

**ROUTING AND ACTION**

**MEMORANDUM**

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ROUTING

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TO:(1) Computing Sciences Division (Iyer, Purush)

Report is available for review

(2) Proposal Files Report No.: -II

Proposal Number: 73501-CS-II.1

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DESCRIPTION OF MATERIAL

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CONTRACT OR GRANT NUMBER: W911NF-19-1-0035

INSTITUTION: Yale University

PRINCIPAL INVESTIGATOR: A. Stephen Morse

TYPE REPORT: Final Report

DATE RECEIVED: 5/8/20 6:23AM

PERIOD COVERED: 1/7/19 12:00AM through 10/6/19 12:00AM

TITLE: Final Report: Network Games: An Approach to Reasoning in An Adversarial Environment

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ACTION TAKEN BY DIVISION

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(x) Report has been reviewed for technical sufficiency and IS  IS NOT  satisfactory.

(x) Material has been given an OPSEC review and it has been determined to be non sensitive and, except for manuscripts and progress reports, suitable for public release.

(x) Performance of the research effort was accomplished in a satisfactory manner and all other technical requirements have been fulfilled.

(x) Based upon my knowledge of the research project, I agree with the patent information disclosed.

Approved by SSL\PURUSH.S.IYER on 5/8/20 7:29AM

ARO FORM 36-E

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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSOR/MONITOR'S ACRONYM(S) ARO
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12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.
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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.
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14. ABSTRACT
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15. SUBJECT TERMS
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16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	UU		A. Stephen Morse
					19b. TELEPHONE NUMBER 203-432-4295

# RPPR Final Report

## as of 08-May-2020

Agency Code:

Proposal Number: 73501CSII

**Agreement Number: W911NF-19-1-0035**

### INVESTIGATOR(S):

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DUNS Number: 043207562

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**Report Date:** 06-Jan-2020

Date Received: 08-May-2020

**Final Report** for Period Beginning 07-Jan-2019 and Ending 06-Oct-2019

**Title:** Network Games: An Approach to Reasoning in An Adversarial Environment

**Begin Performance Period:** 07-Jan-2019

**End Performance Period:** 06-Oct-2019

**Report Term:** 0-Other

Submitted By: A. Stephen Morse

Email: as.morse@yale.edu

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

### STEM Degrees:

### STEM Participants:

**Major Goals:** The major goal of this short-term project was to explore the use of game theory in the allocation of military, economic and political resources in an international setting.

**Accomplishments:** Over the nine month period during which this project was active, a successful study was made of the problem of analyzing a multi-person game in which the relationships between players are specified on a signed graph the sign of of each edge depicts either a friendly{+} or unfriendly{-} relationship. A journal paper on this subject is currently under revision for publication in the IEEE Transactions on Automatic Control.

An effort was made to use games on signed graphs to devise a new theory of alliance politics. A research paper has been prepared which seeks to outline a unified language of alliance politics using network games. This paper is currently under review.

The classical Byzantine General's problem has been formulated and addressed assuming that the relationships involved, evolve on a time-varying graph. This work is scheduled to be presented remotely at the 21st IFAC World Congress in Berlin this coming summer.

An effort was made to use network games to formulate and model certain security issues involving robotic surveillance and agents' mutual influences on communication networks.

This research has led to a paper which is currently under review for remote presentation this summer.

Due to travel constraints imposed because of the current world-wide pandemic, presentations of the main findings of this research will all be made remotely via the internet.

**Training Opportunities:** This project supported the efforts of one post doctoral fellow and her advisor for a period of one year. The post doctoral fellow, who holds a PhD in Political Science from Yale, learned how to formulate and solve allocation problems of military importance.

**Results Dissemination:** The results of the project have been or will be published in four journal papers and also have been presented at four technical meetings throughout the world.

**RPPR Final Report**  
as of 08-May-2020

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**PARTICIPANTS:**

**Participant Type:** PD/PI

**Participant:** Alfred Stephen Morse

**Person Months Worked:** 1.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: Y

Other Collaborators:

**Participant Type:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Participant:** Yuke Li

**Person Months Worked:** 12.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**ARTICLES:**

**Publication Type:** Journal Article

Peer Reviewed: Y

**Publication Status:** 4-Under Review

**Journal:** American Journal of Political Science

Publication Identifier Type:

Publication Identifier:

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Issue:

First Page #:

Date Submitted: 5/7/20 12:00AM

Date Published:

Publication Location:

**Article Title:** A Theory of Alliance Politics

**Authors:** Yuke Li, A. S. Morse

**Keywords:** alliance, game theory, signed graph, bloc, network design, power

**Abstract:** In this paper, a games-on-signed graphs framework developed in Li and Morse (2019) will be applied to develop a theory of alliance politics. The games on signed graphs discuss how countries allocate their military power to multiple fronts for their survival and success in a given international environment, and how countries may change the environment to improve their odds of survival and success, such as through forming or maintaining alliances. This paper is a first and preliminary attempt to construct a unified language of alliance politics using network games. This language allows us to examine how a combination of internal and external factors render a variety of alliances in terms of their effectiveness, cohesion, and ability to shape the international environment. A necessary and sufficient condition for a real "United Nations" also exists, where country blocs formed under different values and principles may be peaceful with one another.

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support: Y



The major accomplishments of this nine month STIR are articulated in the "Accomplishments under Goals" section of this report. To re-iterate, they are:

- The development of a constructive method for analyzing a multi-person game on a signed graph which models the friendly and adversarial relationships between player.
- The introduction of a new method of alliance politics using signed graphs.
- The formulation and analysis of the classical Byzantine General's problem for scenarios in which the associated graph changes with time.
- The formulation and analysis of robotic surveillance and agents' mutual influence problems on communication graphs using concepts from the theory of network games.

Each of these undertakings had led to a research paper for publication in a major journal or presentation at a leading conference.