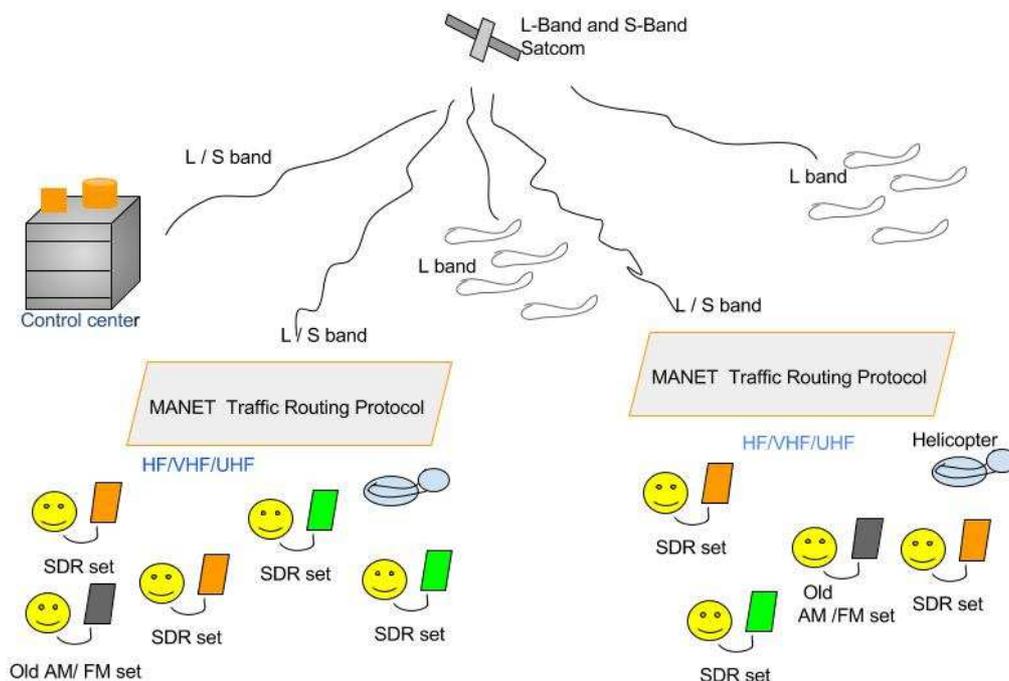


Case Study on SDR: Software Defined Radio



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SDR market in India is emerging from Navy, Army and Airforce. Worldwide market for SDR is growing fast and it is expected to be 27.3 B USD by 2020. India is having one sixth of global market share. One of my earlier venture (Epigon Media Technologies Pvt Ltd) had invested along with National instruments and BEL in SDR enabled wireless Radio Link and same was demonstrated to Indian Navy during 2009/09/16. Looking forward to use **Make in India** and address local market need.



Press release

Present central government on SDR with German government

'Indian and German companies signed five agreements on smart mobile urban solutions, Software Defined Radios, development of solar projects, skills development in electrical semiconductors and collaboration in machine tools on Tuesday.' <http://www.mediaeye.in/more-details.php?id=1238>

BEL developing software-defined communication radios.

http://www.business-standard.com/article/companies/bel-developing-software-defined-communication-radios-110111800015_1.html

Software Defined Radios Penetration will Increase in Defense, Commercial, and Homeland Security Segments

<http://www.marketsandmarkets.com/ResearchInsight/software-defined-radios-market.asp>

Market Leaders (Worldwide)

Some of the key vendors in software defined radio market are BAE Systems PLC, Elbit Systems Ltd., L3 Communications Corporation, Raytheon Co., Thales Group, Viasat Incorporated, SAAB AB, Rockwell Collins, Northrop Grumman Corp., ITT Corporation, Harris Corporation and Datasoft Corporation, among others. <http://www.futuremarketinsights.com/reports/software-defined-radio-market>

SDR Manufacturing For India Market

- **Market Segment:** Indian Navy, Army and Airforce, Metro Rail Transport service companies and upcoming ever green Smart cities of India
- **Objective:** Use Make in India and create SDR for India requirements
- **Total Market in India:** 4.8 B USD (in another 2 to 3 year time)
- **Addressable market:** 800 M USD market (Indian Navy and Army)

Need to create SDR in India

Attack (26/11) in Mumbai via sea route had created big jerk in Navy and WESEE (part of Navy) had called for immediate and urgent meeting in 29/11 and requested us to invest and innovate in development of Wireless link for Indian Navy such that “boat and ship can have communication by using 128 kbps wireless data link”.

Early Efforts in SDR in India

Epigon Media Technologies had proven itself during that point of time frame (2008) in Digital Signal processor (DSP) enabled Satellite radio Receiver product for WorldSpace Inc. Epigon had innovated along with National Instruments and created 760 kbps wireless link and the same is demonstrated to Indian Navy in Mumbai. BEL had worked as front end company deploy SDR in India for Navy. Following picture is from Pilot demo of our Wireless link in Indian Navy Mumbai.

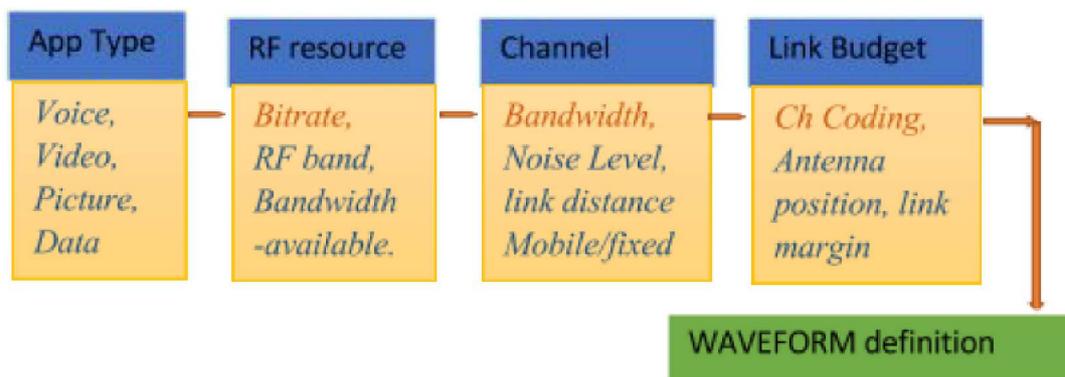


1) Standards and Protocols Software

1.1 Communication waveforms: Development Tools

Modern software tools in communication software industry provides infrastructure to build communication link for pre-defined waveform. In fact, waveform is defined by expert committee and given specification for waveform such that implementation team can pick up tools for the same. Most of the time, tools companies also works along with standards committee (GSM, 3G, 4G etc) and bring out tool that can fit exactly for given specification in terms of bandwidth, RF band, bitrate etc. Thus, design engineers not have many option in selecting software tools and associated library for design and testing. However, in tactical communication is not same as given in the above and it demands new set of environment for design and development. For example tools like ADS, MATLAB, SCILAB, LABVIEW etc provides easy interface with user to design and development of “waveform of their choice”. But

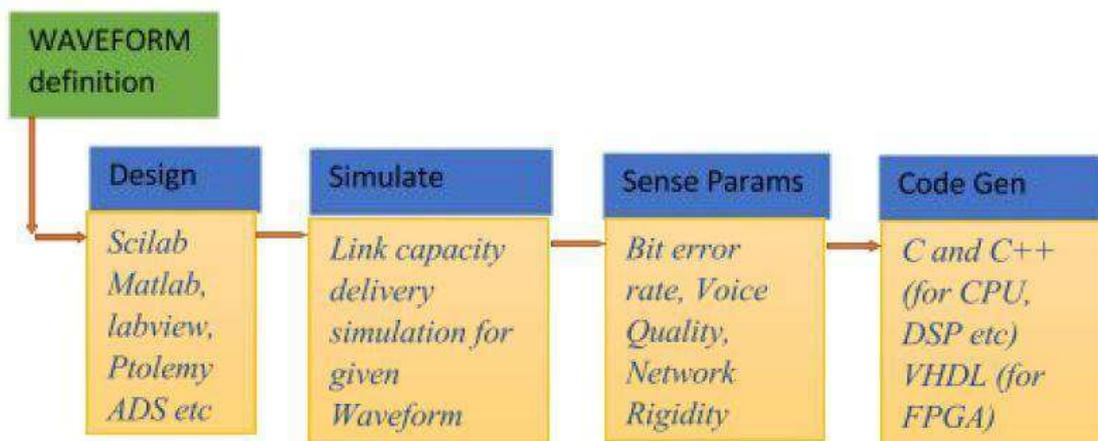
realization of such a waveform on given (or specified) h/w target will be an issue. User need to go for target specific tools such that realization of waveform is easy. For example, if modem link is Narrow bandwidth 64 kbps in 90 KHz bandwidth, then Blackfin DSP (BF5xx) and TI55xx (from TI) are target hardware. Mentioned DSP's requires software environments such as VisualSP, Code Composer Studio etc. Suppose communication link is broadband then Xilinx Virtex-7 FPGA or any other FPGA will be h/w platform. These h/w requires tools like modelsim etc. Thus use of tools for implementation and realization become h/w platform centric. These tools mostly stand alone and they are not web-enabled as of now and thus, it will be tough to put in use via remote to get the waveform implementation. On testing side of waveform requires tools from software and also from hardware. For example, to test modem implementation on Blackfin DSP requires JTAG ICE (or USB ICE) to debug and test run time condition of modem. Same case is with other DSPs and FPGAs. Plan is to provide integrated environment for Waveform developer by using very innovative process capture user requirements.



Above figure provides information on functional flow of parameters that are critical to generate Waveform configuration (on definition). Integrated environment provided to user to arrive Waveform definition from user dashboard. Mentioned tool will work on lightweight devices such as Tablet PC and also in Laptop or higher versions of machine. Voice interface is provided to user to give input to the above functional flow in any sequence. There will be default parameter will be used, if user did not provide all above mentioned parameters. Another parameter will be given by user or tool to calculate optimal link margin. But parameter like Antenna plays major role by placing antenna in good place by user. Thus, Antenna position parameter will be critical and also Antenna size (along with polarity). Noise level parameter is something user need to define such that waveform can be generated for given noise condition. Noise condition might require lot more time to arrive by domain specific and knowledge on physical condition of planned communication link. RF band and bandwidth are two important parameters, that need to be owned by user. Application definition provides real important parameter for a waveform generation. .

1.2 Design and Development of waveforms

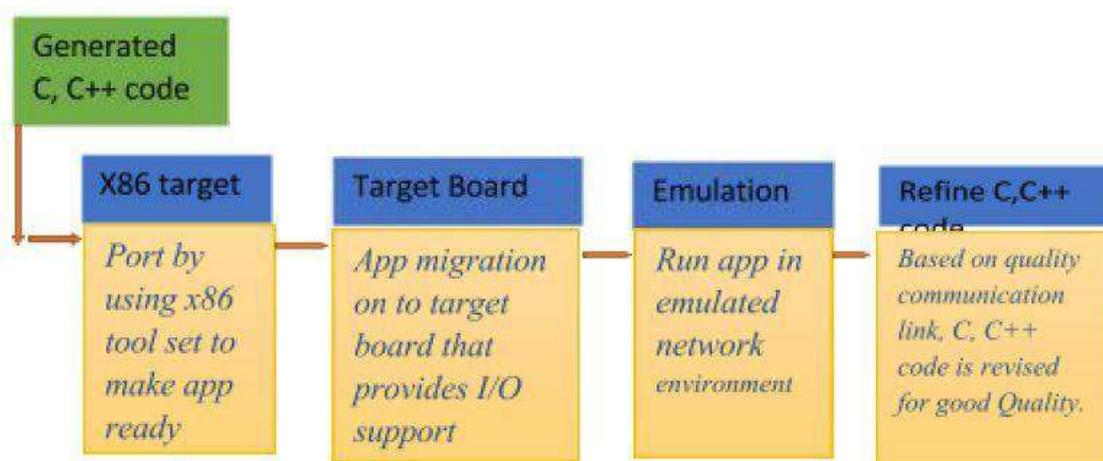
Waveform configuration will be used to design a waveform. In the following design flow is given.



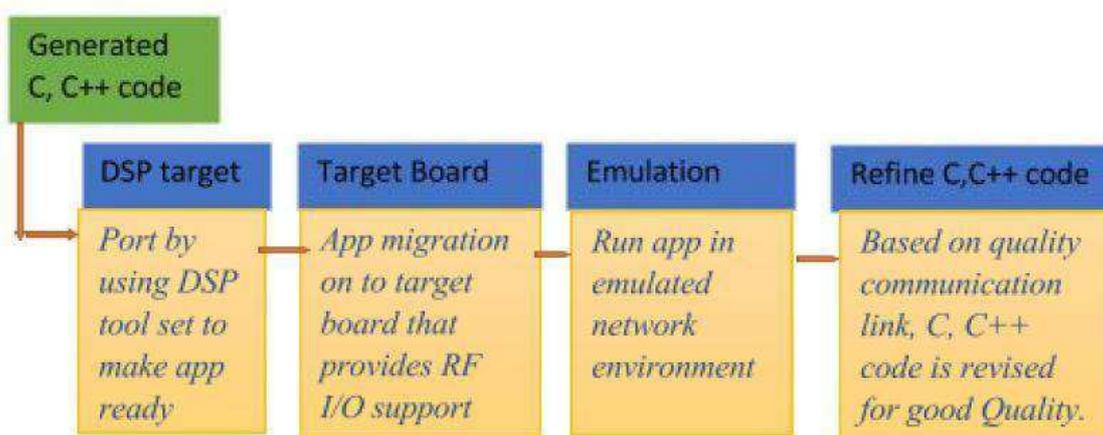
Design of Waveform is using configuration given by user and generates code in any one of platforms such as Scilab, Matlab, Labview and Ptolemy etc. During design, automated software will take care of constraints in terms of Noise in channel and Antenna position etc. Thus, there is need to involve human resource in design stage of waveform. Complete simulation of link capacity delivery in a given network configuration is very important. This mentioned simulation is done extensively by using exhaustive input test vector for simulation. This interface to existing instruments will enable us to be cost effective in testing infrastructure else cost of testing will be very high by going with closed door policy on simulation environment. Thus, simulation environment will have interface with “Matlab, Scilab, Labview, Ptolemy, ADS etc and also interface with 3rd party signal generation unit and other vendors unit as well. Parameter sensing is very important. Apart from routine engineering parameters measuring, there is a need to measure Network Rigidity (this provides service level confidence). After satisfactory level on Quality of given design then C code generation will be done. In Code generation, C and C++ code generated to support CPU and DSP processors. VHDL code is generated to support Xilinx and Altera FPGA target devices.

1.3 Customization of waveforms

Generated code for given design is ported on to particular platform. Most of the time, porting of given code will invites good amount of work because nature of custom built boards and associated target devices.

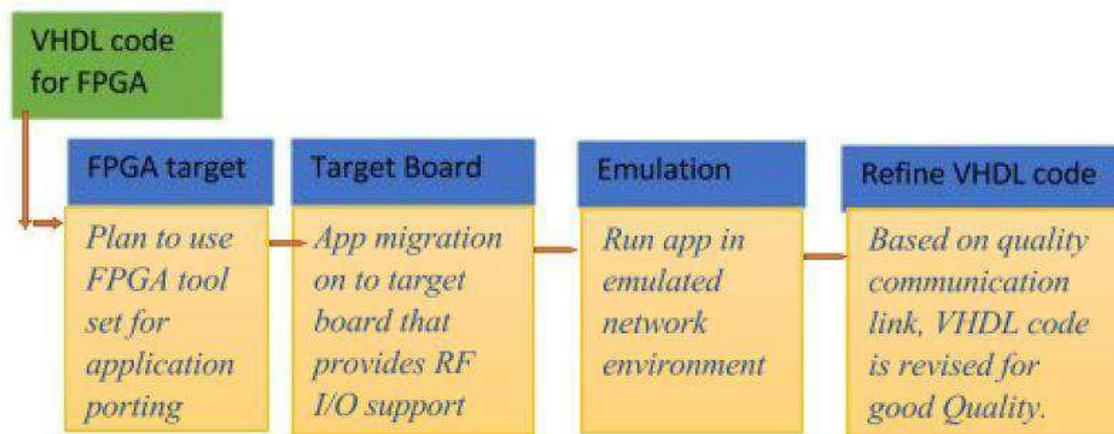


In the above customization of C and C++ code for X86 platform is given. There is need to bring DSP based devices to complement strength of X86 platform such that full app can provide expected quality performance.



In the above customization of C and C++ code for DSP platform is given. DSP is having vendor specific tools to work with associated DSP's. Porting C, C++ code on DSP processor is done by using respective tool set (VisualDSP for Blackfin DSP, Code composer studio for TI DSP, Codewarrior for Starcore DSP.). After that, by giving defined inputs (RF or IF) to DSP board emulation will be carried out. Output of emulation will provide opportunity to refine C, C++ code to give better communication link. It has been observed that, present state of art of DSP's are expected (apart from B4860 from Freescale) to work well for Narrow Band communication link.

For high bandwidth, it appears that there is need to go for FPGA based target device. In the following (next page) customization of VHDL code for FPGA platform is given. As mentioned in earlier part of document, every FPGA is having vendor specific tools to work with associated FPGA's. Porting VHDL code on FPGA device is done by using respective tool set (ISE for Xilinx Virtex 7 (Zynq tm 7000), Quartus II Modelsim for Altera Stratix V) and migrate application onto given target board. After that, by giving defined inputs (RF or IF) to FPGA board emulation will be carried out. Output of emulation will provide opportunity to refine VHDL code to give better communication link.



It has been observed that, present generation FPGA's supporting 128 mbps link by using OFDM. Thus, most of the requirement emerged out of user application can be met with by using FPGA based target board.

1.4 Ownership of waveforms

Ownership is with Designers or respective user involved in design of waveform.

1.5 Collaboration in Waveform Design

Tactical communication demands communication link and associated parameters to be secretive in all sense. Thus there is no option of Collaboration during waveform design and development. However, collaboration can be thought for consumer communication devices.

1.6 Collaboration in Waveform Design

1.6.1 SDR Standards

Whether the existing standards are being used/ modified and the interoperability with Indian/ International/ open standards. ?

Discussion: Server centric communication will be using TCP/IP for command and control applications. In the case of media streaming (video call or voice call), RTCP /UDP will be used such that real time requirement. These standards are used in internet based applications. Tactical communication also need to be part of internet but it should be in secured from end to end. These above mentioned standards are international and there is nothing user Specific. May be security and definition of encryption and decryption need to be taken care by User side. This part will be discussed with user and will be followed as by instruction of User.

1.6.2 IPs in SDR

IPR issues.

Discussion: TCP/IP related IPR need to handle as other international IPR procedure. In the case of encryption and decryption, user can protect their version if they disclose it else it can be secretive and not known to others.

1.6.3 SDR Solution

How the solution offered would enable efficient utilization and facilitate interoperability.

Discussion: Tactical communication includes server side and also in client side. But during communication, client side devices need to be part of network such that it can communicate with other user who is in part of network. IP centric network (at all instant) provides interoperability to interact with each other or use with it. For example, handset join part of network and start communicate others who are already part of network. In this case, handset and its make and versions will be an real issue for basic part of communication and data exchange. Suppose call is based on video call if other set do

not have rendering capacity then there will be an issue. Thus, planned solution will resolve all these operational issues by going with properly planned transcoder in server side and this will be aware of “how to serve a given client at given point of time”. Mostly, intelligence is incorporated in server about each client by using client registration with server.

1.6.4 SDR Compatibility

Compatibility issues.

Discussion: IP centric central backend does transcoding to solve compatibility issues because of old equipment. This means there is a need to have server backend which can interact with old equipment’s and then integrate old equipment also part of network. This looks very simple but this will be most complex item because it has to carry all kind of modulation and demodulation techniques that are used in old equipment’s. In this will be real use of software defined radio by having all possible models in software in server side and interact with given client at a time.

1.6.5 SDR Upgrade

Future upgrades.

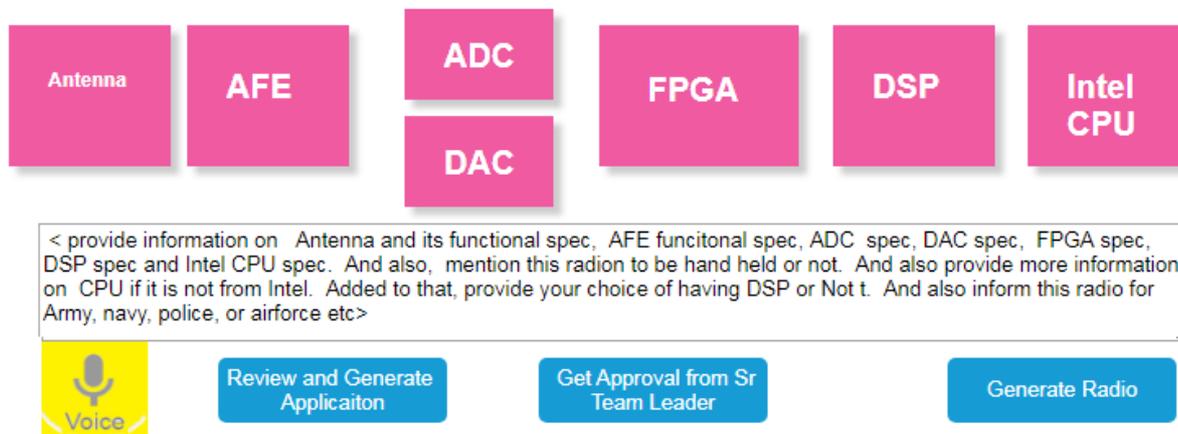
Discussion: Upgrade will from Tools side by respective vendors (DSP software tools, FPGA software tools, CPU software tools) with their own versions. But this might be real issue and thus for 5 years or more there will be single window upgrade for device centric tools such as VisualDSP, codewarrior, CCS etc. And on host side, tools like Scilab, Matlab, and LabVIEW are coming up with their own upgrade and thus there is a need to have single window for host tool upgrade as well. Apart from 3rd party vendor tools, local design environment upgrade will be communicated with User and business team will coordinate the same with User.

1.6.6 SDR Unique features

Unique features (in any).

Discussion: Data handling in terms of packets is central to software defined radio. In fact, this will be in line with packet switched communication instead of circuit switched communication.

Generate Radio Software For Target Hardware



1.7 Military Symbology

1.7.1 SDR and Old Radio Standards

Whether the existing standards are being used/ modified.

Discussion: Representation of events or objects with Symbol code is linked with domain of knowledge. But issue is, how to map with existing symbols in communication segment of military. SCA 2.2.2 provides framework on communication but not providing particular symbol or any other associated item to represent it. Thus there is a need to discuss with User on this and create table that can be guideline for User interface designers

1.7.2 Tactical Graphics

Methodology to address point symbols and tactical graphics.

Discussion: This part again in the same line as discussed in SDR and Old Radio Standards. There is a need to work or collaborate with User and create User Interface such that tactical communication representation is taken care and also user can feel home with same old representation of symbols and associated decisions.

1.7.3 SDR Methodology

Methodology to assign attributes.

Discussion: This part also in the similar lines as discussed in SDR and Old Radio Standards

1.7.4 SDR Symbol

Symbol encoding

Discussion: This part also in the similar lines as discussed in SDR and Old Radio Standards

1.7.5 SDR Unique features

Unique features (if any).

Discussion: Will be discussed on server centric User Interface and also Client centric user interface are two main items that need to be taken care.

2) LabVIEW vs SCA 2.2.2 in SDR

2.1 Software Communication Architecture (SCA)

In SCA, member variables of modem is not exposed to the outside world. Thus, there is a need for Broker component. (Broker is LabVIEW platform)

2.1.1 Uses Attributes

Where attributes have implicit set and query operations. (Possible in LabVIEW)

2.1.2 Uses Operations

To serve request from application (LabVIEW VI provides operation)

2.1.3 Hardware Configuration

SCA does not specify a hardware configuration (LabVIEW provides front end for all h/w.)

2.2 Resource Interface

- TestableObject (VI is testable object in LabVIEW)
- PortSupplier (LabVIEW takes care of Port supply)
- LifeCycle (VI version control is in place)
- PropertySet (VI is having clear definition of VI property)

2.3 Radio's transmitter

- Alter frequency range (possible in LabVIEW)
- Modulation type (possible in LabVIEW)
- Maximum radiated or conducted output power

2.4 Component Placement

CORBA middleware allows software components to be distributed anywhere within the radio. The Core Framework provides distributed object launchers for each processor board within the set. // LabVIEW allows VI to be there on multiple target. For example, FPGA, HOST etc //

Radio application factory launches a waveform or application by providing the object files and execution parameters to the various processors within the radio. //User can load Waveform in form of VI that can work with in Radio//

2.5 Dynamic Software Configuration

CORBA middleware allows the two objects to pass data or send control information. CORBA provides distributed processing the two software components in the diagram can actually reside in different processors within the radio. // LabVIEW allows VI to be there on multiple target. For example, FPGA, HOST etc//

3) Pilot in Mumbai Navy

Software defined radio (SDR) is one of the modern tool that can be very useful to interact with old equipment based communication and also emerging future communication equipment's.



In this line, SCA 2.2.2 provides guideline for communication network but is not giving guideline for particular device or communication waveform. Thus, it is part of implantation strategy that need to work out good things in version of SDR which is good for customer who will be using this system in tactical communication side.

Essentially, SCA 2.2.2 provide scope to

- "Load waveform of user",
- "test user waveform",
- "manage user waveform",
- "use waveform for communication",
- "unload user waveform"

but these mentioned items form a core of SDR. To implement the above functions, implementation team on choice of tool such that it need not be constrained by particular tool set vendor. For example, it is not must that one has to use CRC (from Canada). In the past, above functionalities have been implemented by (Epigon media Technologies Pvt Ltd) using Labview and in FPGA platform (Xilinx virtex V) along with Intel Host processor. In fact cost advantage is very huge by going with modern and consumer centric tools for SDR platform design and development. For example, CORBA centric object communication is one of the old technique and in fact much better option available in Labview in-terms making Virtual Instruments (VIs). Thus team in Epigon had very interesting experience in this field by using modern tool chain to design and develop SDR in a given short period of time. Mentioned experience was part of providing demonstration to WESEE and BEL Bangalore. Mentioned demonstration was in real time that achieved 760 kbps for 18 nautical miles (2 way communication). This was in 2009 Sep.



However, it is important to take some of the proven modules from USA or from Europe and customize it for tfor local need. For example, ICs and associated tools need to come from USA or from Europe. Implementation and waveform design tools will be from India and this is critical for high rigidity communication.

About the author Dr. S. Jayakumar:

Algorithm design and development for Digital Signal Processing have been a core strength of Jayakumar for 20 plus years. More in particular Digital audio and Digital Radio are tjose two major segment. Jayakumar is part of founding team in Rinanu Semiconductor,. Epigon Media Technologies, PiiTech Systems, GPTL etc. He had worked in HAL (Helicopter Design Bureau), Cranes Infotech, Mistral Solutions and Essel Utilities etc, His dream project was design and development of Karaoke Machine (which was project from Analog Devices and MIT Media lab) for TAITO Corp. He also worked on Satellite Radio Receiver for WorldSpace broadcast Satellites (and DAB Radio Receivers), which was fully software driven solution at that time using low cost Digital Signal Processors. He had lead team to design and develop 768 kbps Wireless data link for Indian Navy. His PhD thesis was in “simultaneous stabilization of Feedback systems and Masters Project in “Robust Pole placement for Flight Control system”. Both M.Tech and PhD are from IIT Mumbai systems and control engineering department. His under graduation from Madras Institue for Technology Aeronautical Engineering department and Mathematics in Madras University. Jayakumar is invited Member of “IEEE India Standards SIG (Special Interest group)”

Canada-based researchers have developed an Augmented Reality system that projects patients' internal anatomy directly on the body, doing away with the need to make incisions. Called ProjectDR, the technology uses infrared cameras and body markers that project images while tracking body movement. Further, doctors can choose to see only the lungs or blood vessels, depending on the case.

Air New Zealand has developed a program that analyses users' facial reactions to different sites and attractions in Queensland, Australia. After analysing facial cues, the service creates an itinerary of recommended locations in New Zealand. Once the video ends, users can see which activities made their face change the most and receive recommendations on how to book a trip.

Billionaire investor George Soros has said governments would soon start regulating Facebook and Google as they control over half of all internet advertising revenue. Speaking at the World Economic Forum, the 87-year-old said, "Davos is a good place to announce that their days are numbered". He also predicted the tech giants would "compromise themselves" to access markets like China.

Global spending on robotics and drones is expected to grow 22.1% year-on-year to reach \$103 billion in 2018, according to a report by International Data Corporation (IDC). The report also said the spending will more than double to \$218.4 billion by 2021. Robotics spending will account for over 90% of all spending between 2017 and 2021, report added.

American automaker Ford has filed for a patent for a self-driving police car. The patent describes the artificial intelligence-driven vehicle would be able to detect traffic violations by another vehicle, either on its own or with the help of surveillance cameras. It also describes a method by which officers within the car could manually take control or use it wirelessly.

According to a report by The New York Times, actors, politicians, and television presenters were among those who bought millions of fake social media followers. The report said the accounts were bought from a company called Devumi which claims to increase a user's "social media presence". In a statement, Twitter said it is working to stop Devumi and similar companies.

Google is testing a tool called Bulletin that would allow anyone to publish information about local interests like bookstore readings, sporting events, or street closures. The company described Bulletin as a lightweight app for capturing photos and videoclips from the phone and publishing them without having to create a blog. The service is currently being piloted in select US cities.

Talking about artificial intelligence (AI) at a recent event, Alibaba's Founder Jack Ma said, "The AI, Big Data is a threat to human beings." He also said that AI will kill a lot of jobs as they will be done by machines in the future. He added that technology should always do something that enables, not disables people.

According to Accenture, investments by companies in artificial intelligence (AI) and human-machine collaboration can raise global employment by 10% by 2022.