SOFTWARE DEFINED RADIO

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INTRODUCTION TO SOFTWARE RADIO CONCEPTS

Need for Software Radios

With the emergence of new standards and protocols, wireless communication is developing at a furious pace. The challenge in creating sophisticated wireless internet connectivity is compounded by the desire for future-proof radio, which keep radio hardware and software from becoming obsolete as new standards, techniques, and technology become available.

The concept of Integrated seamless global coverage requires that the radio support 2 distinct features.

1. Global roaming (or) seamless coverage across geographical regions.
   * Multimode phones that can switch between different cellular standards like IS-95 and GSM.

2. Interfacing with different systems and standards to provide seamless services at a fixed location.

* ability to interface with other services like Bluetooth (or) IEEE 802.11 networks.

➔ The rate of technology innovation is accelerating and predicting technological change and its ramifications to business is especially problematic.

➔ As a result, to keep their systems up to date, wireless systems manufacturers and service providers must respond to change as they occur by upgrading systems to incorporate the latest innovations (or) to fix bugs as they are discovered.

➔ Existing technologies for voice, video and data use different packet structures, data types, and signal processing techniques.

Integrated services can be obtained with either a single device capable of delievering various services (or) with a radio that can communicate with devices providing complementary services.

* The supporting technologies and networks that the radio might have to use can vary with the physical location of the user.

* To successfully communicate with different systems, the radio has to communicate and decode the signals of devices using different air - interfaces.

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* To manage changes in networking protocols, services and environments, mobile devices seamlessly support multiple protocols such as IP.

* Such radios can be implemented efficiently using software radio in which architectures in which the radio reconfigures itself based on the system it will be interfacing with and the functionalities it will be supporting.

* 2G wireless technology consists of a handful of incompatible standards, and the goal behind the development of 3G standards is compatibility among these standards within and between different generations' standards.

* Even if cellular standards globally coverage, 3G systems require multimode operation and automatic mode selection.

* with the 4G and possibly 3G systems, the user's application will likely have the ability to control the quality of service and obtain a higher QOS for a higher cost.

What is Software Radio?

* The term software radio was coined by Joe Mitola in 1991 to refer to the class of reprogrammable or reconfigurable radios.

* The SDR Forum defines the ultimate Software radio (USR) as a radio that accepts fully programmable traffic and control information and supports a broad range of frequencies, air interfaces, and applications software.

* The user can switch from one air-interface format to another in milliseconds, use the Global positioning (GPS) for location, store money using smartcard technology, or watch a local broadcast station (or) receive a satellite transmission.

* A radio that defines in software its modulation, error correction, and encryption processes, exhibits some control over the RF hardware, and can be reprogrammed is clearly a software radio.

* A good working definition of a software radio is" a radio that is substantially defined in qsoftware and whose physical layer behavior can be significantly altered through changes to its Software"

* A soft radio denotes a completely configurable radio that can be programmed in software to reconfigure the physical hardware.

Characteristics of a Software Radio

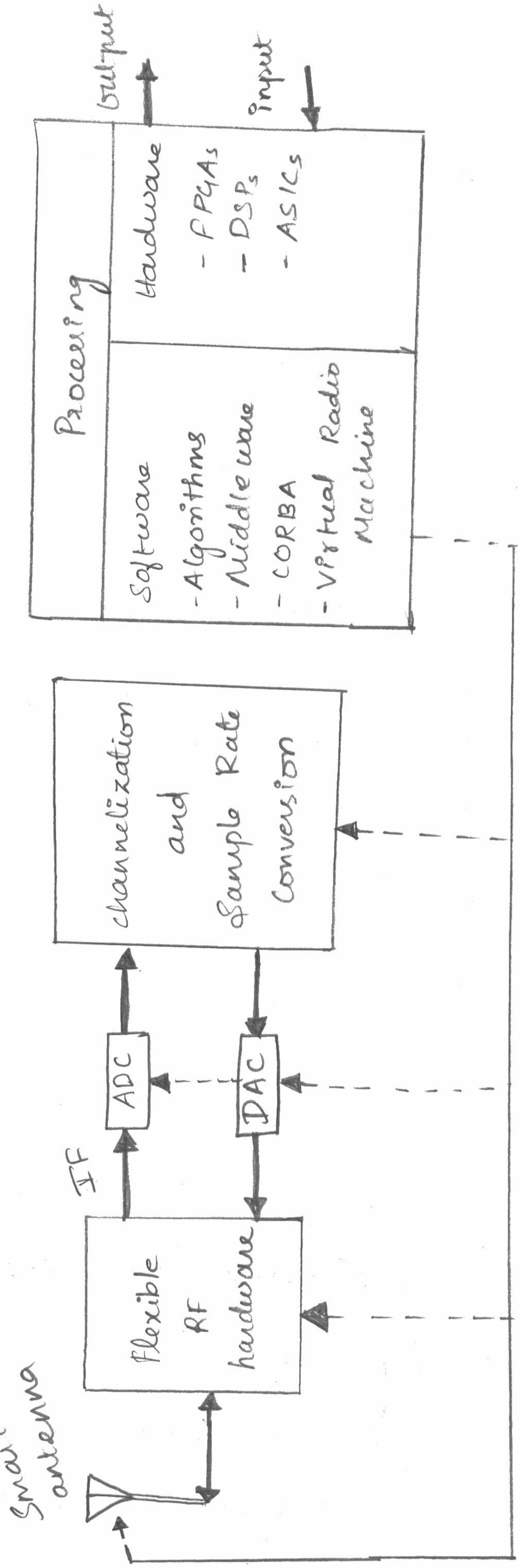

fig: Model of Software radio

* The receiver begins with a smart antenna that provides a gain versus direction characteristic to minimize interference, multipath and noise.

* The smart antenna provides similar benefits for the transmitter.

* The transmitter uses digital to analog converter while the receiver uses analog to digital converter.

* The received signal is digitized in the intermediate frequency band (IF) and a super heterodyne receiver is employed in which the RF signal is picked up by the antenna along with other spurious / unwanted signals, filtered, amplified with a low noise Amplifier (LNA) and mixed with local oscillator (LO) to an IF.

* Processing is performed in software using DSPs, field programmable gate arrays (or) ASICs.

* The algorithm used to modulate and demodulate as middleware eg. CORBA.

* Channelization and sample rate conversion are often needed to interface the output of the ADC to the processing hardware to implement the receiver.

following five factors are expected to push wider acceptance of Software radio.

Benefits of Software Radio.

1. Multifunctionality :-

* With the development of short range networks like Bluetooth and IEEE 802.11 it is now possible to enhance the services of a radio by leveraging other devices that provide complementary services.

* Example: Bluetooth enabled fax machine.

It can able to send a fax to a nearby laptop computer equipped with a Software radio that supports the Bluetooth interface.

2. Global Mobility :-

* A number of communications standard exist today. In 2G alone there are IS-136, GSM, IS-95/CDMA1 etc & in 3G many standards lies under it.

* The need for transparency (ie) the ability of radios to operate with all of these standards in different geographical regions of the world ~~foster~~ fostered the growth of Software radio concept. Eg: Military services also face a similar issue with incompatible radio standards.

3. Compactness and power efficiency -

Software radio results in compact and in some cases, a power-efficient design, especially as the number of systems increases since the same piece of hardware is used to implement multiple systems and interfaces.

Multifunction, multimode radios designed using "velcro" approach increases number of systems.

4. Ease of Manufacture :-

RF components hard to standardize & have varying performance characteristics.

Optimatization of the components may take few years and thereby delay product introduction. Digitization of the signal early in receiver chain can result in design that incorporates significantly fewer parts, meaning a reduced inventory for the manufacturer.

5. Ease of Upgrades :-

In the course of deployment, current services may need to be updated (or) new services may have to be introduced. A flexible architecture allows for improvements and additional functionality without expense of recalling all the units (or)

Design principles of Software Radio

A higher skill level is needed for almost all aspects of the radio design because of the dependency of the radio subsystems.

A generic design procedure to design software radio, as follows.

Step 1: System Engineering:

* Understanding the ~~cu~~ constraints and requirements of the communication link and the network protocol allows the allocation of sufficient resources to establish the service given the system's constraints and requirements.

* Constraints are : Range, transmit power, modulation type, Data rate.

* In ideal Software radio with the ability to change the number of system parameter in real-time, optimizing an active communicati is major challenge.

Step 2: RF chain planning:

The ideal RF chain for the software radio should incorparate flexibility in Selection of power gain, bandwidth, center frequency, sensitivity & dynamic range.

* Acheiving strict flexibility is impratical and trade-offs must be made.

* With software radio design, it is possible to compensate for some of the inadequatecies of the RF components in digital domain. and comepensation of power amplifier distortion (or) power management & the RF circuitary can be accomplished in Digital domain.

Step 3: ADC and DAC conversion selection.

* The AD conversion and DA conversion for the ideal software radio is difficult to achieve.

* The selection requires trading power consumption, dynamic range and bandwidth

* AD conversion and DA conversion selection is closely tied to the RF requirement for dynamic range, frequency translation and channelization requirement.

* Multirate digital signal processing can be used to improve the flexibility of digitization.

Step 4: Software Architecture Selection.

* The architecture should allow for hardware independence through the appropriate use of middleware.

* The software needs to be aware of the capabilities of the hardware (both DSP and RF hardware) at both ends of the communications link to ensure compatibility and to maximum use of the hardware resources.

* The software radio will operate in an existing data infrastructure, it must interface quickly and efficiently with this infrastructure

* Software radio needs to control issues such as attribute naming, error management, and addressing, regardless of the protocol used and must consider latency & timing for whole protocol stack.

Step 5: Digital Signal Processing H/W architecture selection.

* The core digital signal processing hardware can be implemented through microprocessors, FPGAs and/or ASICs.

* The selection of the core computing elements depends on the algorithms and their computational and throughput requirements.

Step 6: Digital signal processing H/W architecture selection.

* It is essential to ensure not only that the communicating units operate correctly, but also that a glitch does not cause system-level failures.

* Interference caused by software radio mobile unit to adjacent bands is an example of how a software radio could cause a system level failure.

* Structuring the software to link various modules with their limitations and deficiencies can help in testing compatibility of software modules.