Software Radio Applications

S-72.333 Postgraduate Seminar on Radio Communications

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WHAT IS A SOFTWARE RADIO

WHAT A TERM "SOFTWARE RADIO" MEANS:

A software radio is a radio whose channel modulation waveforms are defined in software.

- That means, that waveforms are generated as sampled digital signals, converted from Digital to analog via a wideband DAC (Digital to Analog Converter) and then if needed upconverted from IF to RF.

-The receiver side, similarly, employs a wideband ADC (Analog to Digital Converter) that captures all of the channels of the software radio node. The receiver extracts, downconverts and demodulates the channel waveform using software on a general purpose processor.

- Software radios employ a combination of techniques that include:
* multi-band antennas
* RF conversions
* wideband ADC and DAC (used fixed network radio links over 15 years)
* the implementation of IF (radio links uses same IF- and baseband-units to the whole fam.)
* baseband and bitstream processing functions

Basic idea is to get the software as close to the antenna as is feasible. This means that we are turning hardware problems into software problems.

WHO POSSIBLE NEEDS SOFTWARE RADIOS

The Military has been the historical developer of this technology.
There are also some commercial telephone service provides who have began to express interest in its longer term economic benefits trying to find cheaper solutions via this technology.

If we believe that future radio services should be provide seamless access across mobile cellular systems, W-LAN, Wimax, PCS (Personal Communications Systems) and satellite mobile modes of communications, including integrated data and voice, solutions would be software based system?

But there are many questions and problems to which must be find the solutions.

THE FREQUENCY BANDS

Currently, the frequency bands used by television, voice radios, mobile phone networks, W-LAN networks and radio link systems are heavily regulated. Even if we look only the national level networks. There are lot of different type of solutions and many operators (e.g. mobile phone operators) are working in the same area.

Every operator have the their own mobile network (GSM, GPRS, UMTS, may be TETRA and so on) and also radio link networks connecting the base stations together the forming working networks, are operators own.

This means that there is finite space for different stations and / or also they will interfere with each other.

THIS IS ONE OF THE BIGGIST PROBLEM if we want to use the software radios in the our networks today.
Also the Military software radio solutions and use they must be based on the regulated frequencies today.

Big questions is that how to allocate (or reallocate) scarce radio frequency (RF) spectrum? What says ITU-R and regulators over the world?

THE FREQUENCY BANDS

It should be best solutions that every software radio users have their own frequencies on the every locations in the country what they can use freely. But this is not possible today.

If we think the mobile networks:
- mobile network operator uses there pico -, micro - and macro – cells depending on the area where the network are installed and working.
- is it possible that software radio basestations are possible to put every place where the operator needs base stations?
- e.g. different mobile networks are different specifications and that means that mobile networks are designed different way (cell sides, cell locations and so on). Different mobile networks are different capacity (broadband, narrowband), frequencies, transmitters output powers, sensitive values of receivers.

Also use of the multimode terminals are quite complex in the future. PC based systems give many possibilities. Uses can ask for more capacity from networks when they need (depending on services they are using), they may be want to change the frequency bands…and so on.

And what about MIMO – technology?

These are quite complex area to find good solutions.

INTERFACES TO THE OTHER NETWORKS

If we use the software radios in our networks e.g. as a basestation or networks components, we must remember the interfaces to the currently used networks.

In this situation there must be the gateways or matching to the:
- e.g. GSM, GPRS and UMTS basestation controllers
- data networks

And if we are using VoIP, we need also gateways to the PSTN networks (e.g. in Finland)
- MD 110 and ISDX
- DX 200, AXE and Siemens exchanges

These gateways depend on the software versions of the exchanges. And when software are updated, then these gateways should be updated also.

These functionalities are not included in the software radios base versions directly.
They are quite expensive and these components takes lot of space.
And the implementations are not so easy.

In the future in the software radio there will be the open interfaces. But there are not any international specifications yet ready.

INTERFACES TO THE OTHER NETWORKS

If we use the software radios in our networks e.g. as a basestation or other purposes in the future:

- specifications must be done or harmonize (IEEE, ITU-T, ETSI, IETF)
- frequencies must be allocate new way (ITU-R)
- make a decisions in what frequencies bands software radios will be working in the future
- security problems
- what and which way a person can do new allocations to his terminals

SOFTWARE RADIO NETWORK PROBLEMS

There are the same problems waiting for solutions than today used wireless networks:

- MAC-sub layer (there are lot of work to do before that layer is working well)
- handover procedure (delay)
- roaming between mobile networks and W-LAN-networks (delay)
- power control procedures (near-far problem)
- network security
- access procedures in the W-LAN networks

Special wireless networks:
- interferences (used frequencies)
- jamming problems (broadband, narrowband, pulsed)
- security problem
- users terminal movements (handover)

CAPEX AND OPEX

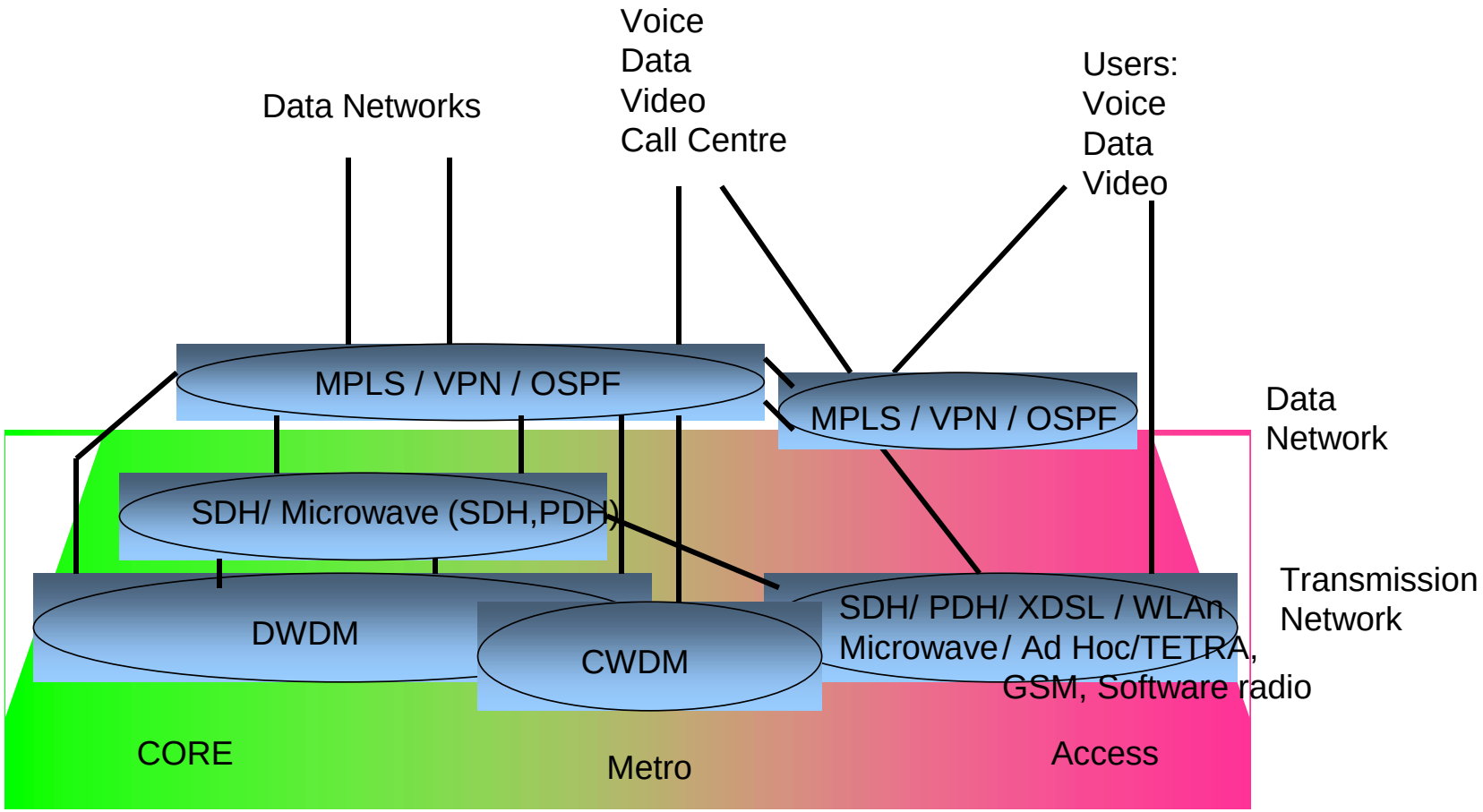
The networks operators are looking for quite carefully CAPEX and OPEX values, because they want to get good revenues from their networks and services.

They want the optimize their network investments and managements costs.
This means that they are not so interested in to invest new technologies if it`s not giving to them something …..
They are also looking for carefully their wireless networks value chains (network itself and services).

In the future there will be more and more different type of operators in the field-
- Network operators
- Service providers
- the communications stations owners
- Network owners
- Network managements
- Service managements

CAPEX = Capital Expenditure
OPEX = Operational Expenditure

COMMUNICATIONS NETWORK ARCHITECTURE



SOFTWARE RADIO APPLICATIONS

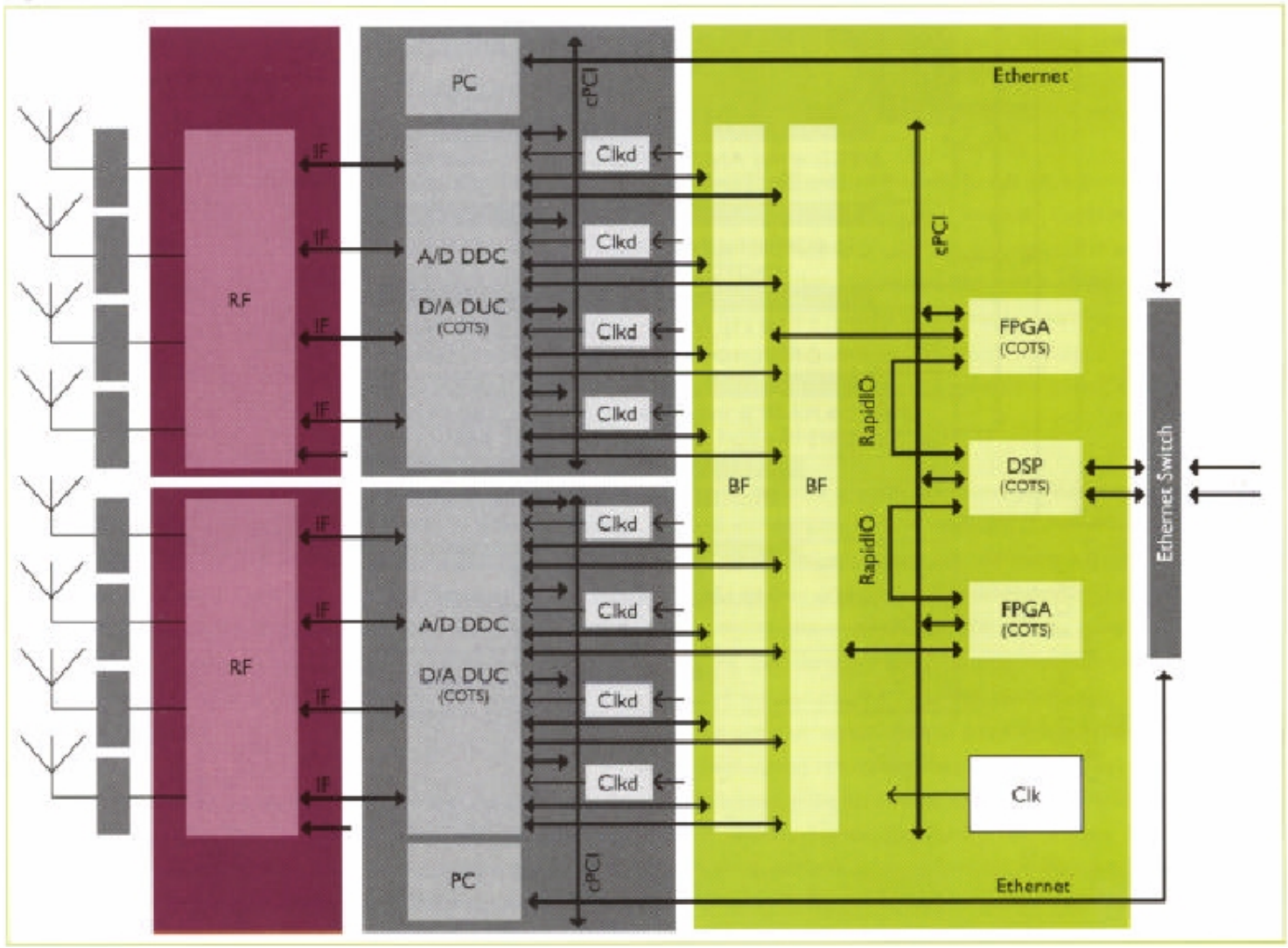
Application 1: COMMUNICATION SYSTEMS TO THE MILITARY TROPS

In Finland we have a software radio project.
This the Finnish Software Radio Programme (FSRP) was established to support requirements for:

- Mobility
- localization capabilities
- interoperability between national and international civil authorities
- interoperability within own armed services and foreign armed forces
- operations in hostile electromagnetic environment
- extensive use of commercial components and standards

Today that project is in the demonstration phase.
The demonstrator programme consist of
- software defined radio platform on witch
- adaptive AJ/LPI/LPD networking waveform for Tactical Radio Communication system (TRCS), (AJ = AntiJam, LPI = Low Probability of Interception, LPD = Low Probability of Detection)
- National Tactical Positioning System (NTPS)
- Adaptive Antenna System (AAS)

SOFTWARE RADIO APPLICATIONS



SDR demonstrator structure

SOFTWARE RADIO APPLICATIONS

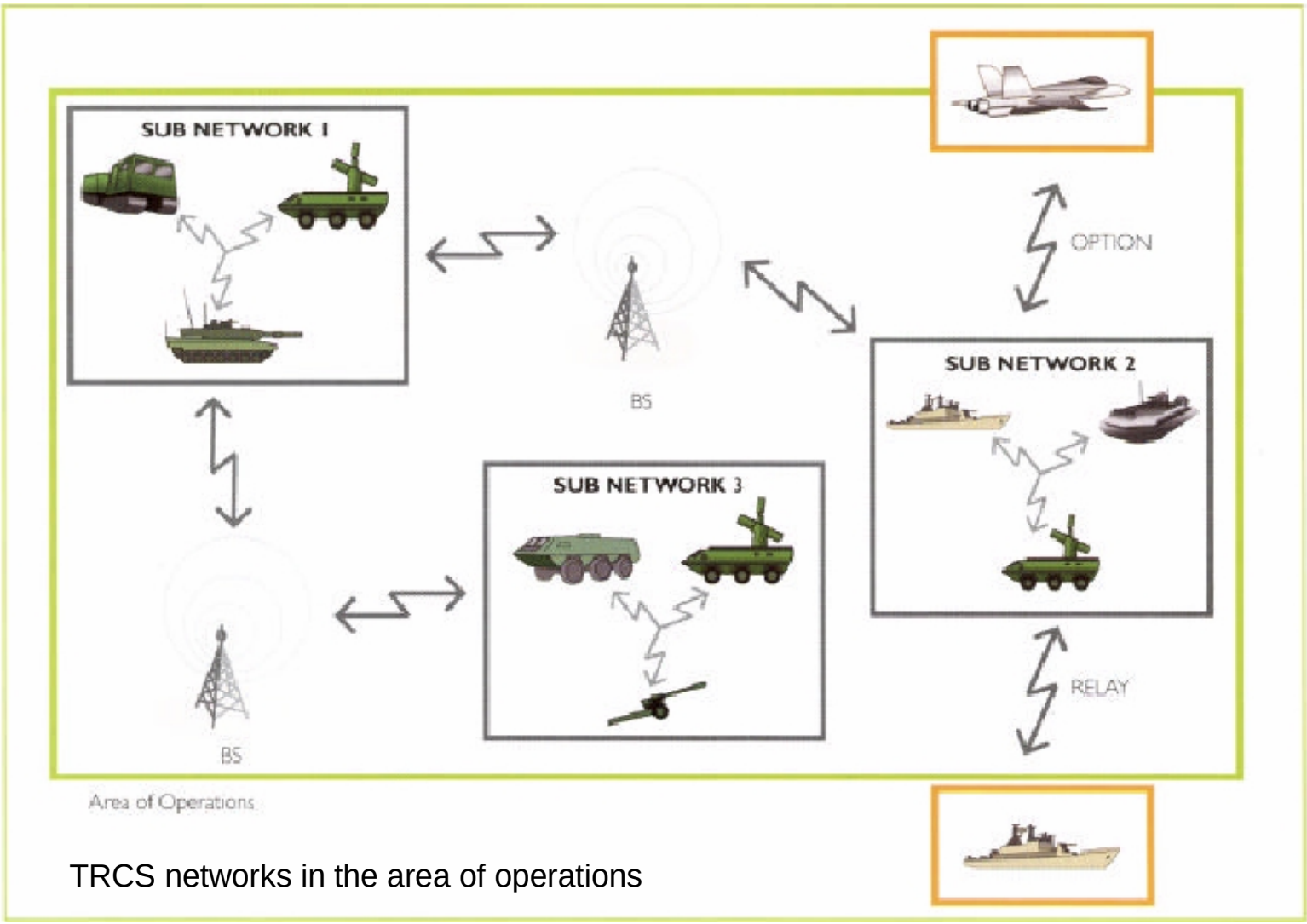
Application 1: COMMUNICATION SYSTEMS TO THE MILITARY TROPS

Implementation by a software defined radio (SDR) platform guarantees easy upgrating of the system and compatibility between different radio systems. On the network layer, the idea is use semi Ad Hoc routing possibilities.

The subproject product, Tactical Radio Communication System (TRCS)
- is based on software defined radio platform
- is spread spectrum system with advanced waveforms
- data rates from few bits to megabits
- supports interoperability
- there are possible to priorities communications
- voice, data, video
- use adaptive antennas
- enables several simultaneous logical connections

It will be used
- battle ships
- army forces
- air forces

SOFTWARE RADIO APPLICATIONS



TRCS networks in the area of operations

SOFTWARE RADIO APPLICATIONS

Application 2: ELECTRONIC INTELLIGENCE

Electronic Intelligence using software radio.

Most modern governments use electronic intelligence technology to gather information . Now days it is used in the fight against terrorism and crime.

This kind of system is quite good concepts for the software radios.
It is a radio receiver in which as many elements as possible are reprogrammable.
This allows one system to be used to decode signals from many different sources.

In this concept, producer are using FPGA (Field Programmable Gate Arrays) technologies with DSP (Digital Signal Processors) processors and integrate that processing power with very fast communications ADC`s, capable of sampling IF signals directly.

That concept are easy to do because it do not interfere any other networks and systems.

SOFTWARE RADIO APPLICATIONS

Application 3: COMMUNICATION SYSTEMS TO THE SHIPS

Ships are quite far a way on the see when they are crossing the oceans.
They need navigations systems and communication systems.

Ships are lot of place to many antennas and also big antenna arrays.
It good place to use software radio.

Ships needs GPS-systems to the navigations, HF- / VHF-radios to the communications, satellite systems to the TV- and radio programs and also for communications purposes.

It`s also possible to arrange the GSM- , UMTS- and TETRA - base stations services to the ships with software radio and make connections to the base stations controller via satellite. When you want to work in the ship with computers you need also W-LAN systems. It´s quite easy to make connections to the internet via satellite.

I think, the ships are the most promising area to use the software radios.

SOFTWARE RADIO APPLICATIONS

Application 4: COMMUNICATION SYSTEMS TO THE TRUKS AND LORRIES

Now days lot of trucks are going over the country sides and quite far a way in the Europe. They needs modern communications systems also to the

- logistics purposes
- communications (HF - / VHF- radios)
- navigations (GPS)
- radios (programs)

SUMMARY

This representation:
- We have seen main ideas of the software radio
- We have seen advantages and disadvantages of the software radio platform
- and we have seen some applications how to use it for the wireless communications purposes

HOMEWORK

What are those biggest problems in the software radio networks when you are using VoIP concept there?

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