

# Implementing a Base Station Using the SDR Platform for Coexistence of Heterogeneous Wireless Systems



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# Outline

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- Introduction
- Spectrum Access Scheduling
- System Specification



# Problem: Spectrum Scarcity

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- The radio spectrum is a precious and limited resource.
- Fixed allocation.
  - Most of the usable part of the spectrum has been divided among various radio services.
- Continuous and fast emergence of wireless standards.
- Running out of the radio spectrum?
- Actually, the currently allocated spectrum is not fully utilized.



# Proposed Solution: Spectrum Access Scheduling (SAS)

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- Reason: the conflict between the spectrum scarcity and underutilization.
- Proposed approach: Spectrum Access Scheduling
  - To improve the spectrum utilization efficiency.
  - The underutilized spectrum is shared among heterogeneous systems.



# Cognitive Radio V.S. SAS

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- Related work: Cognitive Radio
  - Primary users and Secondary users
  - Secondary users apply a **opportunistic** method to access spectrum holes.
- Our solution: Spectrum Access Scheduling
  - All wireless users are considered as first-class citizens of the spectrum domain.
  - Users apply a **deterministic** method to access the common bands.



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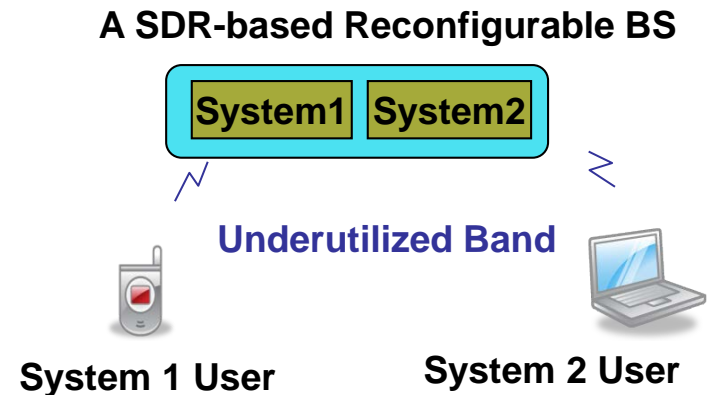
# SAS System

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- A centralized system.
  - Mostly affecting the base station of the overall system architecture.
    - The protocols are aware of each other at the base station, so that the spectrum is shared with minimum disruptions.
  - A cost-effective SDR-based base station.

# SAS System (cond't)

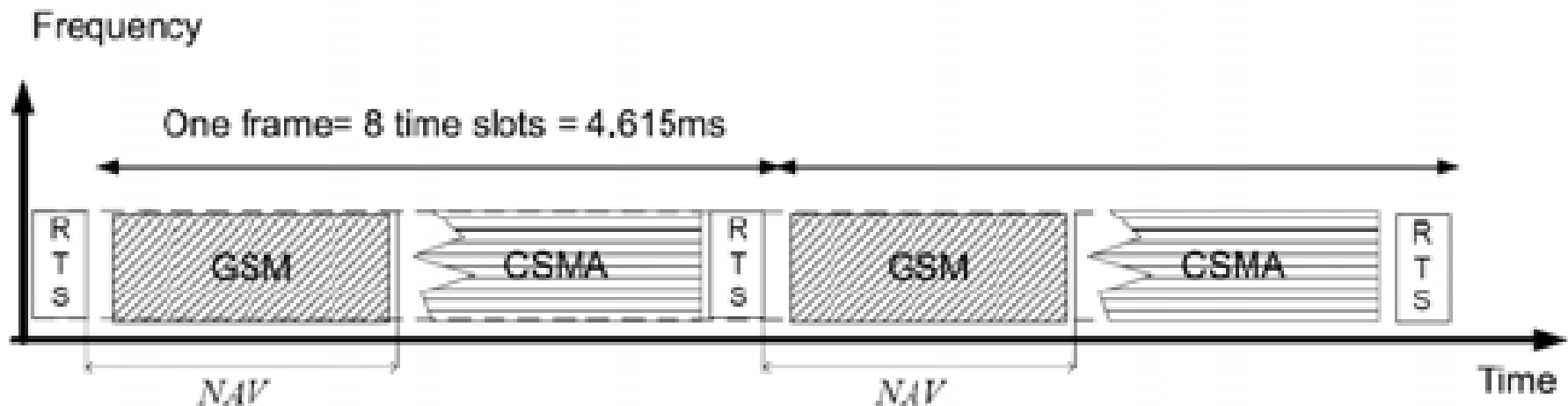
- The underutilized spectrum is time-shared between heterogeneous systems.
- Channels can be shifted to the same band through frequency up/down converters.





# Example: GSM and Carrier Sensing Multiple Access (CSMA)

- GSM and CSMA time share the GSM-900 band.
  - The base station sends RTS (Request To Send) control frames to reserve the channel time periods for GSM.
  - Every CSMA node receiving the RTS frame has to set its NAV (Network Allocation Vector) in accordance with the duration field of the RTS frame.





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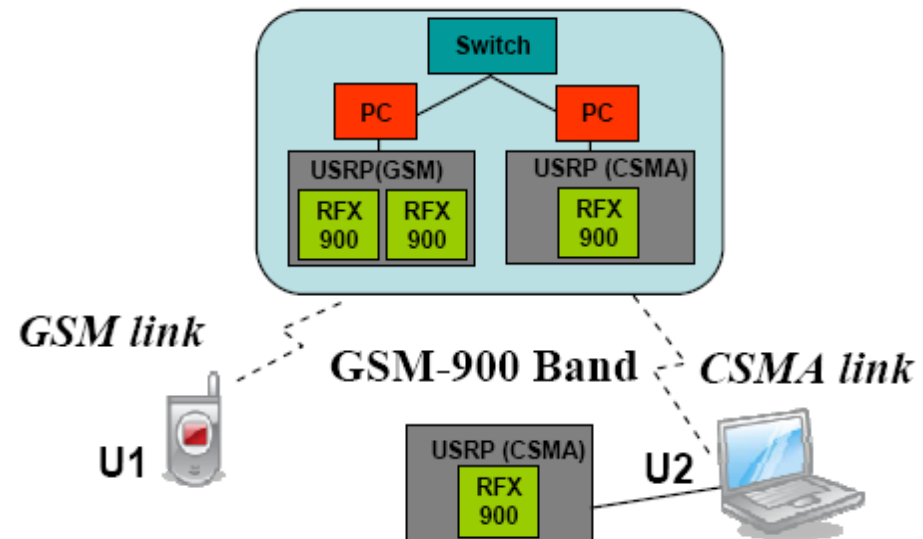
# SAS Base Station

## ■ Configuration

- General purpose computer
- USRP (Universal Software Radio Peripheral)
- RFX 900 daughterboard

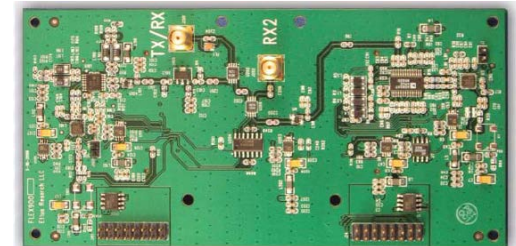
## ■ For simplicity, we use two sets of computing hardware systems to virtually simulate a single base station .

- A virtual base station eliminates the complexity of the OS kernel programming, and allows us to focus on protocol engineering issues for coexistence.
- The two computers are synchronized by the PTP daemon (PTPd).
  - PTPd implements the Precision Time protocol (PTP) as defined by the IEEE 1588 standard.



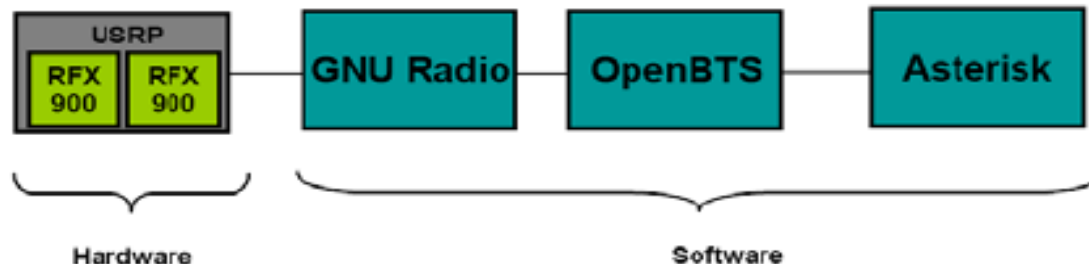
# USRP (Universal Software Radio Peripheral)

- USRP motherboard
  - ADC and DAC
  - FPGA
    - The FPGA implements the control logics to reduce the samples.
- RFX900 daughterboard
  - Frequency Range: 750 to 1050 MHz
  - Transmit Power: 200mW (23dBm)
  - Daughterboards turn a USRP into a complete RF transceiver system.



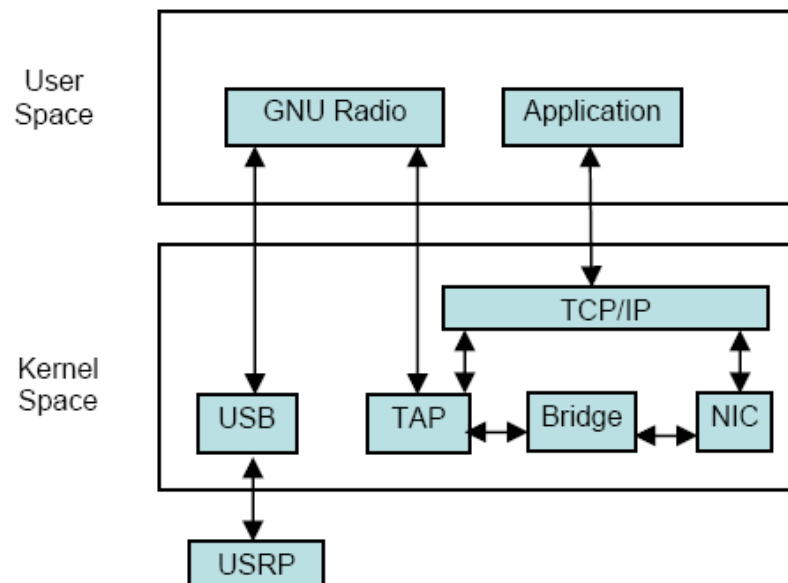
# OpenBTS

- OpenBTS is an open-source project.
- OpenBTS uses the USRP to present a GSM air interface ("Um") to standard GSM handsets.
- OpenBTS interfaces with libusrp libraries to use USRP.
- OpenBTS uses the Asterisk PBX (Private Branch Exchange) software to control and manage calls between GSM handsets and VoIP endpoints.
- OpenBTS supports GSM functions without supporting functions provided by traditional GSM components – the Base Station Controllers (BSCs), Mobile Switching Centers (MSCs) or Visitors Location Registers (VLRs).



# CSMA

- A TAP (a virtual Ethernet network device) is generated in the kernel, so Ethernet frames can be sent and received through the TAP.
- A virtual bridge is generated to connect the TAP and the physical network interface card (NIC) that connects to the Internet.

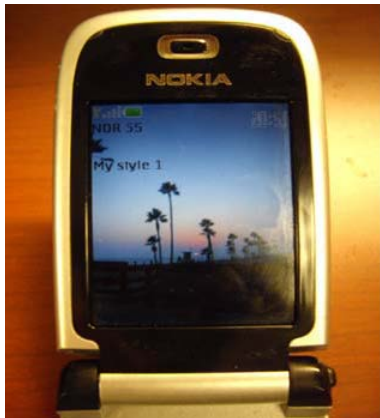


# Coexistence of GSM and CSMA

running the ping function

- Carrying out two communication sessions simultaneously.

- GSM
- CSMA



a commodity cell phone

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root@dhcp-055223:/usr/local/src/gnuradio_trunk/gnuradio/gnuradio
File Edit View Terminal Tabs Help

root@dhcp-055223:/usr/local/src/... root@dhcp-055223:/usr/local/src/...

PING 128.195.55.244 (128.195.55.244) 56(84) bytes of data.
From 128.195.55.229 icmp_seq=2 Destination Host Unreachable
From 128.195.55.229 icmp_seq=3 Destination Host Unreachable
From 128.195.55.229 icmp_seq=4 Destination Host Unreachable
From 128.195.55.229 icmp_seq=6 Destination Host Unreachable
From 128.195.55.229 icmp_seq=7 Destination Host Unreachable
From 128.195.55.229 icmp_seq=8 Destination Host Unreachable
64 bytes from 128.195.55.244: icmp_seq=12 ttl=64 time=21.8 ms
64 bytes from 128.195.55.244: icmp_seq=13 ttl=64 time=22.7 ms
64 bytes from 128.195.55.244: icmp_seq=14 ttl=64 time=21.2 ms
64 bytes from 128.195.55.244: icmp_seq=17 ttl=64 time=21.8 ms
64 bytes from 128.195.55.244: icmp_seq=18 ttl=64 time=22.9 ms
64 bytes from 128.195.55.244: icmp_seq=19 ttl=64 time=24.0 ms
64 bytes from 128.195.55.244: icmp_seq=28 ttl=64 time=24.0 ms
64 bytes from 128.195.55.244: icmp_seq=29 ttl=64 time=18.6 ms
64 bytes from 128.195.55.244: icmp_seq=35 ttl=64 time=20.4 ms
64 bytes from 128.195.55.244: icmp_seq=39 ttl=64 time=25.6 ms
64 bytes from 128.195.55.244: icmp_seq=40 ttl=64 time=22.1 ms
64 bytes from 128.195.55.244: icmp_seq=42 ttl=64 time=26.2 ms
64 bytes from 128.195.55.244: icmp_seq=54 ttl=64 time=22.4 ms
64 bytes from 128.195.55.244: icmp_seq=55 ttl=64 time=19.8 ms
64 bytes from 128.195.55.244: icmp_seq=60 ttl=64 time=22.3 ms
64 bytes from 128.195.55.244: icmp_seq=64 ttl=64 time=21.8 ms
64 bytes from 128.195.55.244: icmp_seq=65 ttl=64 time=19.7 ms
64 bytes from 128.195.55.244: icmp_seq=71 ttl=64 time=21.7 ms
64 bytes from 128.195.55.244: icmp_seq=74 ttl=64 time=22.5 ms
64 bytes from 128.195.55.244: icmp_seq=75 ttl=64 time=20.2 ms
64 bytes from 128.195.55.244: icmp_seq=76 ttl=64 time=21.2 ms
64 bytes from 128.195.55.244: icmp_seq=81 ttl=64 time=21.1 ms
64 bytes from 128.195.55.244: icmp_seq=82 ttl=64 time=21.3 ms
64 bytes from 128.195.55.244: icmp_seq=86 ttl=64 time=24.5 ms
64 bytes from 128.195.55.244: icmp_seq=92 ttl=64 time=19.3 ms
64 bytes from 128.195.55.244: icmp_seq=96 ttl=64 time=25.3 ms
64 bytes from 128.195.55.244: icmp_seq=101 ttl=64 time=22.3 ms
64 bytes from 128.195.55.244: icmp_seq=102 ttl=64 time=19.8 ms
64 bytes from 128.195.55.244: icmp_seq=111 ttl=64 time=20.7 ms
64 bytes from 128.195.55.244: icmp_seq=115 ttl=64 time=23.6 ms
64 bytes from 128.195.55.244: icmp_seq=116 ttl=64 time=21.1 ms
64 bytes from 128.195.55.244: icmp_seq=117 ttl=64 time=21.9 ms
64 bytes from 128.195.55.244: icmp_seq=121 ttl=64 time=25.4 ms
64 bytes from 128.195.55.244: icmp_seq=126 ttl=64 time=21.5 ms
64 bytes from 128.195.55.244: icmp_seq=131 ttl=64 time=19.8 ms
64 bytes from 128.195.55.244: icmp_seq=132 ttl=64 time=21.7 ms
64 bytes from 128.195.55.244: icmp_seq=135 ttl=64 time=22.6 ms
64 bytes from 128.195.55.244: icmp_seq=136 ttl=64 time=19.8 ms
64 bytes from 128.195.55.244: icmp_seq=137 ttl=64 time=24.9 ms
64 bytes from 128.195.55.244: icmp_seq=139 ttl=64 time=20.7 ms
64 bytes from 128.195.55.244: icmp_seq=143 ttl=64 time=20.6 ms
64 bytes from 128.195.55.244: icmp_seq=158 ttl=64 time=20.5 ms
64 bytes from 128.195.55.244: icmp_seq=159 ttl=64 time=22.4 ms
64 bytes from 128.195.55.244: icmp_seq=162 ttl=64 time=24.1 ms
64 bytes from 128.195.55.244: icmp_seq=167 ttl=64 time=21.3 ms
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# Conclusions

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- Spectrum access scheduling (SAS) for spectrum reuse purpose.
- Cognitive Radio V.S. SAS
  - CR
    - Primary users and Secondary users
    - Opportunistic
  - SAS
    - Equal spectrum share holders
    - Deterministic





# Questions?

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Thank you !