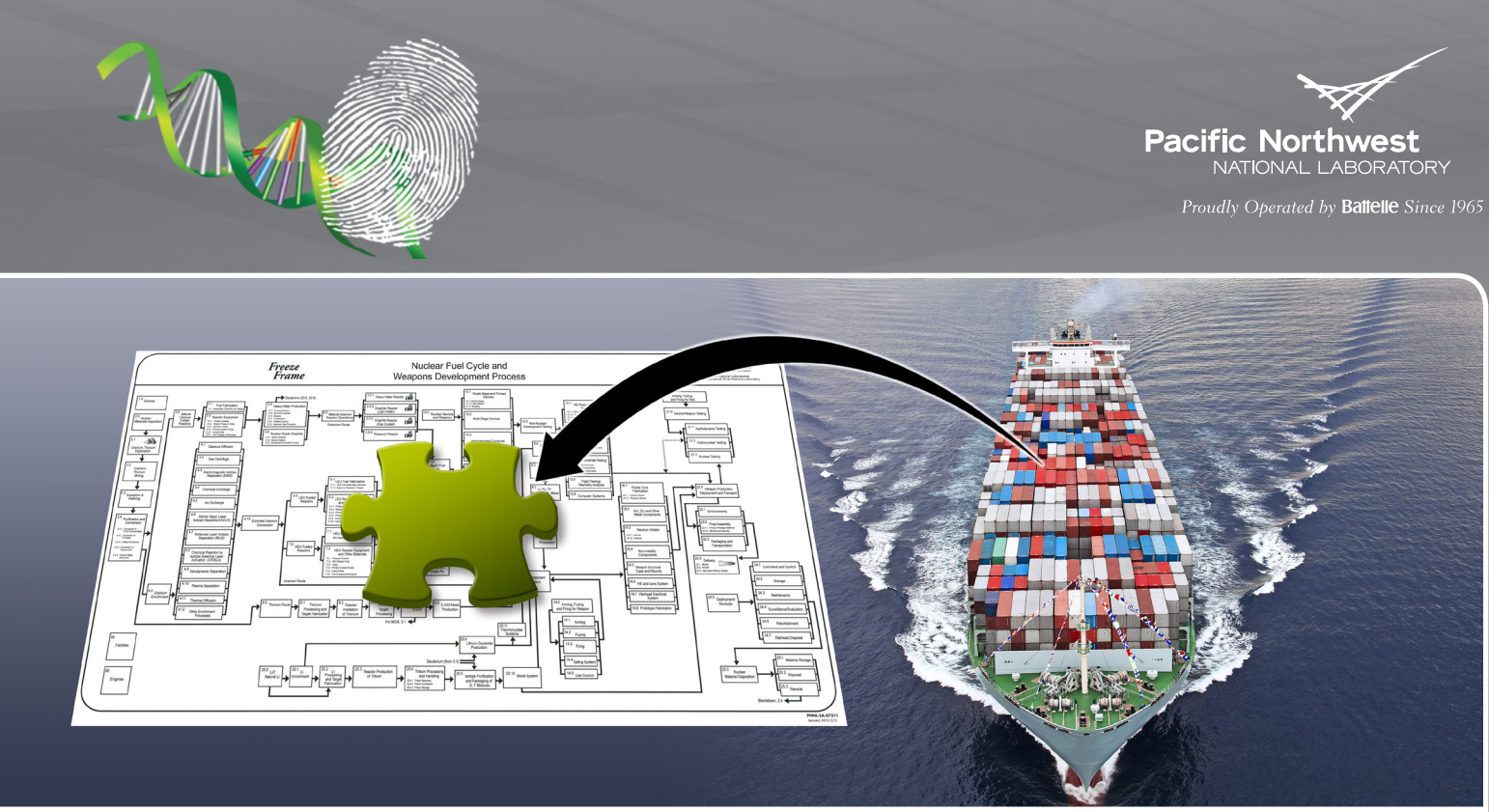



# Signatures of Illicit Nuclear Trafficking of Strategic Goods (SINT)

*Applying signature discovery processes to discover, exploit, and validate signatures of networks of strategic nuclear goods in international commerce*

## CHALLENGE

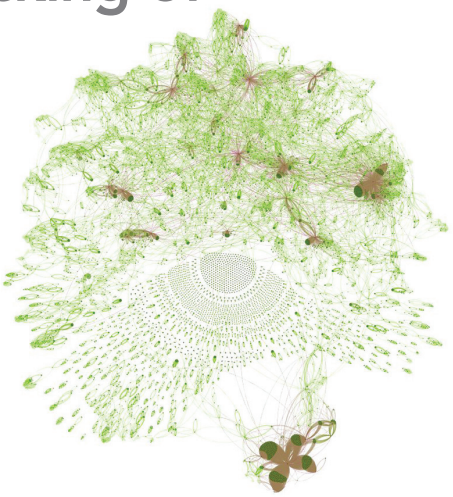
Analysts in the nuclear nonproliferation field evaluate the problem from various depths to identify collections of businesses or individuals working to obtain a set of materials and technologies that will support development of a clandestine nuclear program. These collections of individuals/businesses, commodities, and transactions make up a procurement network, whose structures naturally form a graph. While the information found in these networks may provide insight for nuclear nonproliferation analysts, data sets are often too complex to comprehend using human cognition alone.

## GOAL

The goal of the Signatures of Illicit Nuclear Trafficking of Strategic Goods (SINT) project is to apply the Pacific Northwest National Laboratory (PNNL) Signature Discovery Initiative (SDI) tools and methods to establish a more rigorous and efficient approach to detect and characterize procurement networks dealing in dual-use and strategic nuclear technologies.

## APPROACH

The SINT project uses a mathematical process to incorporate graph theory and nonproliferation subject matter expertise to define the structure of procurement networks. In this approach, we describe the role (distributor, consumer, supplier, or manufacturer) and motivation of the actor of interest (node) within that network based on the contents and movement of commodities in which they deal.



*International commerce data sets are often too complex to comprehend using human cognition alone.*

## APPLYING SIGNATURE DISCOVERY

We are working with a variety of methods in topic modeling, clustering, set theory, and graph comparison to construct reasonable mathematical features that correspond to social science and business practice concepts. The rigorous construction of signatures required an initial phase of exploratory data analysis to precisely define both the problems of interest and the content and noise of the data. This was followed by a second analysis cycle where the features and signatures are iteratively defined and tested.

Our approach to signature construction is three-fold:

- Classify a node based on its commodity, time-induced patterns, and role to identify a behavioral pattern. This allows us to abstract away from a company or individual's identity and focus on its function within a network.
- Classify a node based on its consistency to other nodes in networks in a similar industry.
- Classify the procurement network (a collection of nodes abstracted to their roles and motivations) in which the node operates.

To evaluate our signatures, we will conduct an experiment comparing the SINT project methods of network analysis to the results of an expert analysis, measuring accuracy, time, and confidence in the results. Our project team has worked extensively with nonproliferation analysts at PNNL to ensure that the capabilities being developed have relevance to the problems analysts face, support or enhance their current processes, and are designed to ingest data for which there exists an analogue in their work.

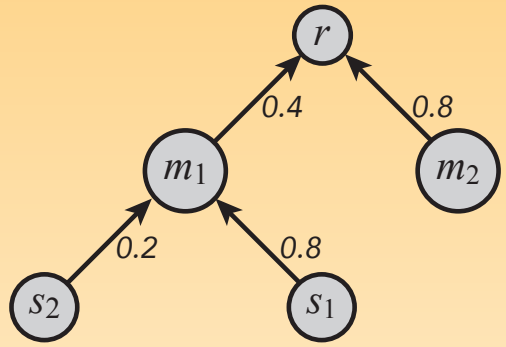
## BENEFITS

If successful, our work could support analysts in more efficiently

- identifying and characterizing international procurement networks having important implications to nuclear nonproliferation efforts,
- improving the contextual information available to analysts to support their conclusions regarding the use of export-controlled commodities within international commerce, and
- providing a mathematically rigorous and repeatable foundation upon which to base their analysis and support their analytical reporting requirements.

## FUTURE DIRECTION

The SINT project team is seeking research partners and new network-related problem spaces to test the algorithms and methods developed in this research project.




*We are applying mathematical processes, graph theory and nonproliferation subject matter expertise to define the structure of procurement networks. In this example,*

- *Nodes (circles) are companies and edges (lines) are shipments.*
- *S1 and S2 are suppliers, M1 and M2 are manufacturers, and R is the root company of interest.*
- *Functions on the tree can be formulated to indicate movement of goods to a centralized location.*
- *Each node can be classified as a distributor, consumer, supplier, or manufacturer.*
- *Each node has a motivation based on the set of commodities.*
- *Each node has a distinguishable temporal pattern that can be categorized.*

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