Smart Radio Challenge

Geolocation Based Cooperative Sensing System to Mitigate Interference in Emergency Communications

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Outline

- SDR Forum overview
- Smart Radio Challenge
- Challenge problems
- Our Targets
- Conclusions

SDR Forum

- Established in 1996
- A non-profit international industry association dedicated to promoting the success of next generation radio technologies.
- The Forum's 100-strong membership comprises world class technical, business and government leaders from EMEA, Asia and the America.
- Forum members span commercial, defense and civil government organizations at all levels of the wireless value chain and include service providers, operators, manufacturers, developers, regulatory agencies, and academia.
- dedicated to serving the industry's needs through advocacy, opportunity development, commercialization and education.
- URL:http://www.sdrforum.org/

SDR Challenge

- SDR Forum's Smart Radio Challenge,
- Worldwide competition among student engineering teams design, develop and test software defined radio (SDR) or a cognitive radio technologies.
- Address relevant problems in the advanced wireless market.
- Solutions are evaluated by a panel of industry judges
- Scholarships for
  1. Challenge Winner
  2. Best Design
  3. Best Paper
  4. The Mathworks Design Award
- Scholarships for competing teams to join the SDR Forum annual technical conference and product exhibition
- URL: http://www.radiochallenge.org/

Challenge 2009

- 3rd Annual Smart Radio Challenge
- The Smart Radio Challenge will have seven student teams this year:
  1. Notre Dame (Team Notre Dame)
  2. Penn State University
  3. Tokyo Institute of Technology
  4. University of Calgary (UofC Team)
  5. Stevens (Stevens Software Defined Radio Group)
  6. Virginia Tech
  7. Worchester Polytechnic Institute

Deadlines

- Important Dates:
  - 6 March 2009 → Challenge Announced
  - 10 April 2009 → Proposals Due
  - 22 April 2009 → Teams Announced
  - 16 April 2010 → Final Results

Rules

- Problem must be solved entirely by student teams consist of graduate and/or undergraduate students.
- At least 3 members with a designated team leader and must have a faculty advisor.
- No help by third parties other than outlined in documentation.
- Academic challenge is international in nature, and open to colleges and universities world wide.
- The final work product of each team must be original.
- Must not be reverse engineered from any existing hardware or software product.
- Must use licensed software

Phases

- Two Phases → qualifying round → one or more development rounds.
- Phase 1: Qualifying round
  - Submitted a 25 page proposal to SDR forum
  - Assesment criteria were:
    - Overall technical approach, preliminary assessment and developmental (50%)
    - Maturity of design process (10%)
    - Use of materials provided by corporate sponsors (10%)
    - Feasibility and performance (10%)
    - Commercial viability (10%)
    - Quality of documentation and deliverables (to include simulations) (10%)

Phase 2:Development phase

- Develop a solution addressing the proposed problem(s).
- Monthly reports must be submitted to the SDR Forum by each team identifying their progress.
- Final report must be delivered by April 16, 2009 detailing the solution developed by the student teams.
- Final report will be available to the advanced wireless community through the SDR Forum web site.
- The final Phase 2 solution will be captured in a webinar and presented to judges on the week of April 1216, 2010.
- Webinars will be recorded by the SDR Forum and may be made available on the SDR Forum website.
- Winner announcements April 30, 2010.
- Scholarship money handover within 1 month.

Phase 2: Assessment

- The technical approach innovation and depth of analysis (10%)
- Ability of the Matlab models to accurately model the RF environment for a variety of public safety use cases (10%)
- The ability of the Matlab model to perform geolocation and mitigate the impact of multi-path (10%)
- The ability of the Matlab model to recognize different signal types (10%)
- The extent to which VRT standard is utilized (5%)
- The extent to which the efforts leverage working group efforts of the SDR Forum: the MLM, Transceiver API, Smart Antenna (5%)
- Documentation: monthly reports, PDR design and trade-off analysis, final report, clarity of webinar presentation (10%)
- Viability to transition final results into real products for public safety applications (5%)
- Demonstration equipment software and hardware architecture (15%)
- Demonstration equipment measured performance (20%)

Previous Challenge: 2007

- Problems were:
  1. Spectrum Access for First Responders
  2. Communications Interoperability
  3. Traffic Management
  4. Rapid Application Development
- Grand prize $\rightarrow$ Virginia Tech CWT
- Best paper $\rightarrow$ University of Utah
- Best design $\rightarrow$ Virginia Tech MPRG (Mobile & Portable Radio Research Group)
- Award winning schools all received cash scholarships.
- Other finalists $\rightarrow$ France Supelec, Universiti Putra Malaysia, and Clemson.

Previous Challenge: 2008

- Problems were:
  1. Communications from an Infrastructure Damaged Area (extending the range of a wireless network)
  2. Automated Spectrum Mapping (Mapping frequencies and locations of RF emitters)
  3. Next Stop Elbonia (Preparing a Rapid Waveform Development)
- Six finalists solved one of the problems
- Overall Winner, Best design and Problem 2 $\rightarrow$ Carnegie Mellon University ($7000, two plaques and a trophy)
- Best paper $\rightarrow$ Penn State University ($1,000and a plaque)
- Problem 1 $\rightarrow$ Virginia Tech ($2,000 and a trophy)
- Problem 3 $\rightarrow$ University of Calgary ($2,000 and a trophy).

Challenge 2009 (Problem Statement)

- An earthquake has occurred centered in a major metropolitan area measuring 10.0 on the Richter scale.
- Existing communications infrastructure is out
- Emergency medical services, police, fire, state and federal emergency management personnel arrive on the scene from all over the world
- All begin setting up their own communications systems to aid in rescue efforts.
- Finding available spectrum becomes a challenge resulting in unintentional interference between communications of various services.

Challenge 2009 (Final Solution)

- Develop a cooperative sensing system that will create and maintain a database of public safety emitters on the scene,
- Database should consist of
  - Emitter location
  - Modulation type
  - Transmit frequency
  - Association to which emergency team is using this frequency
  - waveform.
- At least 20 different emergency response teams are present and trying to coordinate their activities.

Challenge 2009 (Final Solution)

- Develop Matlab to model the possible RF Environment for these various public safety applications.
- Emergency environment may occur in rolling hills rural setting, large obstructions in a city environment, suburban, or even other extreme conditions (such as underground subways).
- Able to demonstrate the signal degradation such as multi-paths impact on geolocation as well as effects on the modulation spectrum shape.
- Emergency radios are set up that use the VITA 49 Radio Transport (VRT) standard as a data transport mechanism to transfer time-stamped signal data between radios to perform geolocation (www.digitalIF.org).
- Identify a set of signals that are important for public safety geolocation applications and demonstrate Matlab algorithms to perform signal recognition in conjunction with geolocation.
- Implement an SDR radio model capability in Matlab with geolocation and signal recognition capabilities and implement a means to mitigate the impact of multi-path.
- Demonstration of the capability on a hardware platform is desirable, but not required.

VITA 49 Radio Transport (VRT)

- Defines the transport layer protocol for transmission of data between RF (radio frequency) receivers and signal processing equipment.
- Standardizes signal data transport between receivers and signal processors.
- Standardizes metadata transport between receivers and signal processors.
- Signal data is transported using IF Data packets. IF Data packets carry the main information from one radio to another.
- Metadata is transported using Context Data packets. Context data include: center frequency, modulation type, timestamps, bandwidth, gain, absolute and relative power , ADC sampling rate, geolocation information, emitter name etc.

TokyoTech Team

- Advisors
  - Prof. Jun-ichi TAKADA
  - Dr. Minseok KIM
- Team members
  - Md. Abdur Rahman, D1
  - Iswandi, D1
  - Gahadza Mutsawashe, M2
  - Santosh Khadka, M1
  - Azril Haniz, B4

Sponsor Contribution

Gold Sponsor

Silver Sponsor

- Sponsor Contributions:

MATLAB	Simulink
Communications Blockset	Communications Toolbox
Embedded IDE Link CC	Filter Design Toolbox
FixedPoint Toolbox	RealTime Workshop
RealTime Workshop Embedded Coder	RF Blockset
RF Toolbox	Signal Processing Blockset
Signal Processing Toolbox	Simulink Fixed Point
SimulinkÂ® Accelerator	Target Support Package TC6

Targets

- Our targets are
  - Develop a cooperative database of emergency emitters
  - Cooperative sensing
  - Geolocation estimation of the Emitters
  - Propagation channel simulation in MATLAB for public safety applications
  - Implementation on GNU radio

Channel Model

- Applicable to each sensor node to decide the working frequency, modulation system, channel coding, etc.
- Two methods
  1. the distance (based on geolocation) and various channel model (AWGN, flat fading, dispersive fading, etc.)?
  2. adaptive and distributed cognition
- Proposed system will be tested on urban environment
- Test will be done in Matlab-Simulink.
- Aspects
  1. mobility
  2. cover wide frequency range
  3. regarding multipath
  4. parameters: Field strength, SNR, TOA

Concluions and Future Study

- Project is still on track.
- Implementation on GNU radio and MATLAB is big challenge
- Application of VRT standard on sensors need to be considered
- Hopefully, literature survey will be finished by July 2009.
- Future Study
  - Cooperative Sensing and Geolocation
  - Combine the pieces together
  - Database implementation (mysql, PHP, etc.)
  - GNU programming (Python, C++ etc.)

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LaTeX Beamer with IAS theme is used for this presentation

Questions?/Comments/Suggestions

Thank You