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Cross Domain Deterrence: Livermore Technical Report, 2014-2016

Peter D. Barnes, Jr.
Ben Bahney
Celeste Matarazzo
Michael Markey
Jonathan Pearl

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Livermore Role in the Cross Domain Deterrence Minerva Project

Lawrence Livermore National Laboratory (LLNL) is an original collaborator on the project titled "Deterring Complex Threats: The Effects of Asymmetry, Interdependence, and Multi-polarity on International Strategy," (CDD Project) led by the UC Institute on Global Conflict and Cooperation at UCSD under PIs Jon Lindsay and Erik Gartzke , and funded through the DoD Minerva Research Initiative. In addition to participating in workshops and facilitating interaction among UC social scientists, LLNL is leading the computational modeling effort and assisting with empirical case studies to probe the viability of analytic, modeling and data analysis concepts. This report summarizes LLNL work on the CDD Project to date, primarily in Project Years 1-2, corresponding to Federal fiscal year 2015.

LLNL brings two unique domains of expertise to bear on this Project: (1) access to scientific expertise on the technical dimensions of emerging threat technology, and (2) high performance computing (HPC) expertise, required for analyzing the complexity of bargaining interactions in the envisioned threat models. In addition, we have a small group of researchers trained as social scientists who are intimately familiar with the International Relations research. We find that pairing simulation scientists, who are typically trained in computer science, with domain experts, social scientists in this case, is the most effective route to developing powerful new simulation tools capable of representing domain concepts accurately and answering challenging questions in the field.

LLNL's team is actively engaged throughout the two phases of the CDD Project. In **Phase I** (Project Years 1–3), LLNL scientific experts are helping to develop threat models for emerging technologies. This is being accomplished through participation in annual Project workshops, facilitation of in-depth interviews with social scientists, and ongoing scholarly collaboration throughout each of research modules. In the first phase, focused discussions and interviews are important in the development of the understanding of how the technical dimensions of cross domain threats constrain or enable strategic bargaining between political actors. These conversations are also enabling LLNL computer scientists to consult with strategic theorists on threat models and strategic dynamics, refine computational modeling approaches, and conduct small-scale initial validation of pilot computational studies. This progressive and incremental process of discovery is essential for laying the groundwork for large-scale simulation work in **Phase II** (Project Years 4–5) of the CDD Project, if funded.

In this report we summarize our activities on the Project primarily during Project Years 1–2, corresponding to Federal fiscal year 2015, broken down into four areas: our search for a postdoctoral researcher for the modeling effort, conceptual development of our modeling approach, work to understand dimensions of deterrence in space, and other collaborative efforts.

Search for Postdoctoral Researcher

We developed a postdoc job posting tailored to this Project, seeking demonstrated knowledge of agent or discrete event modeling, and familiarity with International Relations concepts. This posting went up in October 2014. We received 18 applications, held phone interviews with 6, and in person interview with one (Rexx Douglas).

Throughout the postdoctoral selection process we had regular discussions with the UCSD team and through these discussion further refined the envisioned role of the LLNL postdoc. In particular, in discussing validation approaches it became clear that an effort to develop empirical data sources would be extremely valuable. These discussions helped refine the role of the LLNL postdoc to require more focused experience on agent and/or discrete event modeling, and identified the need for an additional postdoc at UCSD to develop empirical data sources and analysis. Thus, after interviewing Rex Douglass at LLNL, we determined he was not a good fit for the LLNL portion of the CDD Project, but we referred him to UCSD, which in fact did hire him, to great benefit to the new empirical task and to the Project as a whole.

As a result of these discussions about the roles of potentially two postdocs, and after reviewing the applications we had received, we decided to revise the LLNL posting to focus more on agent and/or discrete event modeling. The revised posting went up June 14, 2015. Given the narrower focus, we also advertised the new posting on the users' email lists for ns-3 and Repast, two widely used discrete event and agent modeling software tools. Since then we received another nine applications, and conducted one phone screen.

After a year of reviewing applications we had to face the reality that the LLNL postdoc position wasn't going to be easy to fill.

In parallel LLNL was making a staff hire in Computer Science, Braden Soper, who in the course of his thesis work developed significant experience in discrete event and agent modeling. When we became aware that Braden was definitely coming to the Lab, and starting in January 2016, we evaluated again our posting and the kinds of candidates applying, and decided it would be more effective for the CDD Project for Braden to work on the Project half time, starting as soon as we could resolve the funding, rather than continuing to look for a postdoc and risk not finding a suitable candidate.

Development of Modeling Approach

From a simulation perspective this problem domain can be characterized as: many agents with complicated and varied rule sets, taking moves at irregular times, with many possible interaction terms in any one move. This type of problem is typically approached with a stochastic discrete event simulation (DES). Our DES lead (Peter Barnes) has participated with the entire CDD collaboration from the beginning, primarily through the twice-annual workshops hosted by UCSD.

At the most recent workshop, 2016-01-29, we made a significant breakthrough, leveraging nascent work by Jon Lindsay, U. Toronto, to articulate in a quantitative way how each agent will respond to others' actions. Each agent represents an actor: state, NGO, or other non-state actor. "Actions" represent things an agent might do: deploy forces, attack, impose trade sanctions, make a statement, *etc*. "Objectives" represent qualities that contribute to an agent's satisfaction:

gaining influence with others, gaining information, reducing risk of conflict, reduce costs. In the simple case each action type carries a weighting vector across the space of objectives, *e.g*, developing and deploying space assets may increase my ability to gain information, but can be relatively costly.

Upon learning of an action, an agent updates its own "satisfaction" score, based on its own weighting of the overall importance of each objective. The agent also updates its assessment of others' satisfaction, based on the agent's beliefs about others' weights, including uncertainty. That is, each agent has an internal priority across objectives, and internal satisfaction, as well as its own estimate of others' objective weights and satisfaction. This enables each agent to evaluate it's own potential moves with respect to both its own gain in satisfaction/utility, as well as impact on others.

The ultimate set of actions and objectives utilized in the models will come primarily from the empirical work, particularly the ICB coding project. In particular, Rexx Douglass has pioneered linguistic approaches to situating action words, for example, from the ICB narratives within well-established hierarchical trees of semantic meaning, enabling us to move smoothly from a large number of very specific terms to a smaller number of more generic terms. This will allow us both to relate different but similar terms within one model instantiation, as well as vary the degree of specificity represented across model instantiations.

Of course these ideas need to be expressed more precisely, and there are a host of generalizations that should be explored.

This work has been and will continue to be informed by ongoing participation by the political scientists on our team, providing frequent feedback on the grounding of our modeling with regard to the body of knowledge in political science.

Space as Proving Ground for CDD Concepts

Our group of LLNL political scientists (Ben Bahney, Mike Markey and Jonathan Pearl) have participated in the CDD workshops since the first one in July 2014. Our overarching goal has been to bring additional analysis and perspective on the larger CDD group's thinking on space security, cyber, and East Asian security issues. Under the CDD funding, we developed a detailed analysis of the role of space security in the 21st century. In particular, we reviewed the current U.S. government thinking on space security, we evaluated how both major and emerging powers are using or developing space and counterspace capabilities, and assessed how those capabilities will affect broader strategic stability and arms race dynamics. We then laid out a set of challenges for "cross domain deterrence" in the context of space security and developed a research agenda for the area, in light of how little attention it has received from the security studies community.

We wrote this work into a chapter on space security and cross domain deterrence for the Project's edited volume, which we recently delivered to the Project PIs. We first gave a talk on the concept behind the chapter at the October 2014 Minerva conference in San Diego, and we got useful feedback from Bob Jervis, Barry Posen, Austin Long and Jasen Castillo. We then wrote the chapter from fall of 2014 to mid-2015, and we presented our final paper at the Minerva retreat in Santa Ynez in September 2015. Our chapter has been accepted into the final manuscript, and was included in the pre-read packet for the May 2016 conference "A New Look

at the 21st Century Cross Domain Deterrence Initiative." Jon Lindsay asked us to review another one of the Minerva draft chapters in early 2016, and our team did an extensive critique of the piece. Based on our feedback, Jon passed on the chapter for the manuscript.

Participation in CDD Collaboration

We have participated in each of the CDD workshops since the first one held in July 2014. At that workshop we presented an overview of our proposed modeling approach for the simulation part of the Project. At subsequent CDD workshops we have been refining our thinking and approach. We have also been working informally with Rex on refining the empirical approach, particularly the ICB coding Project, to ensure that we maximize the utility of the results for instantiating and validating simulation models.