 4 billion mobile phone users today...and growing at a startling rate
 - “7 trillion wireless devices serving 7 billion people in 2017” – *Wireless World Research Forum*
 - “Mobile Internet traffic handled by mobile operators will grow from 7 billion megabytes worldwide [in 2008] into 63 billion megabytes in 2013 (CAGR 54%)” – *Informa*
- Trend: Regulators allowing secondary spectrum access
 - FCC opened door for TV White Spaces in USA
 - CEPT and several administrations are active or getting active
 - Active discussion predicted on regulatory measures in the 2012 World Radiocommunication Conference (WRC-12)



The Facebook logo, with the word "facebook" in white on a dark blue rectangular background.

The Myspace logo, featuring a stylized icon of three people and the text "myspace a place for friends".

The Yahoo! logo, with the word "YAHOO!" in a purple, stylized font.

The Flickr logo, with the word "flickr" in a blue and pink font.

White Spaces – opportunity to cope with growing mobile data traffic?

Envisioned two potential scenarios

“Local area” scenario

- Private networks operated by individuals and companies
 - Data traffic off-loaded from mobile to local network in access point coverage area
 - Local solutions for rural areas – wireless internet for a larger population
- Feasible based on Wi-Fi experience

“Wide area” scenario

- Open networks operated by individuals and companies
 - Access to consumers for free data while on the move
 - Data traffic off-loaded from mobile operators to open networks
- Unclear from technical and business model perspective!

“Local area” scenario – a feasible opportunity

OPERATOR

- Licensed spectrum expected to become congested due to increased data traffic caused by flat rate data plans
- White Spaces offers the opportunity to offload data traffic from mobile broadband to a local solution
- Opportunity to manage cellular network capacity and optimize wide area network investments

CONSUMER

- Coverage extension for Wi-Fi compared to 2.4/5GHz thanks to low frequency spectrum
- Local solutions for affordable internet services to rural areas
- Wide ecosystem drives lower costs for the consumer, assuming global harmonized approach

ECOSYSTEM

- Ecosystem can benefit only if harmonized approach is adopted globally
- Accelerated implementation
- Volumes -> economies of scale

Industry collaboration needed for consistent, standardized and global approach

1. Regulatory question - Licensed vs unlicensed?

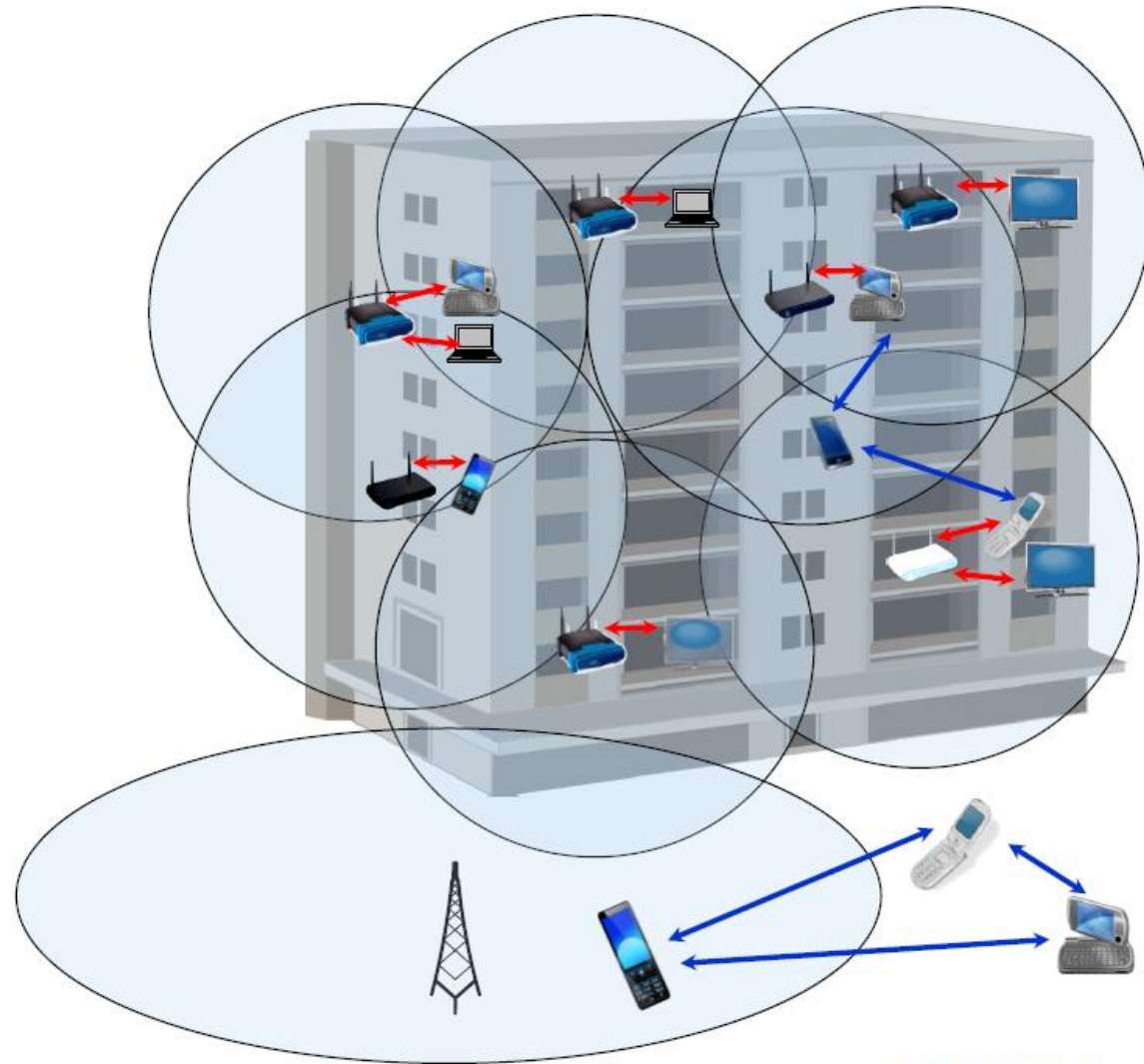
- Challenge with unlicensed use is the **interference**
 - Guarantee of no interference with '*licensed primary use*' and '*licensed secondary use*'
 - Dynamic real-time allocation of the spectrum needed
- FCC decision - unlicensed secondary use approach approved – **direction is set**
- Unlicensed approach supports a **variety of use cases**
 - wireless broadband access
 - device-to-device communication

2. Technology?

- The advanced technology applicable for White Spaces is **Cognitive Radio**
 - enables the real time automatic usage of the available spectrum (location capability, connection to the internet based database, and capability to sense primary users before and during transmitting)
- **Radio technology standards** evaluation is ongoing
 - None of the existing standards fit perfectly as they are today -> development of standards needed

Coexistence – Levels of collaboration

- “Wild West”: Decision-makers optimize their own situation, not taking into account any interests of others
- Cooperation: Decision-makers optimize their own situation, while taking into account the interests of others
- Collaboration: Interacting decision makers to optimize their performance, this is based on active/explicit communication between the decision-makers



From wide area to local optimization

- 1G: Analogue cellular systems (AMPS, NMT, etc.)
- 2G: Transition to digital (GSM, TDMA, CDMA)
- 3G: Fusion of voice and data (WCDMA, CDMA2000)
- 4G: Performance extremes in wide area, more flexible bandwidth and spectrum deployments, flat network architecture (3GPP LTE)

Wide Area
Access

Local Area
Access

Future trend: Cognitive Radio

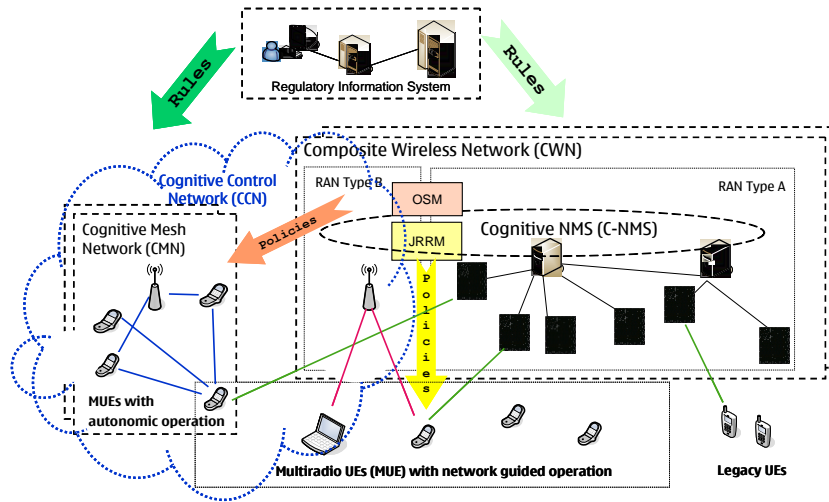
- The research frontier in wireless
- Changing the rules on how spectrum is being used

Initial steps with this technology are about to be taken on the U.S. TV White Space frequencies

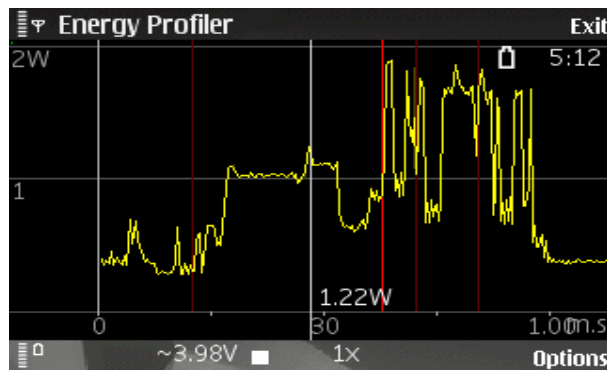
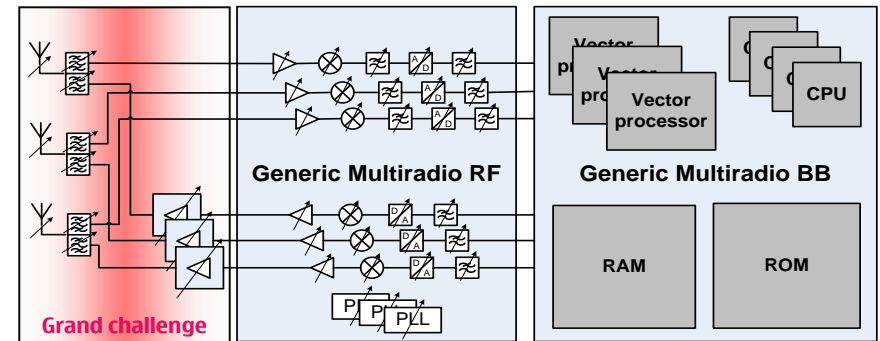


Key technologies for future wireless

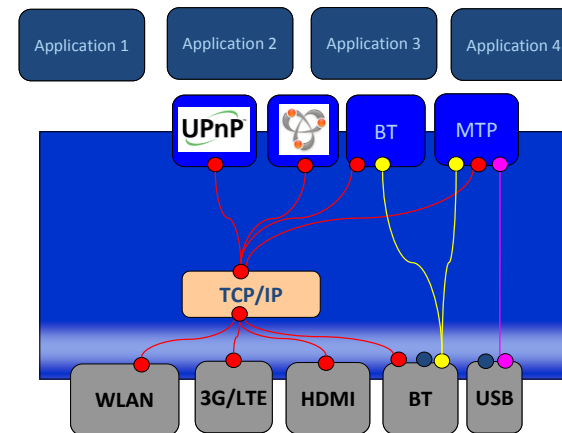
Heterogeneous Networks, Cognitive Radios and Coexistence



Flexible, frequency agile platforms



Technologies to minimize power consumption



SW mechanisms to efficiently utilize heterogeneous network access

Harmonization for White Spaces

- Contribution to the **regulatory consultations**
- **Database regulation** to ensure high level of radio quality for consumers, if/when operators offer data offload from licensed to unlicensed spectrum
- Active participation in **standardization** and support for the goals of the community
- **Partner, customer and industry dialogue** in preparation of contribution
- **Evaluation of potential wireless technologies**
- **Development of capabilities** operating under the White Spaces spectrum based on Cognitive Radio

Finland

- Ministry proactive to enable Cognitive Radio development
- Government ruling [2009/1169](#), Dec 22nd 2009, allows cognitive radio on 470 – 790 MHz since Jan 1st 2010
- First country which allowed *Cognitive Radio*?



The screenshot shows the website of the Finnish Ministry of Transport and Communications. At the top, there are language options: "text version", "suomeksi", "på svenska", and "in English". The main header features the ministry's logo and name. Below the header is a navigation menu with links for "Home", "Press releases", "Transport", "Communications", "The Ministry", "Publications", and "Contacts". A breadcrumb trail reads "Home » Press releases » Press releases » Press releases".

On the left side, there is a "Press releases" section with a list of years from 2009 to 2004. Below this list are links for "Topical" and "Subscription".

The main content area displays a press release titled "Finland to enable field tests in Cognitive Radio". The "Publish date" is 07.10.2009 13.14. The text of the press release states: "Finland wants to ensure that its legislation poses no difficulties for the development of Cognitive Radio and thus efficient use of spectrum. The Finnish legislation concerning radio spectrum will be amended accordingly during this autumn. Testing in Cognitive Radio is meant to be started in the beginning of next year." A quote follows: "It is clear that change is needed and we want to promote Finland's opportunities to be among the leading countries in the development of Cognitive Radio", says Mr Harri Pursiainen, Permanent Secretary at Finland's Ministry of Transport and Communications. A green "link" icon is visible at the end of the quote.

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Valtioneuvoston asetus 2009/1169

Kognitiiviset radioverkot

Kognitiiviset radiojärjestelmät käyttävät taajuusalueita 470–790 MHz siten, että ne eivät saa suojausta muulta radioliikenteeltä eivätkä saa aiheuttaa häiriötä muulle radioliikenteelle.

Opportunity to explore in early phase of technology development

Consumer benefits will drive our wireless future and Cognitive Radio
Ultimately, a truly transparent connectivity experience will be enabled

Nokia develops capabilities operating under the White Spaces
spectrum based on Cognitive Radio

Standardized and global approach is needed

<http://research.nokia.com>

<http://www.youtube.com/watch?v=E3W43pyEgSk>