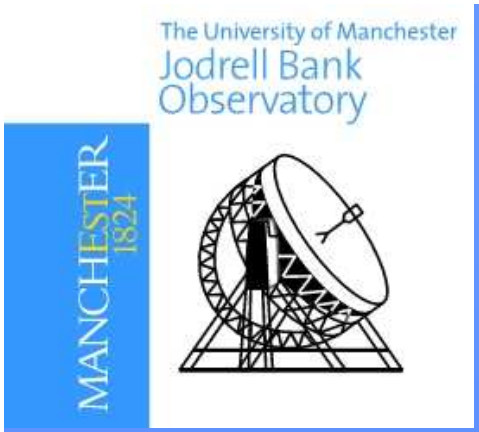

COGNITIVE RADIO

I.U.C.A.F. Summer School

Chile, April 2014

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Radio frequency spectrum

Nowadays, this intangible commodity is in great demand and equates to MONEY

The UK Spectrum Strategy,

Delivering the best value from Spectrum for the U.K.

The U.K. Treasury and Ministers know that
Spectrum is already worth over £50 billion to the UK economy and
Want this to double by 2025.

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Not easy to obtain more spectrum, since it is finite and most of it is already in use.

Politicians and Treasury Ministers are starting to say that

Everybody must share the spectrum !!??

Radio astronomers and EESS very concerned.

Cognitive Radio is an Intelligent radio system that can be programmed & configured dynamically to use spectrum ‘not-in-use’.

First come – First served ?

Will need some form of administration to stop some users ‘camping’ in channels or using bands allocated to other services.

e.g. Bands used by radioastronomers given in footnotes 5.340 & 5.149

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Could the software in a cognitive radio system be hacked so that it checks for transmissions in unauthorised bands, which, if they are passive bands, would find them to be quiet, and would then start transmitting ?

Hacking into a Cognitive radio system software could cost billions of dollars, just as it sometimes does for other computer systems.

Equipment failures do occur.
There would appear to be a greater chance of interference resulting from equipment failures if frequencies to be used for transmission are chosen by software dependent upon their perceived availability.

All spectrum to be shared ?
Not possible and also can be very dangerous.
A contributing factor to the plane crash in Puerto Rico in 1969, when all on board were killed, was that somebody else was transmitting in the same frequency band as the air-traffic controller.

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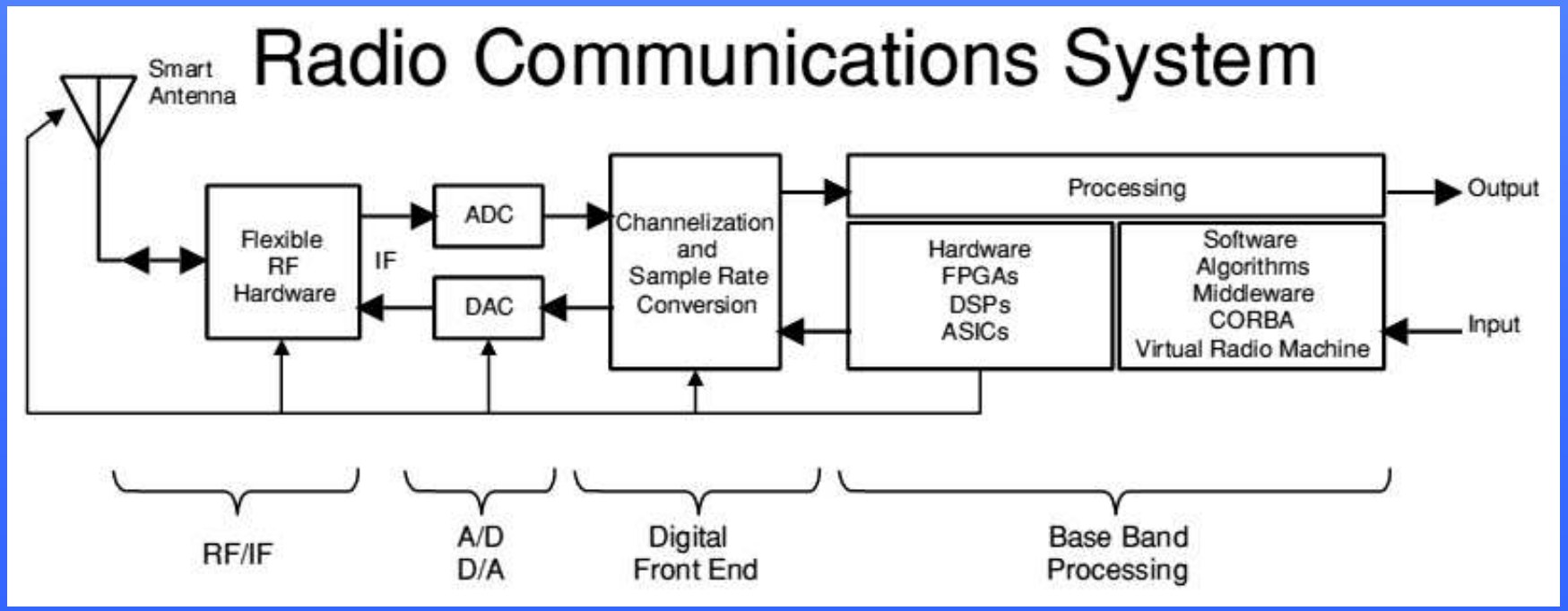
Cognitive Radio first proposed at a seminar in 1998 at the Royal Institute of Technology in Stockholm, Sweden (KTH) by Joseph Mitola

Mitola's Doctorate Thesis entitled
"Cognitive Radio – An Integrated Agent Architecture for Software Defined Radio"

Typical Radio Communications System



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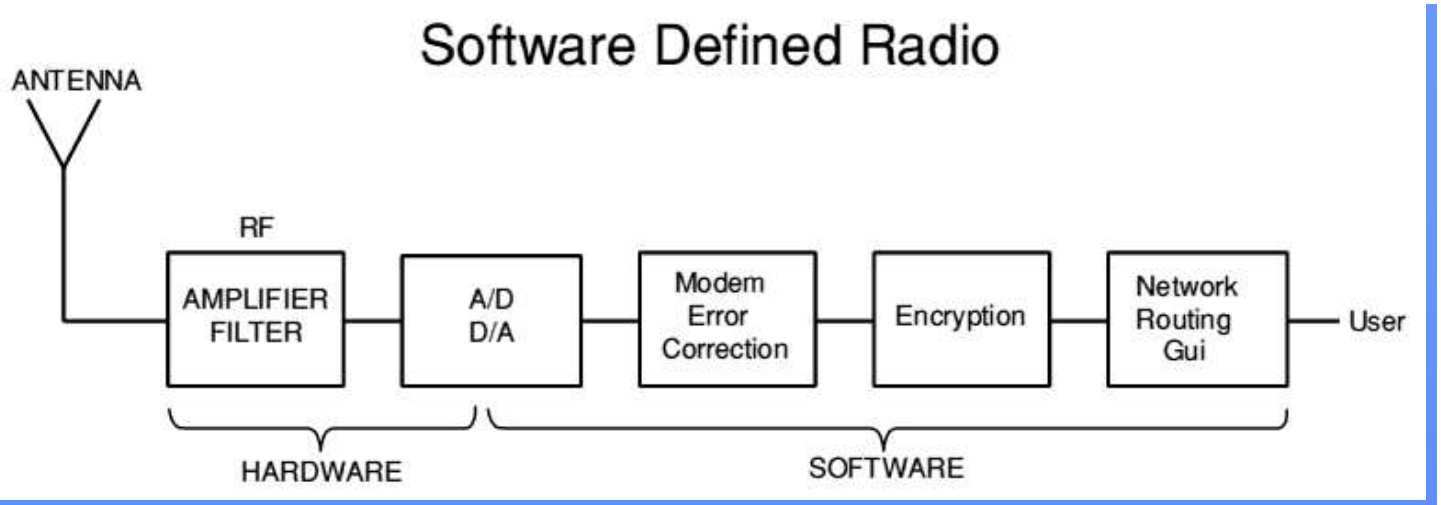

In a software defined radio communication system, many of the components normally implemented in hardware (e.g. Mixers, filters, amplifiers, modulators / demodulators, detectors etc.) are implemented by means of software running on perhaps a personal computer, or more likely on an embedded computer system (normally a real-time computing system with a dedicated function). Nowadays, these would be microcontrollers with a few designated peripherals.

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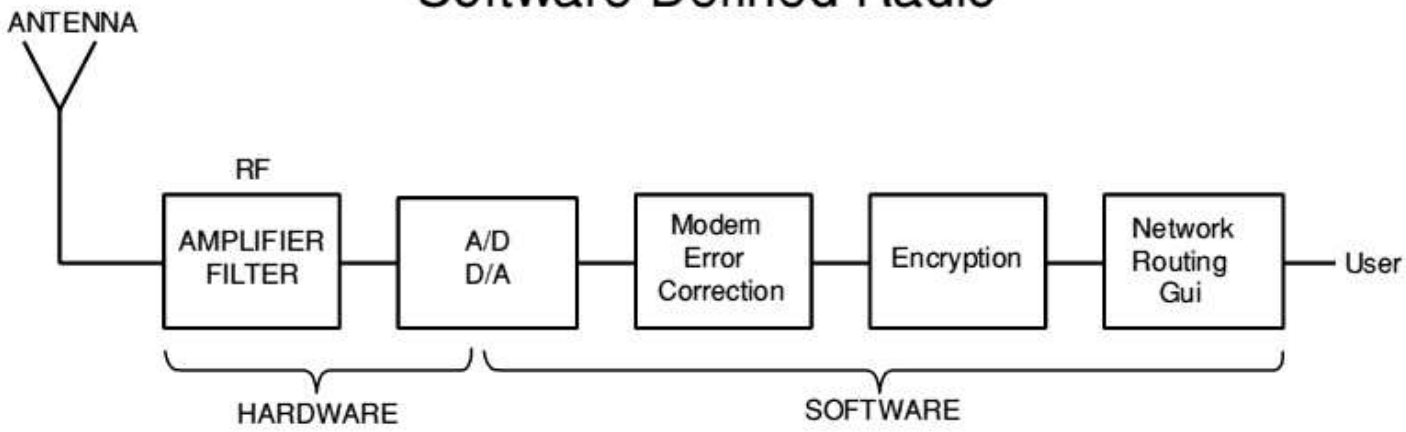
Software Defined Radio



One can think of a simple ideal design for a software-defined radio in which an Analogue-to-Digital convertor (AtoD) is attached directly to an antenna, the data from which is transferred to and digitally processed in a computer to whatever format a particular application requires.

Typically, one would have to take account of communication errors, and the data would probably have to be encrypted for commercial use. A person running the system would want to know the network route in case there are problems / hardware failures. For transmission, the reverse process would take place. However, in reality, for many transmissions, the AtoD conversion could probably not function at a high-enough rate and high-enough accuracy.

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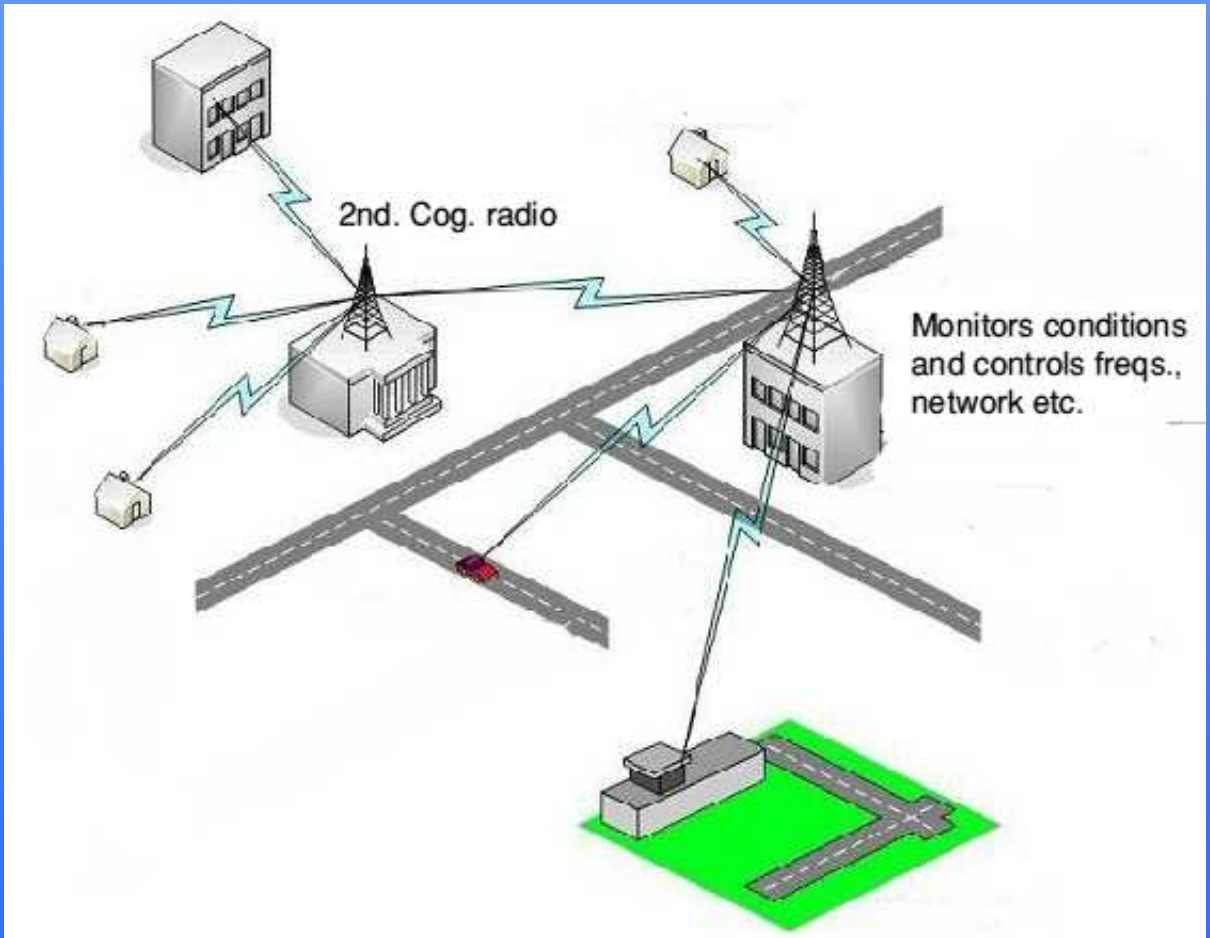
Cognitive Radio System has more intelligence.



In theory, a Cognitive Radio system has more built-in intelligence to enable it to be programmed and configured dynamically. Its transceiver should be designed to use the best wireless channels in its vicinity, configuring the radio-system parameters not only to alter the operating frequency, but also perhaps the waveform itself, the communications protocol and even the networking; i.e. the paths of the communications. Clearly, before any changes can be made to the system parameters of a Cognitive Radio, information must be exchanged about the environment of the networks it accesses and also other Cognitive Radios.

It is clear that a Cognitive Radio must also monitor its own performance continuously as a part of the determination of the RF environment, channel conditions, link performance etc. before any adjustment is made to the radio's settings.

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Change from Analogue to Digital TV results in

less spectrum being required for the transmissions.

The ‘free’ spaces resulting are called ‘TV White Spaces’.

The FCC in the US and Ofcom in the UK are now allowing the use of these white spaces for Cognitive Radio development. Singapore is also conducting trials & Microsoft are rumoured to be conducting trials for the use of these ‘White spaces’ for rural broadband in Africa

Devices that can operate in these ‘White Spaces’ are referred to as ‘White Space Devices’ (WSDs).

Need some form of spectrum sensing (i.e. ability to check that nobody else is using the same frequencies etc.) ?

Very difficult !! More sophisticated techniques required.

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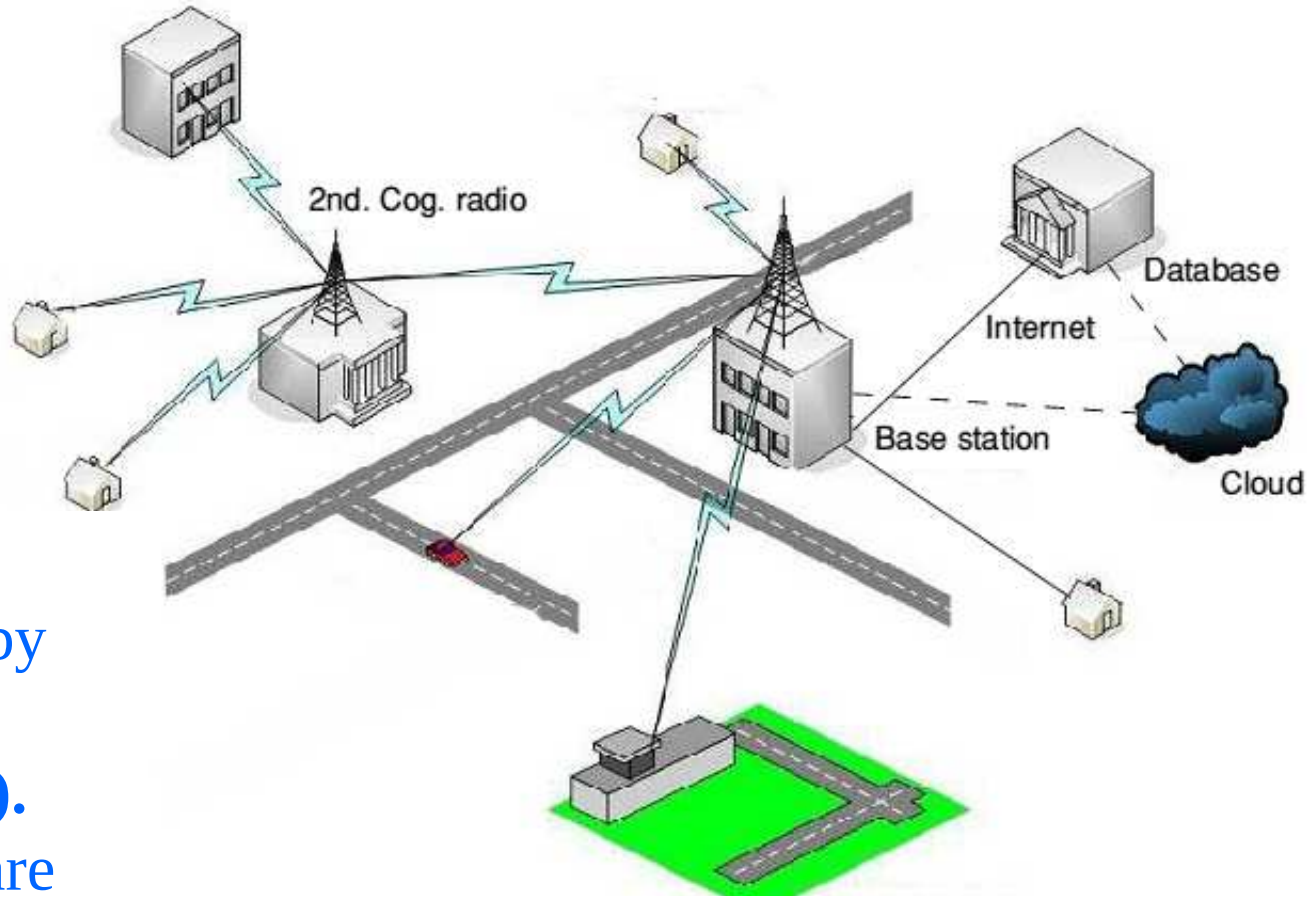
A much more secure system



New standards and protocols developed by **Weightless Special Interest Group (SIG).**

Companies involved are accenture, ARM, Cable & Wireless, CSR & neul.

Bandwidths are based on those of the TV channels; i.e. 6, 7 or 8 MHz, dependent on the continent and there is provision for 100 kHz sub-bands and for using two adjacent channels for a larger bandwidth, but with reduced output power.

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The Regulatory status for using ‘White Space’ spectrum is still being discussed and defined.

Work is being undertaken by CEPT and at the ITU by WP1B, and no doubt in the U.S. and other countries.

There are ECC reports:- Nos.159, 185 & 186

ETSI has produced a European Harmonisation Standard for TV WSDs
http://www.etsi.org/deliver/etsi_en/301500_301599/301598/01.00.09_30/en_301598v010009v.pdf

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In the U.K., Ofcom approach is to classify WSDs as licence-exempt, although many think that they will have more control than they do over licensed stations

Considering White Space outside the TV UHF bands, there are several considerations to be taken into account.
e.g. Ranges of transmissions at higher and lower frequencies.
There may not be any gaps in bands.

Useful reading ?
The CEO of Weightless has written a book on dynamic white-space spectrum access, that can be downloaded for free from http://www.webbsearch.co.uk/?page_id=24

Presentation slides from ITU Working Party 1B workshop available from ITU.

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Thank you

&

A Thank You to Rob Millenaar of ASTRON in the Netherlands for presenting this lecture for me.