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14. ABSTRACT
This project supported travel and other related expenses for two workshops on the quantification of Moving Target Defenses (MTD). While there has been considerable interest in this area from US Government organizations, FFRDCs and academia, most current research efforts have been working independently of each other. The workshops' objective was to create a community of MTD quantification researchers to share ongoing technical approaches, synthesize the advantages and disadvantages, and identify the most promising future research directions. The two workshops were held at George Mason University on August 31 – September 1 2015 (first

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Report Title

Final Report: Moving Target Defense (MTD) Quantification Workshop

ABSTRACT

This project supported travel and other related expenses for two workshops on the quantification of Moving Target Defenses (MTD). While there has been considerable interest in this area from US Government organizations, FFRDCs and academia, most current research efforts have been working independently of each other. The workshops' objective was to create a community of MTD quantification researchers to share ongoing technical approaches, synthesize the advantages and disadvantages, and identify the most promising future research directions. The two workshops were held at George Mason University on August 31 – September 1 2015 (first workshop) and June 28 2016 (second workshop). There were over 40 workshop participants.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 20.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received	Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: .....

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The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):.....

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:.....

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense .....

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: .....

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Forward

This project supported travel and other related expenses for two workshops on the quantification of Moving Target Defenses (MTD). While there has been considerable interest in this area from US Government organizations, FFRDCs and academia, most current research efforts have been working independently of each other. The workshops' objective was to create a community of MTD quantification researchers to share ongoing technical approaches, synthesize the advantages and disadvantages, and identify the most promising future research directions.

Problem Statement

Today's computers, network systems, and their defenses change slowly and deliberately. Consequently, they are easily reverse engineered and exploited by attackers. In response, Moving Target Defenses, and more generally Adaptive Cyber Defenses (ACD), have been attracting considerable research attention for their ability to minimize attacker leverage of information obtained from system probes and open documentation.

The MTD and ACD concepts are so compelling that researchers and system implementers have developed over 90 different types of techniques. This area has been full of claims and counterclaims about which methods are most effective with respect to effectiveness and implementation/operation costs.

Summary of Results

The workshops brought together people involved in various ongoing efforts to quantify and assess MTDs. Among them were several entirely different evaluation methods. We identified several proposed evaluation techniques, concluding that no single technique can effectively quantify all MTD performance dimensions. Moreover, different techniques can be used complimentarily so that coordinated and synthesized approaches might prove to be most effective in the end.

Major workshop findings include:

- the need for testbeds and realistic scenarios
- the need for comparison, validation and extensions of MTD quantification
- the need to quantify operational costs and risks of MTD techniques
- the need for modeling human analyst understanding of large scale MTD deployment

Attendees at the workshops included the following registered people:

1. Max Albanese, George Mason University
2. Michael Atighetchi, BBN Raytheon
3. Gabriela Barrantes, University of Costa Rica
4. Emery Berger, UMass Amherst
5. Jon Brickley, US Army Cyber Institute
6. Javier Camara, SEI CMU
7. Kevin Carter, MIT Lincoln Labs
8. Marco Carvalho, Florida Institute of Technology
9. John L. Cole, USARMY ARL
10. Thomas Cook, US Army Cyber Institute
11. George Cybenko, Dartmouth
12. Jack Davidson, University of Virginia
13. Scott DeLoach, U Kansas
14. Kate Farris, Dartmouth
15. Robert Gray, BAE Systems
16. Michael Higgins, USARMY CERDEC
17. Sushil Jajodia, George Mason University
18. Amin Kareem, U Michigan
19. David Last, USAF AFRL RI
20. James Lawton, AFOSR
21. Peng Liu, Penn State U
22. Stephen Lucas, USARMY CERDEC
23. Lisa Marvel, USARMY ARL
24. Joseph Matthews, Naval Research Laboratory
25. Patrick McDaniel, Penn State U
26. Eric Meihling, U Michigan

27. Andrew Mellinger, SEI CMU
28. Rick Metzger, USAF AFRL
29. David Myers, USAF AFRL RI
30. Tristan Nguyen, AFOSR
31. Hamed Okhravi, MIT Lincoln Labs
32. Robert Reschly, USARMY ARL
33. Jonathan Santos, USARMY CERDEC
34. Greg Shannon, OSTP
35. Ehab Shaer, U NC Charlotte
36. William Streillen, MIT Lincoln Labs
37. VS Subrahmanian, University of Maryland
38. Kun Sun, College of William and Mary
39. Jason Syverson, Siege Technologies
40. Joshua Taylor, Siege Technologies
41. Ralph Wachter rwachter@nsf.gov
42. Cliff Wang, USArmy ARO
43. Chip Willard, NSA

Technology Transfer