Estimating the near-term changes of an organization with simulation

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Introduction

- Interesting 'what-if' scenarios
  - What if some employees in a company resign,
    - Can the company perform at the same level?
  - What if some officers in a unit are not operable,
    - Can the unit be as responsive as usual?
  - What if some terrorists in a terrorist network are captured,
    - Can the network perform operations successfully?
- Also,
  - What would be the worst/best scenarios?
  - Are there any ways to create the scenarios systematically?

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Background and related works (1)

- Interesting experiments with people
  - Virtual software company (Weber er al, 2004)
    - Varied company structure, from centralized/hierarchical to decentralized/egalitarian
    - Centralized/hierarchical firms -> rapid development
    - Decentralized/egalitarian firms -> easy assimilation of new entrants
  - Decision makers of organizations (Jin and Levis, 1990)
    - A parallel structure versus a hierarchical structure
    - Individual difference has more influence on performance in the parallel organization
    - Interactions in the hierarchical organization restricted the choices of the decision makers.
  - Unit of Action experiments (Graham, 2005)
    - Role-playing with an experimental command and control structure
    - Small cell structures and inter-cell connections
    - Identified social distance, physical distance and background similarity as important factors of shared situation awareness

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Background and related works (2)

- Interesting experiments with multi-agent simulations
  - CORP (Carley and Lin, 1995)
    - Examined organizational structures and their performance under various test conditions (operating in optimal conditions, operating under internal/external stresses, etc)
  - Construct (Schreiber and Carley, 2004)
    - A validation study on Construct
      - Compared the generated probability interaction matrix to the communication frequency from surveys
    - An empirically validated what-if analysis
      - Did what-if analyses with the cases showing high correlation between the simulation result and the survey result
      - Plot the expected performance changes over time
  - Virtual Design Team (Kunz, Levitt and Jin, 1998)
    - Develop computational tools to analyze decision making and communication behavior to support organizational reengineering
    - Output includes the predicted time to complete a project, the total effort to do the project, a measure of process quality, etc.
    - Reducing time to market -> previously sequential activities

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Common aspects of previous papers

- Some important factors considered in the papers
  - Organizational structure
  - Distribution of resource/knowledge
  - Dependencies among tasks, resource and knowledge
- Multi-agent simulation/experiment

Dynamic Network Analysis and Computational Modeling

- Proposed 'Near-Term Analysis' use Dynamic Network Analysis approach (Carley, 2003)
  - Input requires information about agent, knowledge, resource, task, and etc.

    -> Meta-Matrix
  - Generated networks have probabilistic ties.

    -> Treating ties as probabilistic
  - Bridging ORA and Construct

    -> Combining social networks and multi-agent system

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Near Term Analysis

- What if we isolate a few agents in a network
  - How fast can knowledge be diffused?
  - How accurately can tasks be performed?
  - How might the network structure be affected?
- Near Term Analysis assumes the what-if scenario (isolation of agents, resource, or knowledge) and performs a simulation with the scenario.

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Input data – Network info.

- Need two datasets
  - network information and isolation scenarios
- Meta-Matrix
  - Knowledge, resource and task nodes are required for Near-Term analysis.

	People / Agents	Knowledge / Resources	Tasks / Events
People / Agents	Social Network	Knowledge Network	Assignment Network
Knowledge / Resources		Information Network / Substitutes	Needs Network
Tasks / Events			Precedence Ordering

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Input data - Isolation strategy (1)

- To make a what-if scenario, we need a set of agents for exploring isolation strategies
  - Input from ORA
    - Intelligence Report identifies several key nodes (agent, knowledge, resource, organization)
    - Isolate each node from Intelligence Report that is identified by any measures one at a time
    - Isolate all the top nodes for a measure as identified in Intelligence Report and repeat for each measure
  - Input from User
    - Isolate nodes as a user specifies

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Input data - Isolation strategy (2)

- Intelligence report includes the lists of nodes identified by various measures.

Measure	Implication
Cognitive demand	Measures the total amount of effort expended by each agent to do its tasks.
Total degree centrality	The Total Degree Centrality of a node is the normalized sum of its row and column degrees.
clique count	The number of distinct cliques to which each node belongs.
eigenvector centrality	Calculates the principal eigenvector of the network. A node is central to the extent that its neighbors are central.
betweenness centrality	The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.
high betweenness and low degree	The ratio of betweenness to degree centrality; higher scores mean that a node is a potential boundary spanner.
shared situation awareness	A measure of situation awareness between agents.

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Other input parameters

- Length of simulation time period
- Number of replication

- **Note:** The Near-Term Analysis runs using agents interactions based on relative similarity of the knowledge network by default
  - The ability to change these parameters will be available in upcoming versions.

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Near Term Analysis Result

- The changes of performance measures
  - Knowledge Diffusion
  - Task accuracy
- The changes of network itself
  - An evolved meta-matrix

- These results shows the near term impact of isolating one agent in organization.

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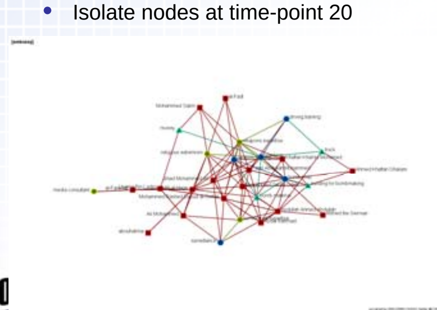
Near Term Analysis Result – meta-matrix evolution

- Evolved meta-matrixes
  - Three factors
    - Agent-to-Agent friendship matrix based on relative similarity (range: [0..1])
    - Agent-to-Agent advise matrix based on relative expertise (range: [0..1])
    - Agent-to-Agent interaction matrix based on interaction during simulation (range: integer)

    -> Generate a network with the weighted sum of the above matrixes

A sample dataset

- Embassy bombing case
  - Use embassy.xml meta-matrix
  - Use Its intelligence report from ORA
  - 3 replications
  - 52 simulated time-point
  - Isolate nodes at time-point 20



INTELLIGENCE REPORT FOR [EMBASSY]

KEY ACTORS

===

Emergent Leader (cognitive demand)

Measures the total amount of effort expended by each agent to do its tasks.

1	0.3793	Fazul Abdullah Mohammed
2	0.3411	Khalfan Khamis Mohamed
3	0.3007	Mohammed Rashed Daoud al-Owhali
4	0.2807	Jihad Mohammed Ali
5	0.2702	Mohammed Sadiq Odeh
6	0.2450	Abdullah Ahmed Abdullah
7	0.1925	Mohammed Salim
8	0.1842	Ahmed the German
9	0.1825	Wadih al Hage

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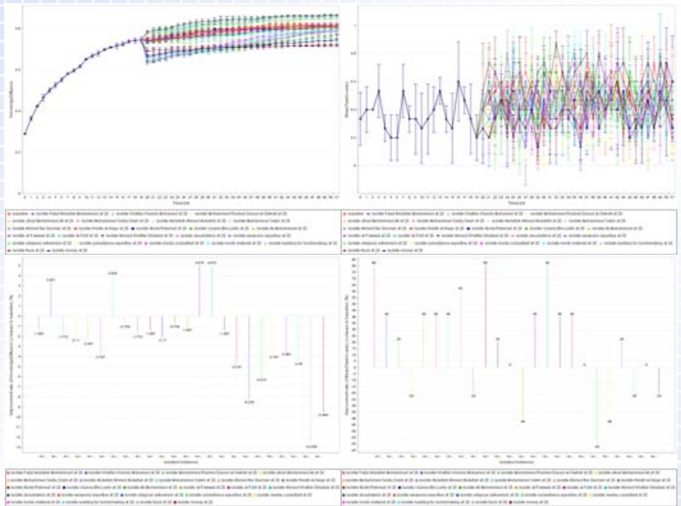
Results from the sample dataset



- Results from Embassy bombing case with isolation strategies set by intelligence report.
- Jump at the isolation timing
- Changes over time
- Some strategies optimized the target organization, and others degraded the organization's performance.

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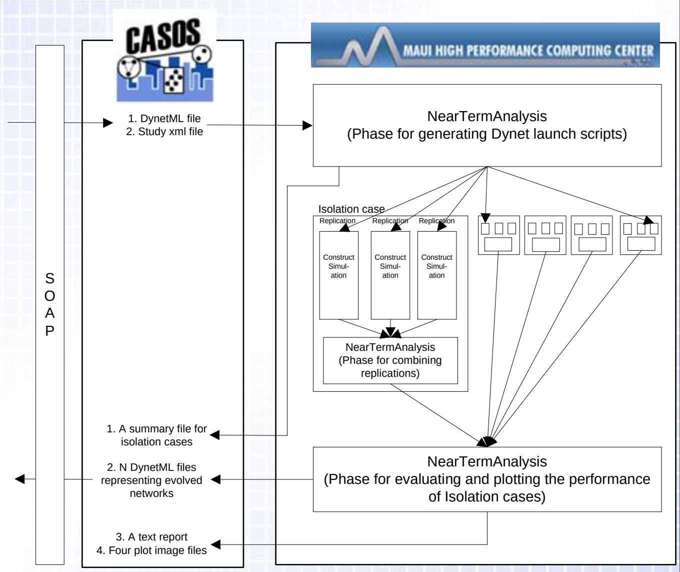
Near-Term Analysis for pseudo parallelism

- The workflow of Near-Term Analysis in MAUI computing center
- Can launch multiple replications at the same time



Questions

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