27 ✓

DARPA SPECTRUM CHALLENGE

Fiscal Year 2013 Report

February 5, 2014

Defense Advanced Research Projects Agency
675 North Randolph Street
Arlington, VA 22203

TABLE OF CONTENTS

1 BACKGROUND

Section 2374a of Title 10 of the United States Code authorizes the Secretary of Defense, acting through the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)), and the Service acquisition executive of each military department, to conduct programs to award up to $10 million in cash prizes to recognize outstanding achievements in basic, advanced, and applied research; technology development; and prototype developments that are potentially applicable to the military missions of the Department of Defense (DoD) (see Appendix A). ASD(R&E) delegated authority under 10 U.S.C. § 2374a to the Director of the Defense Advanced Research Projects Agency (DARPA) to conduct the Spectrum Challenge.

This report describes DARPA's FY 2013 activities under the delegated prize authority and the Spectrum Challenge.

As the use of wireless technology proliferates, radios often compete with, interfere with, and disrupt the operations of other radios. DARPA seeks innovative approaches that ensure robust communications in such congested and contested environments in support of military operations.

The DARPA Spectrum Challenge called on participants to demonstrate radio protocols that can best utilize a given communication channel in the presence of other users and interfering signals. The need to provide robust communications in the presence of interfering signals is of great importance to military applications. The Spectrum Challenge is targeted at finding successful strategies for guaranteeing successful communication in the presence of other radios, each programmable and running its own spectrum etiquette protocols and that may have conflicting co-existence objectives. Awards will be made to the best performing systems in two tournament scenarios:

- Competitive Scenario – Two teams attempt to simultaneously transmit a data file from one of their radios to the other. This tests their ability to design a radio that can best overcome interference.
- Cooperative Scenario – Three teams are grouped together with the objective that each team transmit a data file across their radio pair while causing minimal disruption to the other two teams. This tests their ability to design a radio that can operate in the presence of other radios while causing minimum disruption.

Teams compete head-to-head in a structured test environment, using identical radio hardware, to determine the most capable algorithms, as measured by how quickly a block of data can be transmitted from one radio to another.

The Challenge consists of two tournament events: The Preliminary Challenge Event was held on September 11 and 12, 2013 with prizes of $25,000 awarded to the winners of the Competitive and Cooperative tournaments. The Competitive tournament was won by a team from Vanderbilt University, and the Cooperative tournament was won by a team from Northeastern University.

The Final Challenge Event will be held March 19 and 20, 2014, with $100,000 awarded in prize money.

2 PROGRAM GOALS

The goal of the DARPA Spectrum Challenge is to develop and demonstrate electronic warfare strategies for guaranteeing successful wireless communication in the presence of coalitions of cognitive radios, each running its own spectrum etiquette protocols, which may have conflicting co-existence objectives. The techniques employed by the participants are expected to be representative of next-generation adaptive radio protocols that will be seen in future military and commercial communications systems.

DARPA is managing the Spectrum Challenge to meet these goals using the prize authority.

3 PRIZE AUTHORITY UTILIZATION

To execute the DARPA Spectrum Challenge, participants are challenged to design radios that optimally perform under competitive and cooperative communication scenarios. Participants compete head-to-head in a structured test environment to determine the most capable algorithms, measured by how quickly a block of data can be transmitted from one radio to another. Incentive to participate in the Challenge, which required significant time and effort to implement operating strategies and test and tune the algorithms, was provided by $150,000 in prize funds. Prize authority made it possible to work with academic institutions, small businesses and individuals, most of whom had never worked with DoD. The competition would not have been possible using standard authorities such as contracts, grants, or cooperative agreements.

4 CASH PRIZES AWARDED

On September 12, 2013, at the conclusion of the Preliminary Event, a prize of $25,000 was awarded to MarmotE from Vanderbilt University for winning the Competitive tournament and $25,000 was awarded to WSL-NEU from Northeastern University for winning the Cooperative tournament. Winners of the Final Event competitions in both the Competitive and Cooperative tournaments will be awarded $50,000 in prize money. The Final Event will be held on March 19 and 20, 2014.

5 SOLICITATION AND EVALUATION METHODS

The DARPA Spectrum Challenge was announced on December 13, 2012, in a web feature, posted on the DARPA homepage, and reported in national media and social media outlets. The registration period was open from January 9, 2013, to January 31, 2013, and 94 teams registered for the Challenge.

The first qualification event required teams to complete a series of three technical hurdles that were designed such that each step required more effort and proficiency. Sixty-six teams completed the first hurdle, 59 completed the second, and 45 completed the third. The top 15 teams were selected based on performance that was quantitatively assessed on the Open-

Access Research Testbed for Next Generation Wireless Networks (ORBIT) to participate in the Preliminary Challenge Event, and the remaining teams competed for three additional spots. The top 18 teams and their affiliations are listed in Appendix B.

The Preliminary Challenge Event took place at the Rutgers University Wireless Innovation Network Laboratory (WINLAB) in North Brunswick, New Jersey, with live results viewed by the teams at the DARPA Conference Center in Arlington, Virginia.

For the Competitive tournament, pairs of teams competed head-to-head in a three-game minimum, ladder-style tournament. For each match, the team that completed the data transfer first, or successfully transmitted the most data within the allotted time, was the winner. A total of 39 matches were played. Appendix C shows the results.

For the Cooperative scenario, three teams were grouped together for each match, and a modified round-robin tournament structure provided the opportunity for each team to be grouped with all other teams. For each match, the teams received a group score based on the total number of data packets transmitted by the group. By accumulating scores from each match a team participated in, a ranking was determined. The top four teams played a final round of all combinations of groups of three (four matches) to determine the winner. A total of 28 matches were played. Appendix C shows the results.

6 RESOURCES

The DARPA Spectrum Challenge was organized by government staff members and support contractors. The actual tournament took place at Rutgers University's WINLAB radio testbed. The DARPA Conference Center was used to visualize the results by team participants and invited government personnel.

Prize funds were drawn from the Program Elements (PE) and projects as follows:

PE	Project	Title	FY13	Total
0602702E	TT-13	NETWORK CENTRIC ENABLING TECHNOLOGY	$50,000	$50,000

7 TECHNOLOGY TRANSITION

The DARPA Spectrum Challenge has been a successful demonstration of novel radio protocols under various interference scenarios. The Challenge will conclude in March 2014 with the demonstration of refined protocol techniques. DARPA has been discussing the results with several organizations within the law enforcement, military, and intelligence communities.

8 CONCLUSION

To date, the DARPA Spectrum Challenge has achieved its goals and stimulated interest in the programs and projects of interest to the DoD science and technology community. The event attracted a pool of nontraditional and enthusiastic participants, mostly within the academic community that would traditionally not engage in government research and development programs. The techniques developed and demonstrated by the participants are expected to drive the design of next-generation adaptive radio protocols for future military communications systems.

APPENDIX A

PRIZE AUTHORITY STATUTE

The prize authority statute, section 2374a of U.S. Code Title 10 states as follows:

§ 2374a. Prizes for advanced technology achievements

(a) Authority. The Secretary of Defense, acting through the Director of Defense Research and Engineering and the service acquisition executive for each military department, may carry out programs to award cash prizes in recognition of outstanding achievements in basic, advanced, and applied research, technology development, and prototype development that have the potential for application to the performance of the military missions of the Department of Defense.

(b) Competition requirements. Each program under subsection (a) shall use a competitive process for the selection of recipients of cash prizes. The process shall include the widely-advertised solicitation of submissions of research results, technology developments, and prototypes.

(c) Limitations.

(1) The total amount made available for award of cash prizes in a fiscal year may not exceed $10,000,000.

(2) No prize competition may result in the award of more than $1,000,000 in cash prizes without the approval of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

(d) Relationship to other authority. A program under subsection (a) may be carried out in conjunction with or in addition to the exercise of any other authority of an official referred to in that subsection to acquire, support, or stimulate basic, advanced and applied research, technology development, or prototype projects.

(e) Annual report.

(1) In general. Not later than March 1 of each year, the Secretary shall submit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives a report on the activities carried out during the preceding fiscal year under the authority in subsection (a).

(2) Information included. The report for a fiscal year under this subsection shall include, for each program under subsection (a), the following:

(A) A description of the proposed goals of the competitions established under the program, including the areas of research, technology development, or prototype development to be promoted by such competitions and the relationship of such areas to the military missions of the Department of Defense.
(B) An analysis of why the utilization of the authority in subsection (a) was the preferable method of achieving the goals described in subparagraph (A) as opposed to other authorities available to the Department, such as contracts, grants, and cooperative agreements.
(C) The total amount of cash prizes awarded under the program, including a description of the manner in which the amounts of cash prizes awarded and claimed were allocated among the accounts of the Department for recording as obligations and expenditures.
(D) The methods used for the solicitation and evaluation of submissions under the program, together with an assessment of the effectiveness of such methods.
(E) A description of the resources, including personnel and funding, used in the execution of the program, together with a detailed description of the activities for which such resources were used and an accounting of how funding for execution was allocated among the accounts of the Department for recording as obligations and expenditures.
(F) A description of any plans to transition the technologies or prototypes developed as a result of the program into an acquisition program of the Department.

(3) Suspension of the authority for failure to include information. For each program under subsection (a), the authority to obligate or expend funds under that program is suspended as of the date specified in paragraph (1) if the Secretary does not, by that date, submit a report that includes, for that program, all the information required by paragraph (2). As of the date on which the Secretary does submit a report that includes, for that program, all the information required by paragraph (2), the suspension is lifted.

(f) Period of authority. The authority to award prizes under subsection (a) shall terminate at the end of September 30, 2018.

APPENDIX B

SPECTRUM CHALLENGE QUALIFIED TEAMS

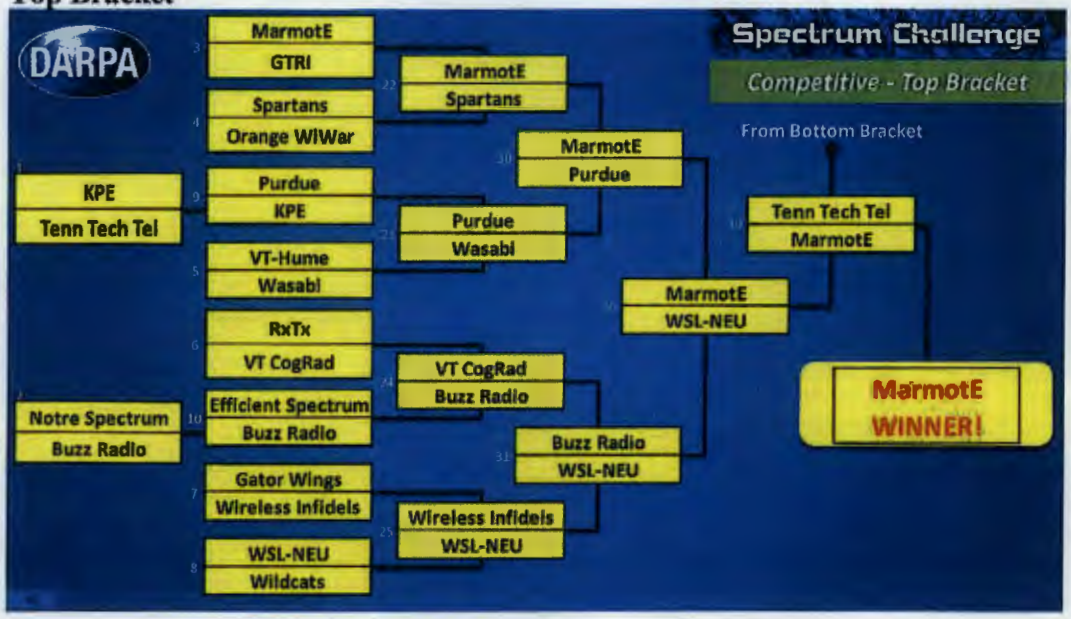
Team Name	Affiliation	Location
Purdue	Purdue University, Raytheon BBN	West Lafayette, IN
Efficient Spectrum	Individual	Centreville, VA
WSL-NEU	Northeastern University	Boston, MA
MarmotE	Vanderbilt University, ISIS	Nashville, TN
Gator Wings	University of Florida	Gainesville, FL
Spartans	San Jose State University	San Jose, CA
RxTx	Individuals	San Diego, CA
VT-Hume	Virginia Tech	Blacksburg, VA
wasabi	Individual	Seattle, WA
VT CogRad	Virginia Tech	Blacksburg, VA
The Orange Wireless Warriors	Syracuse University	Syracuse NY
Wireless Infidels	Polytechnic Institute of NYU	Brooklyn, NY
GTRI	Georgia Tech Research Institute	Atlanta, GA
Wildcats	Northwestern University	Evanston, IL
Notre Spectrum	Notre Dame University	South Bend, IN
KPE	Individual	Albuquerque, NM
Tennessee Tech Telecom	Tennessee Technological University	Cookeville, TN
Buzz Radio	Georgia Institute of Technology	Atlanta, GA

APPENDIX C

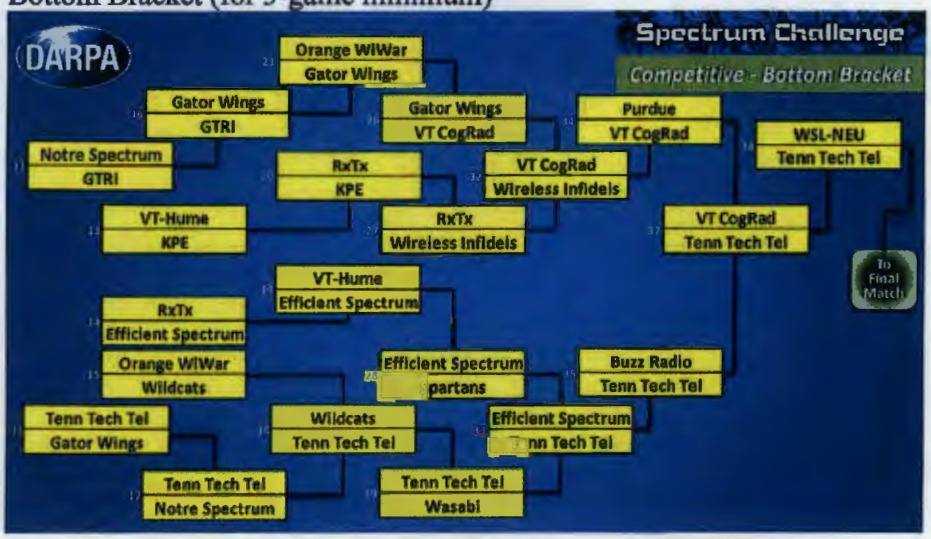
SPECTRUM CHALLENGE PRELIMINARY EVENT RESULTS

Competitive Tournament:

Top Bracket



Bottom Bracket (for 3-game minimum)



Cooperative Tournament:

Final Round

Elimination Round