Large-Scale Social Simulation for Engineering Strategic Communications

Project Kick-Off Meeting
Sandia National Laboratories

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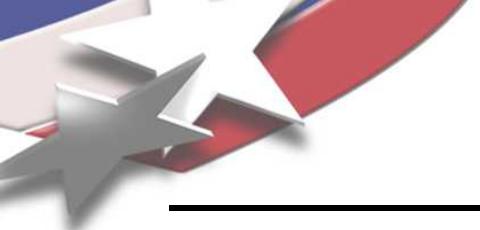
Outline

- **Sandia National Laboratories Overview**

- **Cognitive Science and Technology Overview**

- **Large-Scale Social Simulation LDRD**

- **Large-Scale Social Simulation for Engineering Strategic Communications Project**

- **Milestones and Schedule**

- **Cost Profile**

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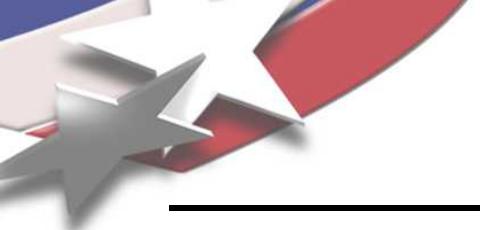
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"Helping secure a peaceful and free world through technology"
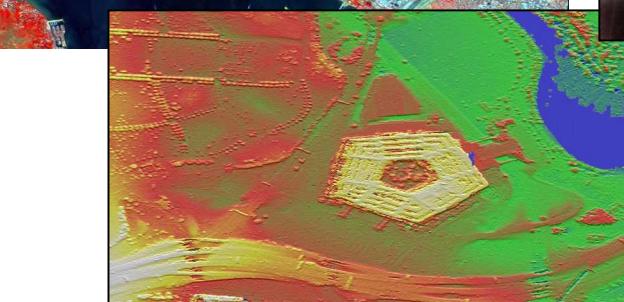
National Security Trends Involve the Human Element More Than Ever Before

National security threats are evolving rapidly
- **terrorism, asymmetry, big data problem**
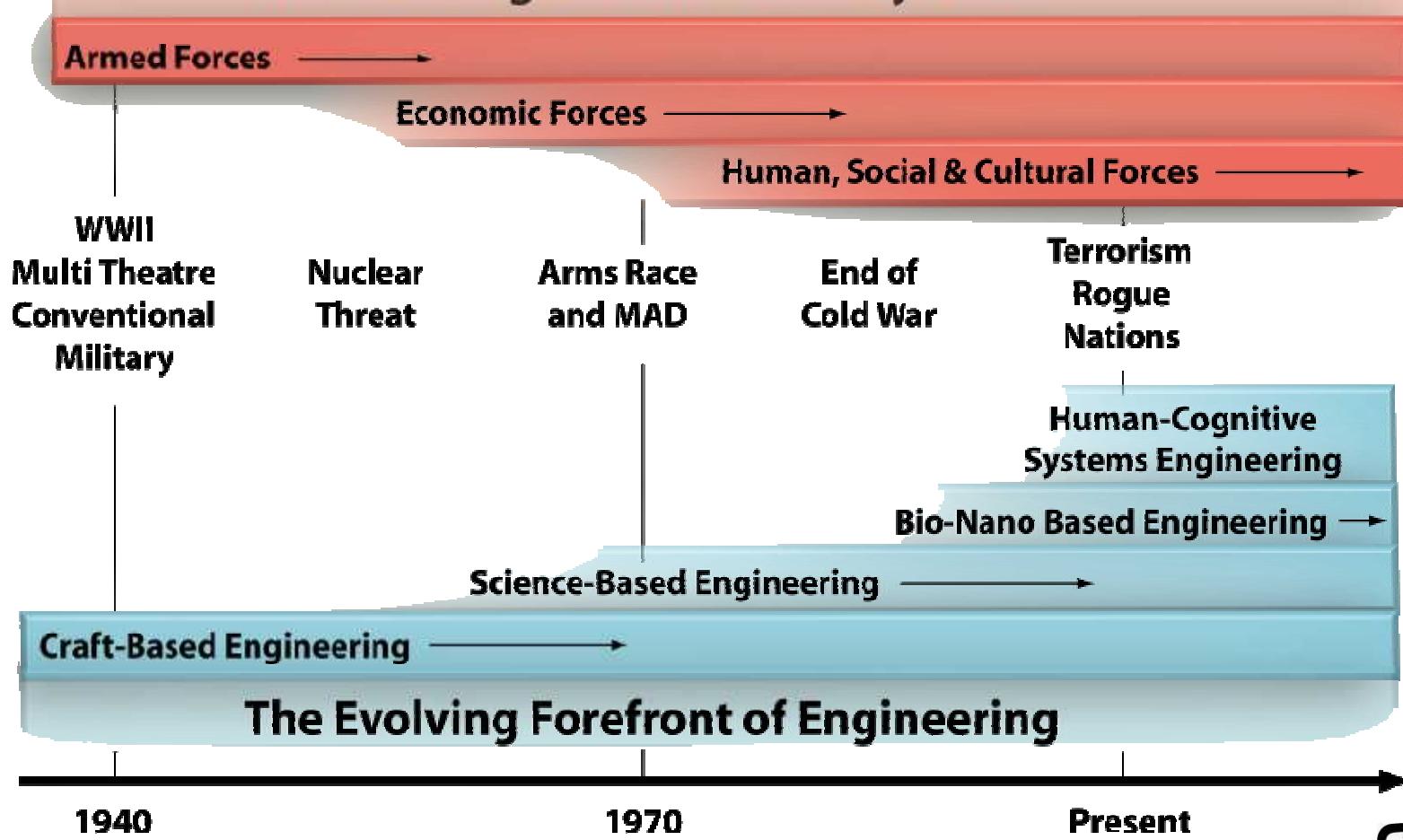
Technical solutions are no longer sufficient
- **include human elements (e.g., social, cultural, limited workforce, retirees)**
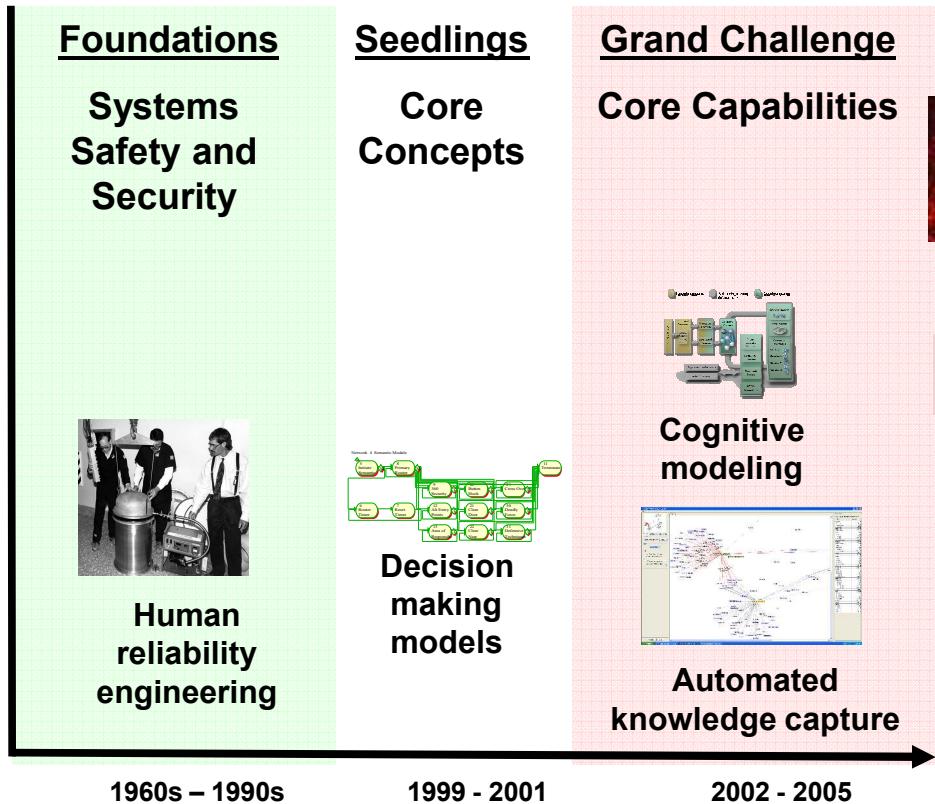
Laboratory and military transformation
- **do more, do better, with less**

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Sandia Must Continue to Evolve to Best Serve the Nation

The Evolving National Security Focus

Armed Forces →

Economic Forces →

Human, Social & Cultural Forces →

WWII Multi Theatre Conventional Military

Nuclear Threat

Arms Race and MAD

End of Cold War

Terrorism Rogue Nations

Human-Cognitive Systems Engineering

Bio-Nano Based Engineering →

Science-Based Engineering →

Craft-Based Engineering →

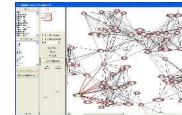## The Evolving Forefront of Engineering

1940

1970

Present

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Cognitive S&T Has Become Laboratory-Wide Focus Area

Cognitive Science and Technology

Foundations

Systems Safety and Security

Seedlings

Core Concepts

Grand Challenge

Core Capabilities

Modeling individuals from text
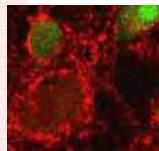
Nanoscale Probes

Atomic Magnetometer

Human reliability engineering

Decision making models

Cognitive modeling
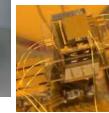
Automated knowledge capture
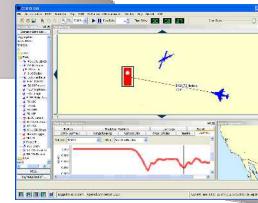
Training technologies

Driver augmentation

| 1960s – 1990s | 1999 - 2001 | 2002 - 2005 |

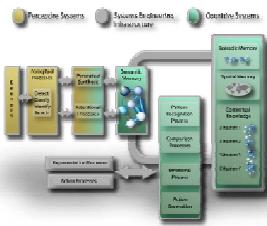**Emphasis on understanding the underlying science to engineer new technology solutions… Science-based engineering**

Laboratories

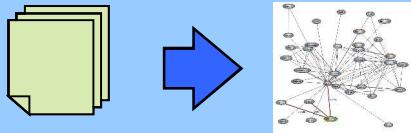# Cognitive Framework and Automated Knowledge Capture Provide Basis for Integrated Products

CS Products

Cognitive Framework

Generic cognitive engine employed with each product

Automated Knowledge Capture

Text Sources

Understand the Model

Use the Model

Machine Transactions

Dynamic Adaptation

Spatial Domains
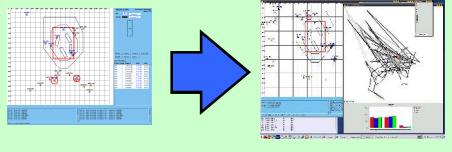
Acquire model of individual through observation of everyday activities

Automated After Action Review
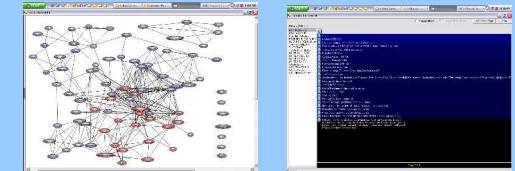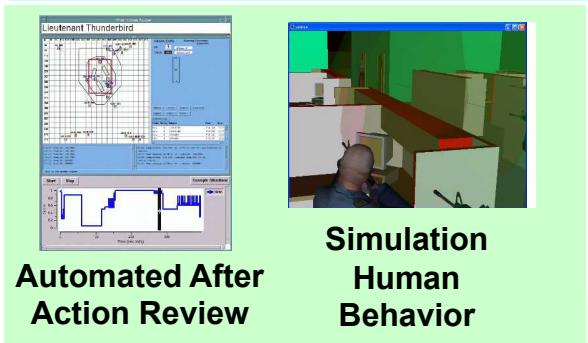
Simulation Human Behavior

Laboratories

FY05-FY08 Sandia Invested to Establish Large-Scale Social Simulation

Problem

In combating terrorist and criminal organizations, analyst need tools that incorporate key facets of **operational social structure** to gain insights into **patterns of influence and resistance** within a target population.

Key Accomplishments

- Front-to-end system spanning data collection to simulation analysis

- Proof-of-principle demonstration based on shift in public opinion in Jordan after November 2005 bombings
  - **Data analysis of first simulation run under way**

- Capability for large simulation (100K agents) using heavy-weight cognitive agents

- Extensible from desktop to High Performance Computing platforms

- Integration of core capabilities in automated knowledge capture, cognitive modeling and agent-based social simulation

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STANLEY Automated Knowledge Capture from Text

Analysis of text enables models to be derived that encompass key concepts, concept associations, and contextual and temporal patterns of concepts.
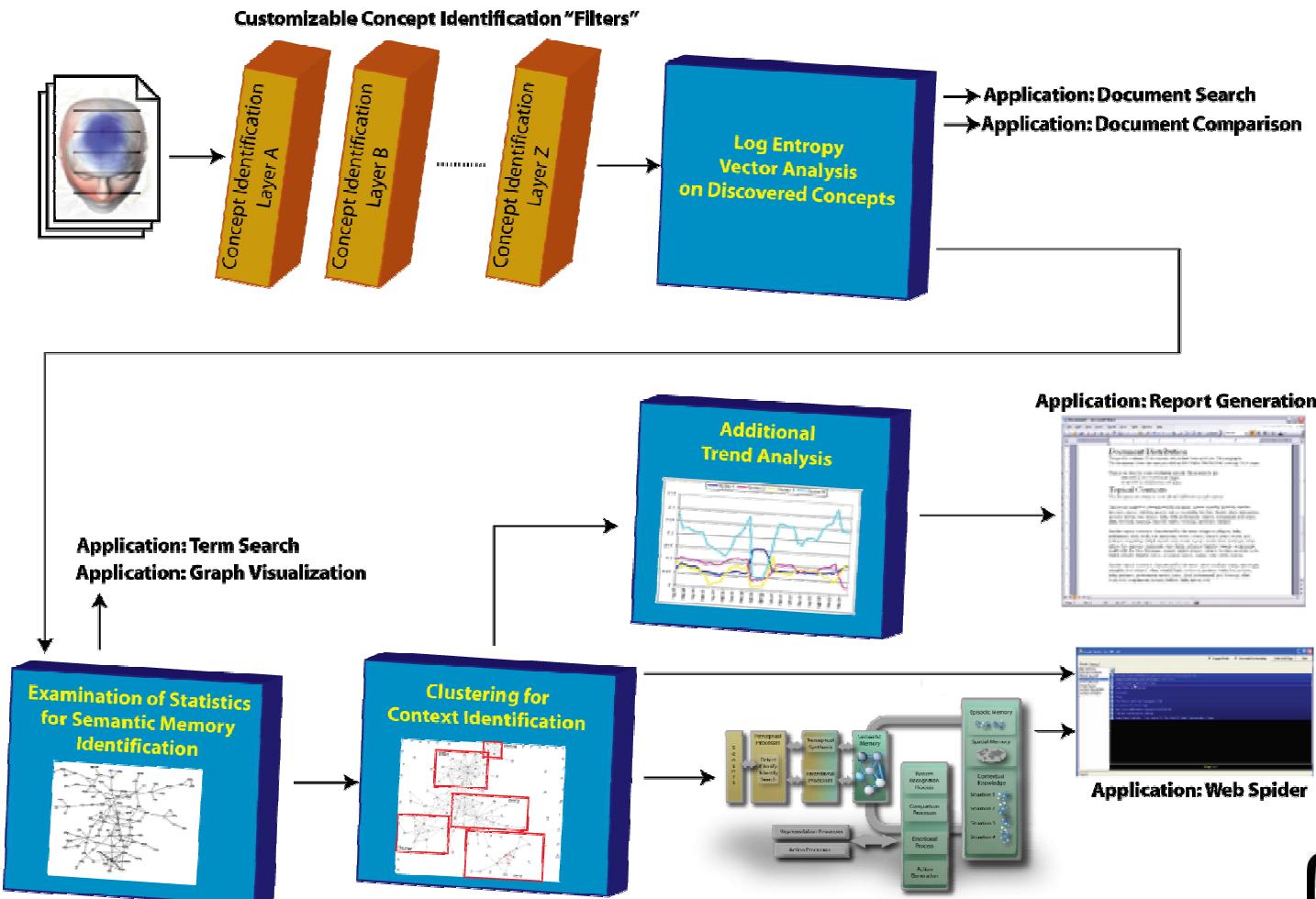
Cognitive Foundry Provides Toolset for Constructing Cognitive Agents

- **The Cognitive Foundry is used to create psychologically plausible cognitive models**
- **The cognitive model is a semantic graph of concepts and their relationships**
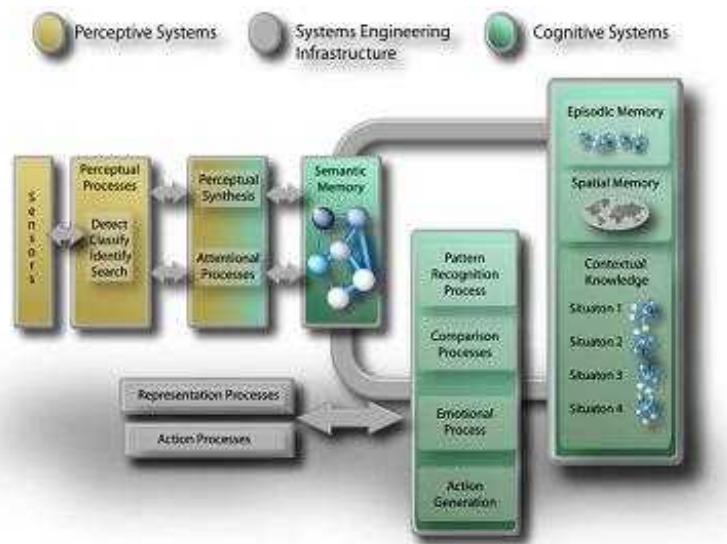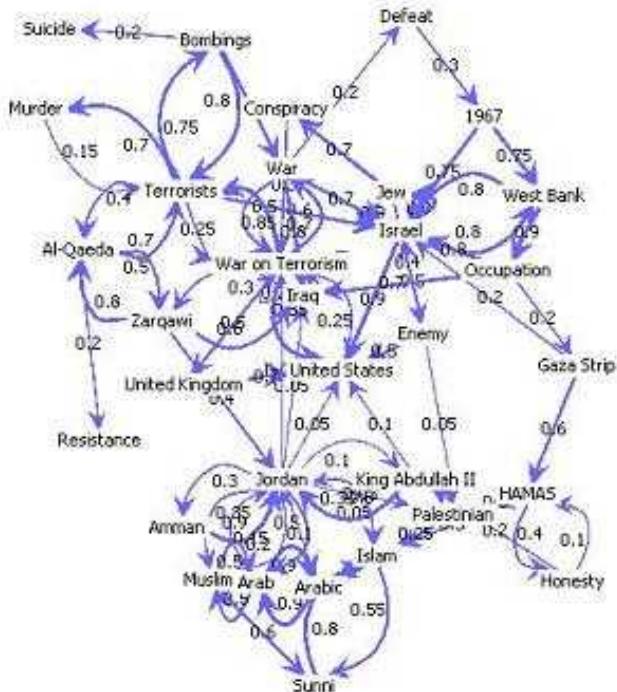
- **Information spreads throughout the graph when activated**
- **Cognitive models are created automatically from text-based documents**
- **A lightweight version of the foundry facilitates running in a parallel environment**

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Seldon Provides an Agent-Based Social Simulation Toolkit

- **Name comes from Hari Seldon in Isaac Asimov's *Foundation* stories**
- **Has been used to study inner-city gang and terrorist recruitment**
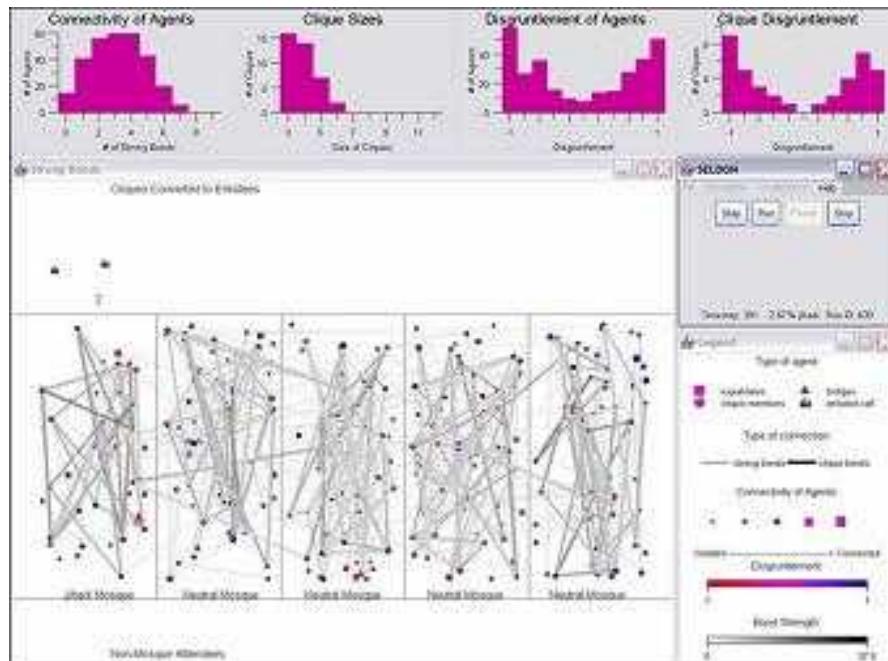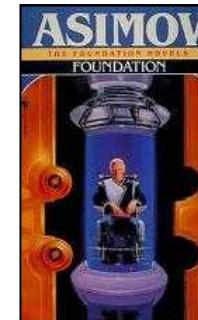
- **An agent can be an individual or a collective (i.e. school, mosque)**
- **Seldon allows for dynamic social network evolution**
  - **Agents interact according to exchangeable rule sets**
  - **Interactions spawn relationships and formation of social networks**

Agent interactions in Cognitive Seldon

4/27/2014

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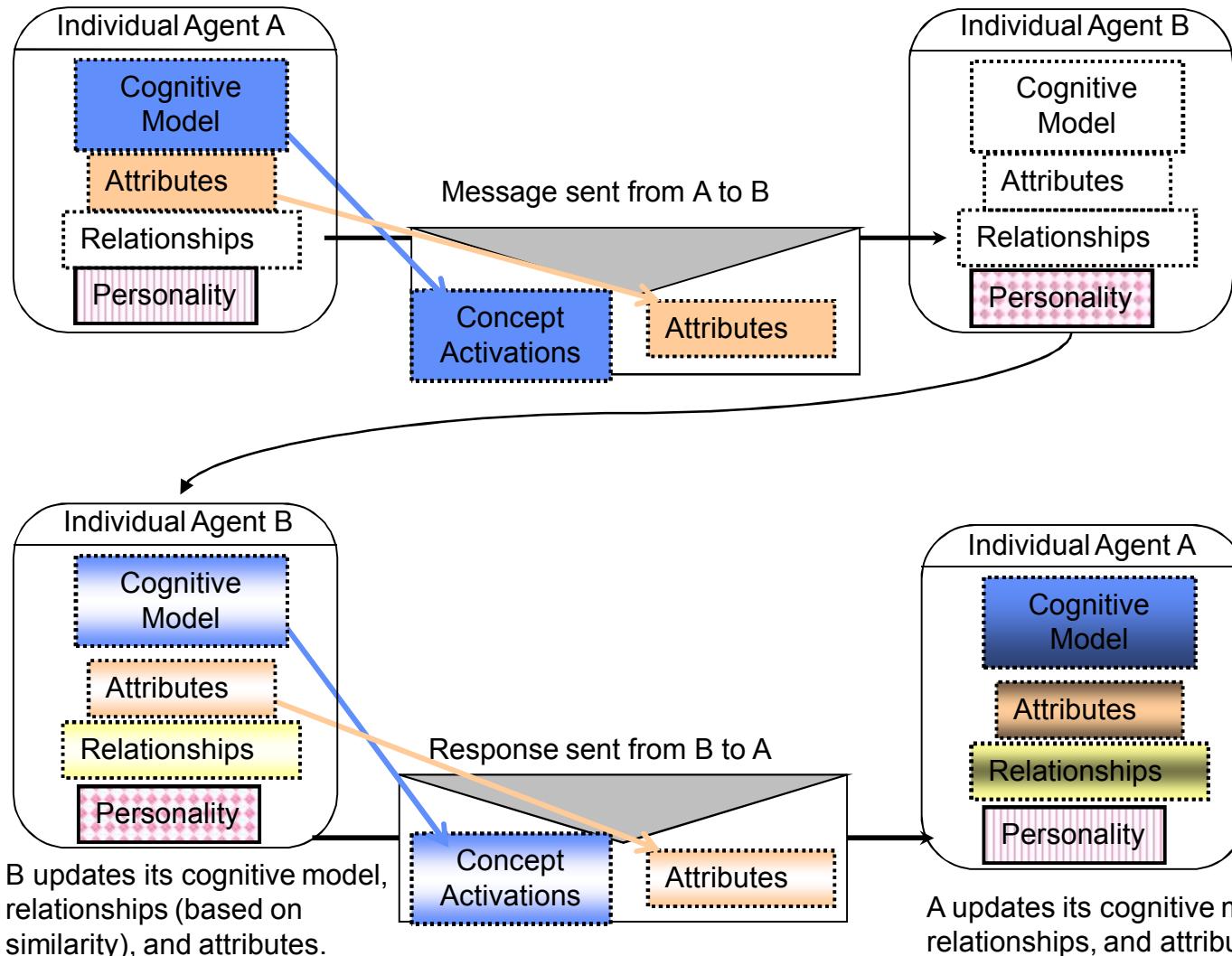
Cognitive Seldon Employs Cognitive Models for Realistic Agent Behavior

Agents exchange cognitive information when they interact

Each agent has a cognitive model that is created automatically from text-based documents. The agents use this model to comprehend new information

Media agents can also introduce new cognitive information during the simulation

The agents interact, form networks, etc. within Seldon

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Cognitive Seldon Architecture
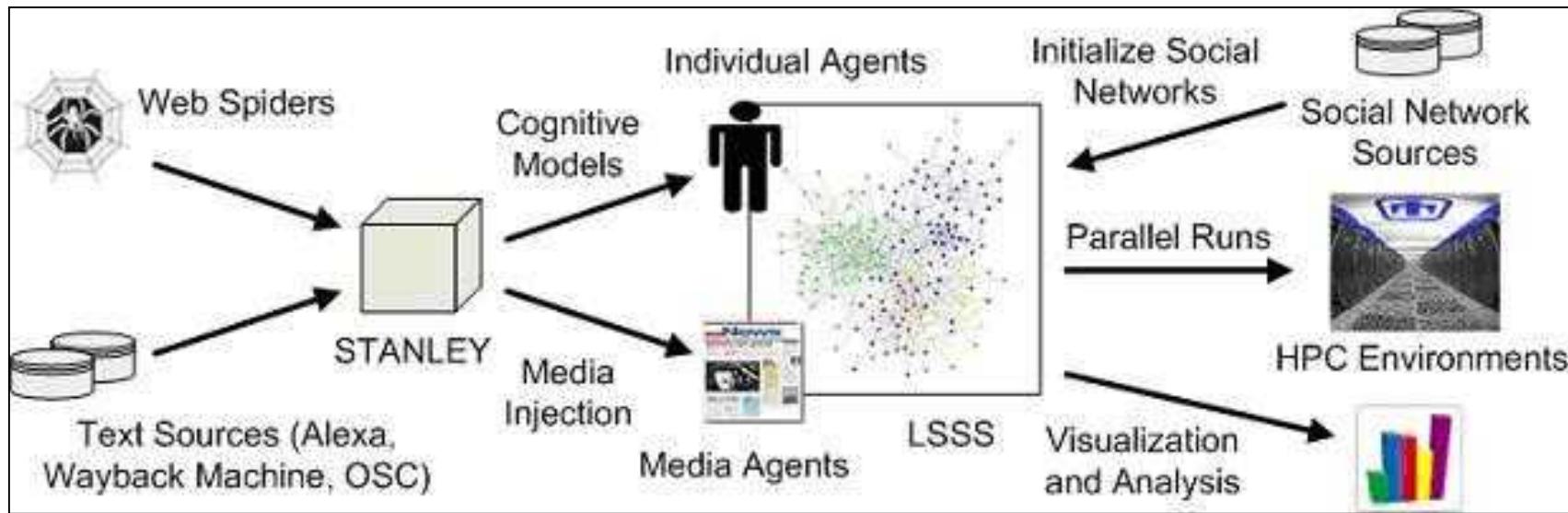
Our Approach

- **Use STANLEY to collect and process internet-based media text (i.e. newspaper articles, blogs)**

- **Translate that media information into the Cognitive Foundry's cognitive models**

- **Integrate the cognitive models into the Seldon social network simulation**

- **Run Cognitive Seldon simulations to produce visualization and other output**

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Analysis of Spatial-Temporal Patterns in Semantic Data Sources

Initial product was tool allowing analysts to examine data collected from media sources to detect and understand spatial-temporal patterns.
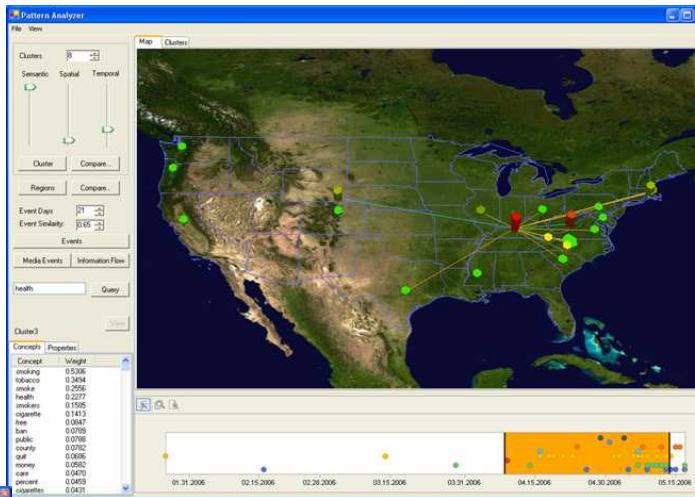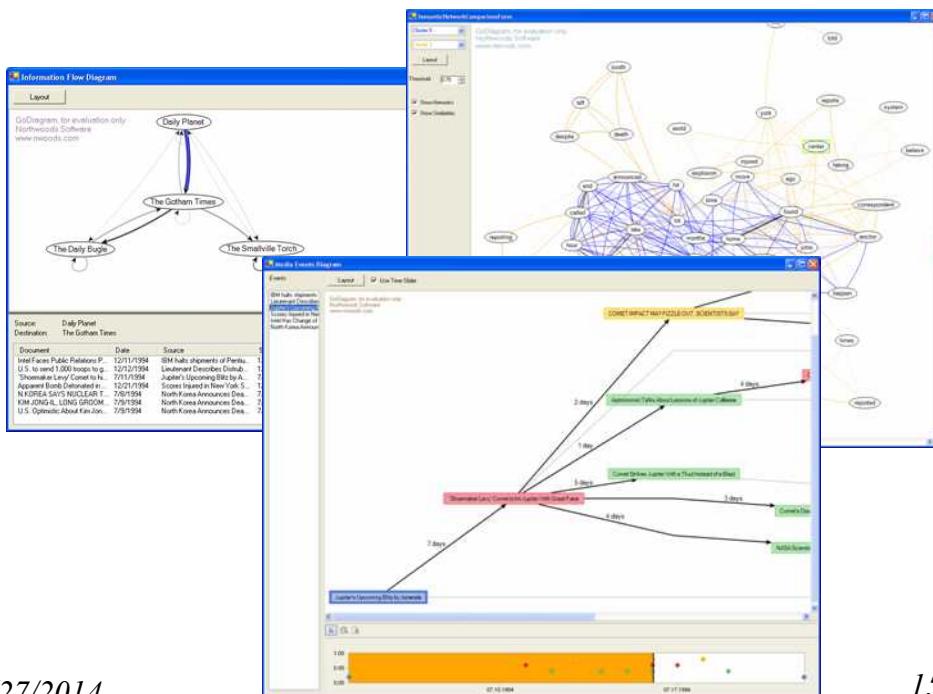
- Tool tracks information flow
  - Automated spatial-temporal pattern analysis
  - Visualization
  - Report generation
- Examine Hypotheses
  - Paths and spheres of influence
  - Sources versus repeaters
  - Differential spin

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FY08 Proof-of-Principle Focused on the November, 2005 Jordan Hotel Bombings
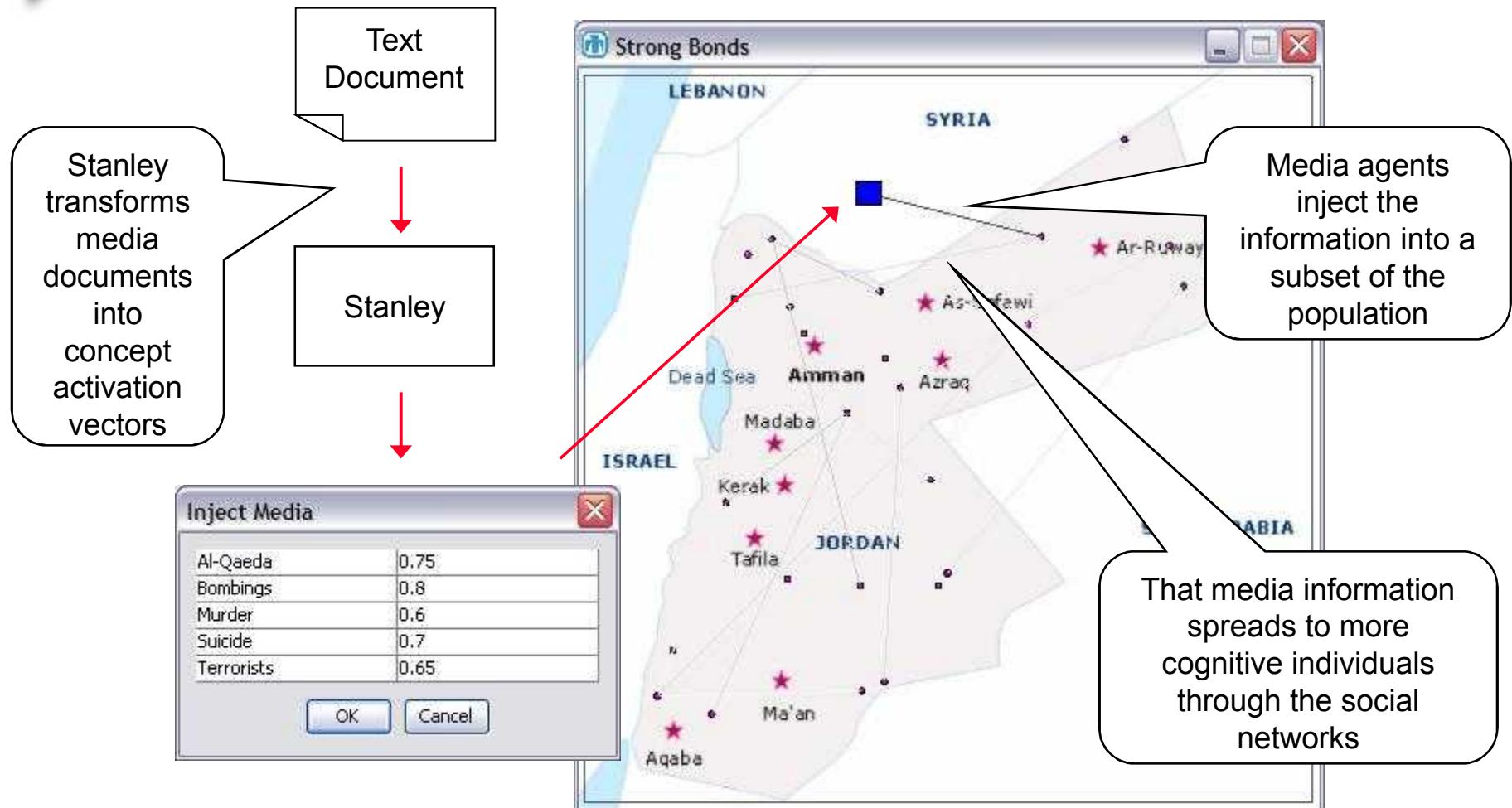
In real life, there was an 18 percent negative shift in public opinion polls taken before and after the bombings regarding how positively Jordanians regarded Al-Qaeda

Sandia Investments in Basic Capability Transitioned to TSWG

Project Title

Large-Scale Social Simulation for Engineering Strategic Communications

Problem

"More than half of the battle is taking place on the battlefield of the media."

Al-Qaeda's Ayman Al-Zawahiri (Pintak, 2008)

• **Messages conveyed through the media can positively or negatively affect beliefs, opinions and behavior, and become the tools of those seeking to influence a population.**

• **The effects of mass communication are complex, moderated by both the social environments in which they are embedded and by the individual predispositions of audience members.**

• **Military and intelligence analysts need tools enabling them to:**
    – **anticipate reactions generated by the words we use and ways in which our words may be used against us,**
    – **understand how media forces within a given nation differentially influence the population,**
    – **discern the methods and relative effectiveness with which different groups utilize and manipulate the media to advance their objectives**

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Research to Advance Strategic Communications and Enable Practical Tools

Objectives

Basic Science – understand and predict media effects on the beliefs and opinions of a population based upon the flow and transformation of ideas as members of different social networks interact

Applied Science – exercise Cognitive Seldon through application to a realistic population and comparison of predictions to actual events

Engineering – develop process and tools:

- (1) facilitate application of Cognitive Seldon to new populations, and their media, and
- (2) enhance analyst interpretation of results obtained from Cognitive Seldon simulations

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Approach for Year 1 Objective: Indonesia Demonstration

Collect media data

Model media <u>sources</u>

Antari

Perspektif Online

Jakarta Post

Characterize <u>population</u>
- Demographics
- Published research
- Common media
- Group-specific media
- Field studies

Automated Generation Cognitive Agents

Characterize patterns of <u>interaction</u>
- Economic and census data
- Published research
- Field studies

Year one demonstration: Cognitive <u>Seldon Indonesia Simulation</u>
- Query media sources regarding key ideas and associations between ideas
- Identify naturally-occurring clusters based on shared beliefs within population (Seldon cliques)
- Query population on beliefs (i.e. simulated polling)
- Present events to predict response by media and subsequent effects on population

Approach for Year 2 Objective: Validation and Benchmarking

Antari

Perspektif Online

Jakarta Post
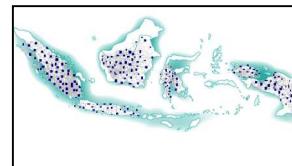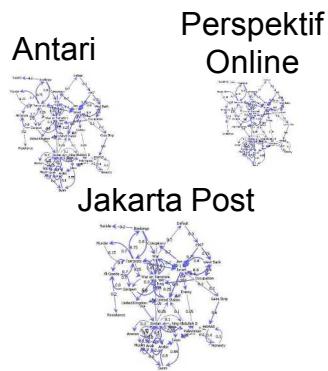
Metric:
Do media models predict coverage by different media sources?

Benchmark Study

End-User Surrogates

• Relative accuracy of predictions
• Level of effort required to reach comparable conclusions

Cognitive Seldon Indonesia Simulation

Significant Event Involving U.S.

Field Study of Beliefs and Opinions

Metric:
Does Cognitive Seldon predict changes in beliefs and opinions

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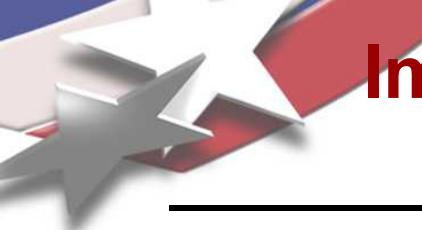
Impact: this project addresses current and future U.S. military needs

- **Provides practical products that may be used in analysis, planning and training for strategic communications and related aspects of irregular warfare allowing military analysts to:**

  - **model strategic communications and their societal impact,**

  - **develop greater understanding of social and cognitive drivers for message influence and resistance**

  - **anticipate how populations will react to events conveyed through mass media**

- **Such tools will improve the effectiveness of U.S. strategic communications, while providing insights regarding the unanticipated consequences of military and political decisions**

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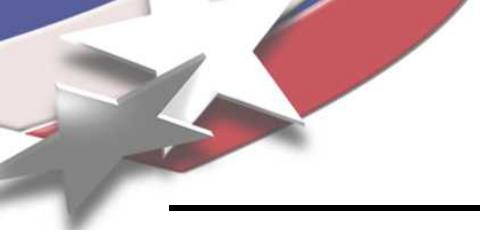
Programmatic Information

- **Proposed Milestones (open to negotiation)** ▶
- **Proposed Cost Profile** ▶

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Questions or Comments

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Back-Up Slides

Cognitive Seldon was developed to address a specific type of problem

Analytical needs have expanded beyond topics like technology and nonproliferation and now have a core central human element.

Analysts need systems that incorporate operational social structure, including patterns of influence and resistance, terrorist groups, criminal groups, and general social organization to produce a massively parallel social simulation for a given local or global conflict.

This three-year project is developing new analytical tools and simulations to facilitate the understanding of these human elements that are scalable to realistic problem spaces. Our Goal is to aid analysts and policy makers in understanding how the propagation of information may be perceived
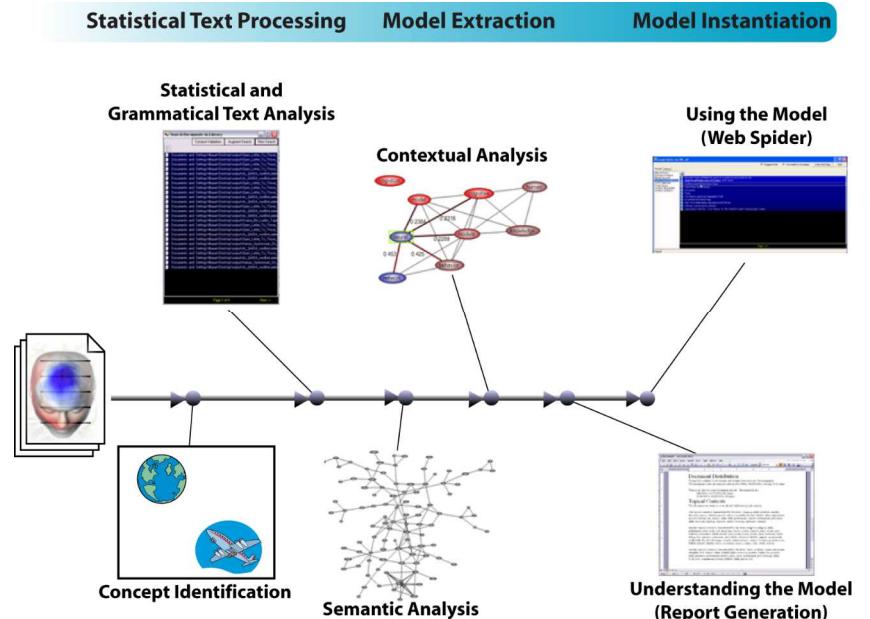

🔴 Critical gaps

- ◆ Automatic generation of human cognitive models based on disparate sources
- ◆ Integration of cognitive models with human behavior/social networks
- ◆ Automatic identification of social networks characterized by a group or population
- ◆ Development of analytic tools to answer real-world questions

4/27/2011

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STANLEY Library

- **STANLEY is the Sandia text analysis extensible library**
  - **Text analysis library designed for building and utilizing models of individuals from text that they produce or access**
- **Main Features**
  - **Reusable library that programmers can implements into new applications.**
  - **Flexible implementation of text analysis algorithms**
  - **Identification of key concepts, relationships, and contexts from text documents.**
  - **Web spider for evaluating new information based on a previous analysis.**
  - **Generation of reports in MS Word describing key characteristics of an individual based on the text analysis.**

| Statistical Text Processing | Model Extraction | Model Instantiation |

Statistical and Grammatical Text Analysis

Contextual Analysis

Using the Model (Web Spider)

Concept Identification

Semantic Analysis

Understanding the Model (Report Generation)

- **Example Applications**
  - **Any application where one wants to integrate Sandia's cognition text analysis capability into some new application.**
  - **Finding new relevant documents**
  - **Understanding how a person or source has changed across time.**

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Sandia Analyst Aide
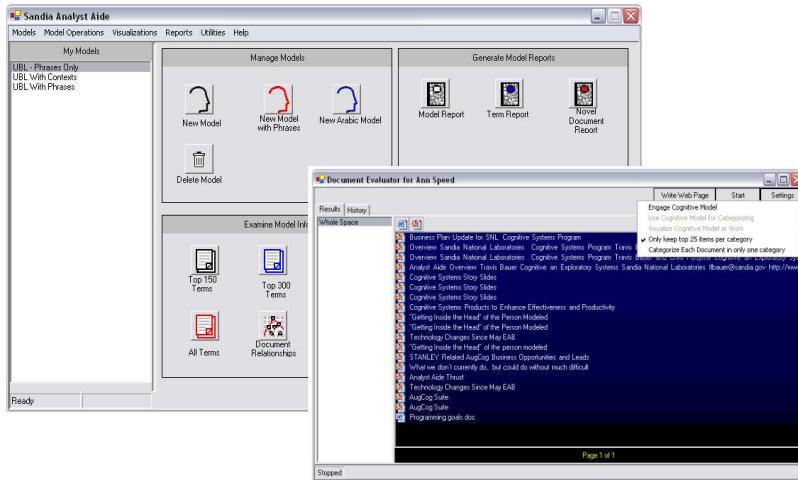
*The Analyst Aide exposes most of STANLEY's functionality*

- **Example Applications**
  - **Understanding the "big picture" of what the key concepts and relationships are for a person.**
  - **Look at how a particular term or group of terms has become more or less important across time.**
  - **Find documents that a person is likely to find of value.**
  - **Query a model of an individual for related terms and documents.**

- **The Analyst Aide is an application for**
  - **Building models of individuals from text they produce**
 - **Understanding and utilizing those models**

- **Main Features**
  - **Convenient interface to most of the features in the STANLEY library.**
  - **Manage multiple models at one time**
  - **Track how a person changes across time.**
  - **Use a model to find new information on the web or evaluate new documents.**
  - **Create graphical visualizations of the relationships among models.**

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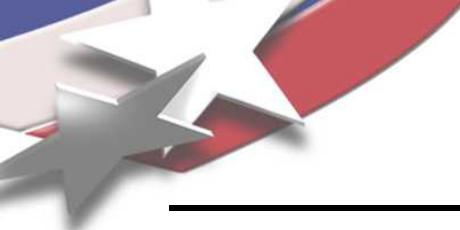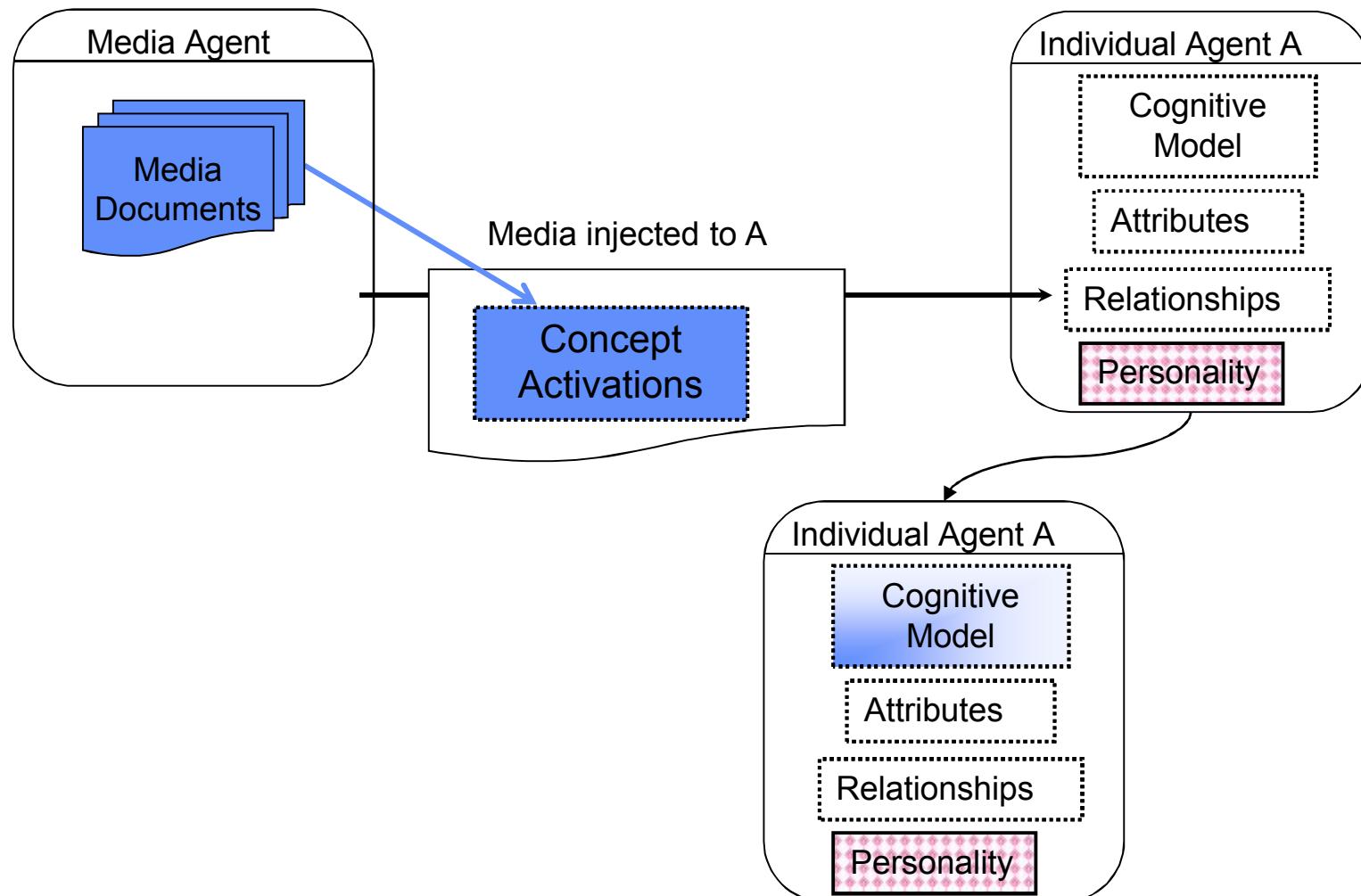
Seldon Toolkit – Networks

- Different levels of **networks**: *acquaintances*, *strong bonds* (friends), and *cliques* (close knit set of friends)
  - In each level, the members are more similar and interact more frequently than the members of the previous level
    - This mimics how people seek to interact with those that they have already met and felt a connection with
  - The networks are built up through random interactions in the world network (which contains all agents). For instance, if you continue to interact with acquaintances, they might turn into friends
  - By varying an agent's interaction with different networks, the underlying dynamics of social scenarios are shown through the types of friendships that form

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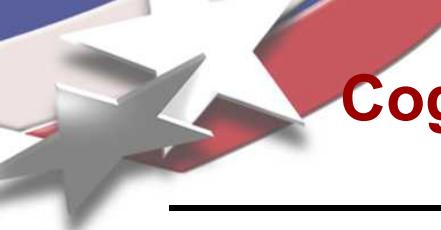
Cognitive Seldon Integrates the Seldon Toolkit and the Cognitive Foundry

- Seldon
  - models society (e.g. the interactions, relationships, and networks among agents)
  - Each individual agent has a cognitive model for comprehending new information in a psychologically plausible manner
- Cognitive models are created automatically (using STANLEY) from textual sources. They represent the semantic relationships described in the documents
  - Each term in the documents is treated as a concept, and relationships between concepts are based on how frequently terms occur together. Contexts are sets of concept activations identified using clustering algorithms
  - Information is exchanged between agents/models using vectors of concept activations
- Media agents introduce concepts from textual documents to a subset of the population

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Interaction with Media Agent

A updates its cognitive model.

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