



# International Command and Control Research and Technology Symposium

June 22-24, 2010

Fairmont Miramar Hotel & Bungalows  
Santa Monica, CA



Department of Defense  
Office of the Assistant Secretary of Defense  
Networks and Information Integration  
DoD Chief Information Officer



# Exploring the Approach Space using abELICIT

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ICCRTS June 2010

# What is ELICIT?



- ELICIT = Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust
- U.S. DoD (OASD/NII) Command and Control Research Program (CCRP) sponsored the design and development of the ELICIT platform to facilitate experimentation focused on information, cognitive, and social domain phenomena
- ELICIT is an experimentation environment supported by software tools and instructions / procedures
  - Human Trials
  - Agent-based Trials

# International Use of ELICIT

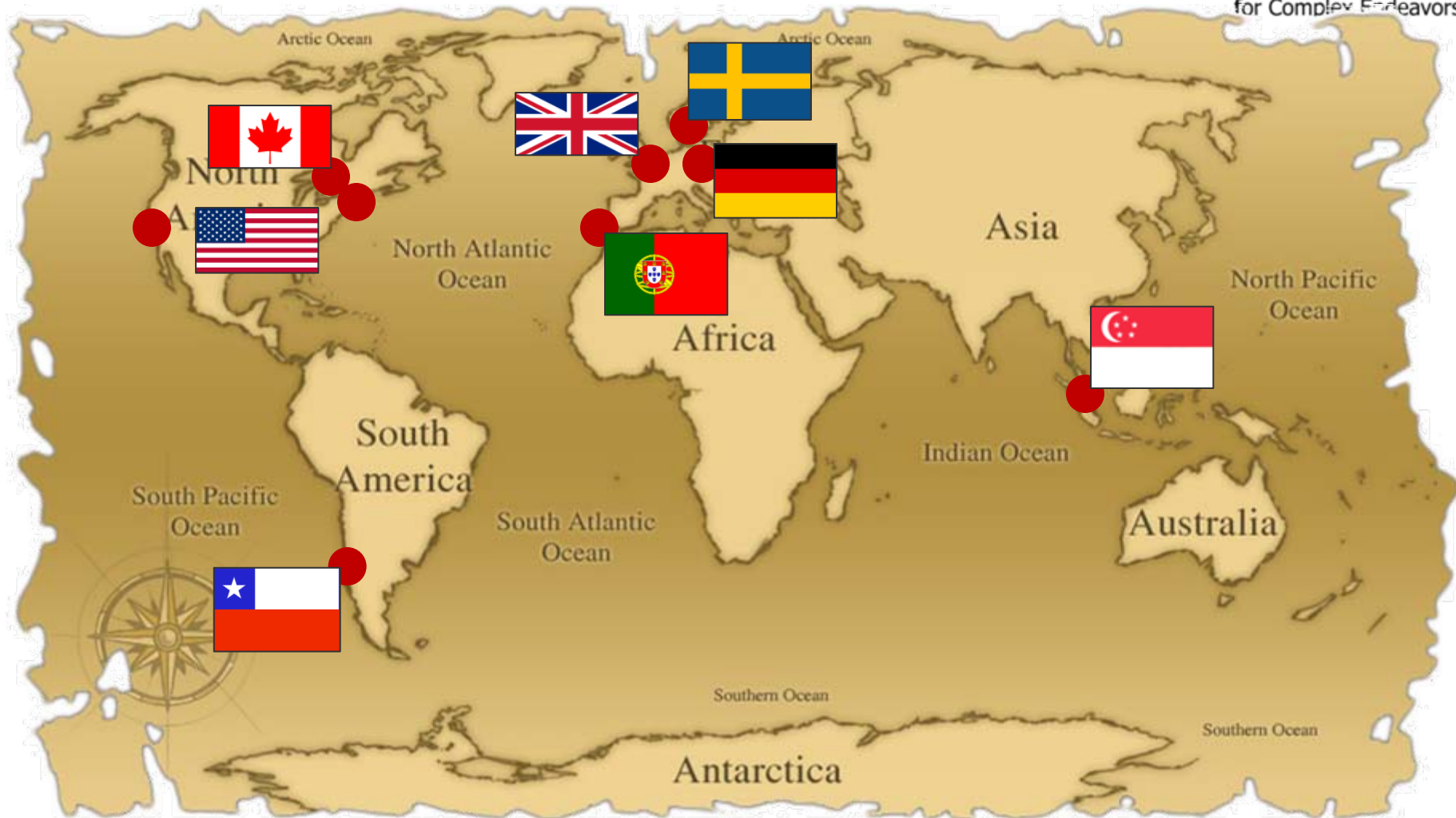


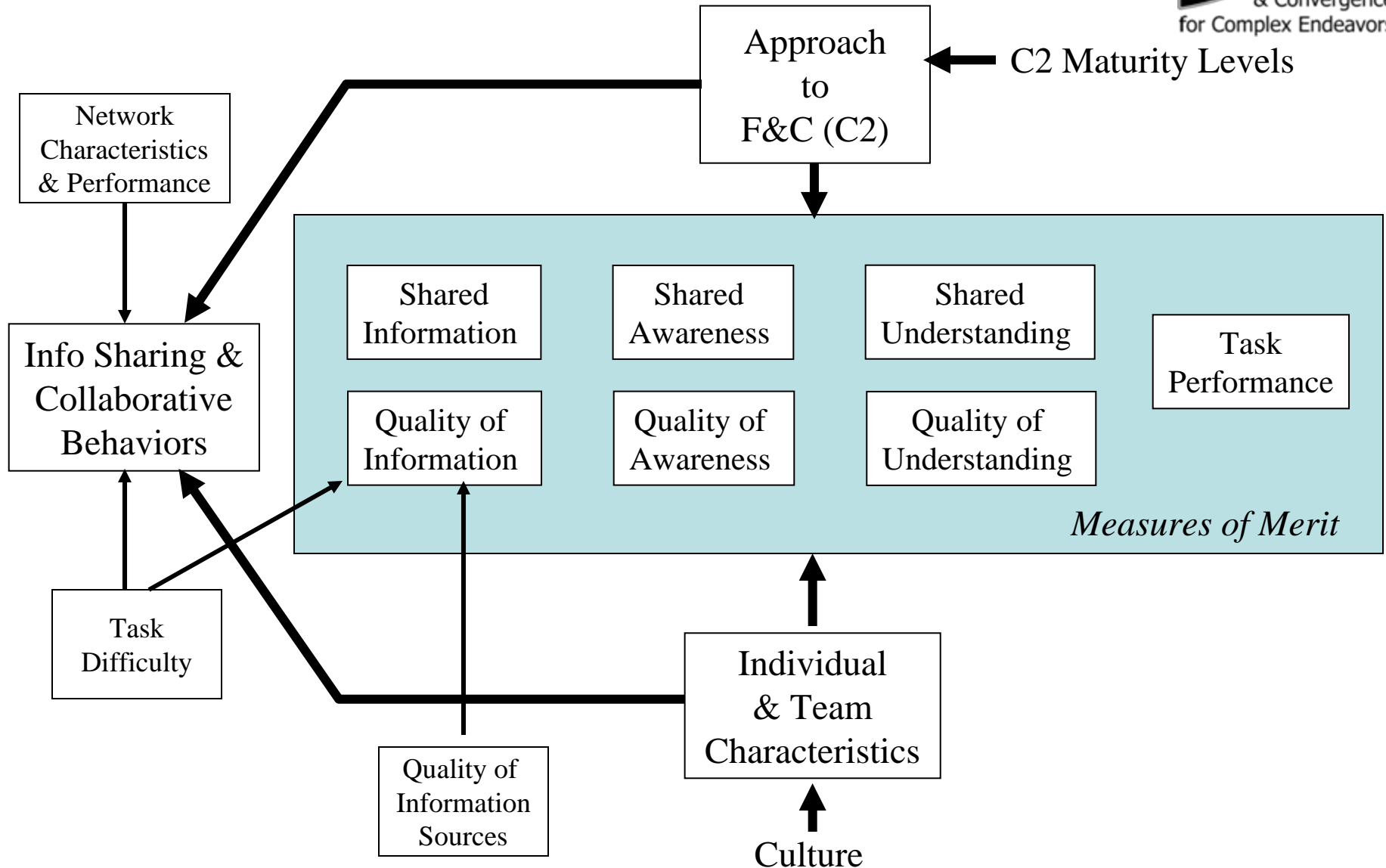
Image: [www.worldtimezones.com/content/worldmap](http://www.worldtimezones.com/content/worldmap)

# Applications since June 2009



- Harvard
- Naval Postgraduate School
- Portugal (Maturity levels)
- National Defense University
- UK MoD Analysts
- Military Polytechnic Academy, Army of Chile
- Army Research Laboratory
- Loyalist College (Second Life)
- Johns Hopkins University
- University of Southampton (Comparison of cultures)

# Variables of Interest



# Acknowledgements



- The development of abELICIT and this analysis were a team effort
- Significant contributors
  - Mary Ruddy
  - Danielle Wynn
  - Christine Anderson
  - Szymon Letowski
  - Richard Hayes

# Agenda



- Introduction to abELICIT
- Research Experiments Exploring the Approach Space
  - Information Age v Industrial Age Archetypes
  - C2 Approaches
- Agent v. Human Activity Comparisons
- Conclusions



# Agent-Based ELICIT Features



- Agents
  - create “mental models” of the situation in the form of truth tables and
  - “judgments” with regard to information sources as a result of factoids received or retrieved and the interactions they have with others.
- Looks like a human to human participants; able to perform all human actions
  - Post factoid(s) to website
  - Pull factoid(s) from websites
  - Share factoid(s)
  - Identify adversary attack
- Configurable behaviors/personalities using 40+ parameters
- Able to run all agent trials or substitute agents for human participants

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# abELICIT Experimentation



- Over the last year, the CCRP has conducted a number of abELICIT experiments to:
  - test the agent design and code
  - validate agent behaviors
  - generate a set of baseline data
  - begin the exploration of important C2-related issues
- This effort has:
  - suggested useful metrics that can be extracted from transaction logs
  - led to improved methods for data extraction and visualization
  - Resulted in improvements to the experimentation platform

# Agenda



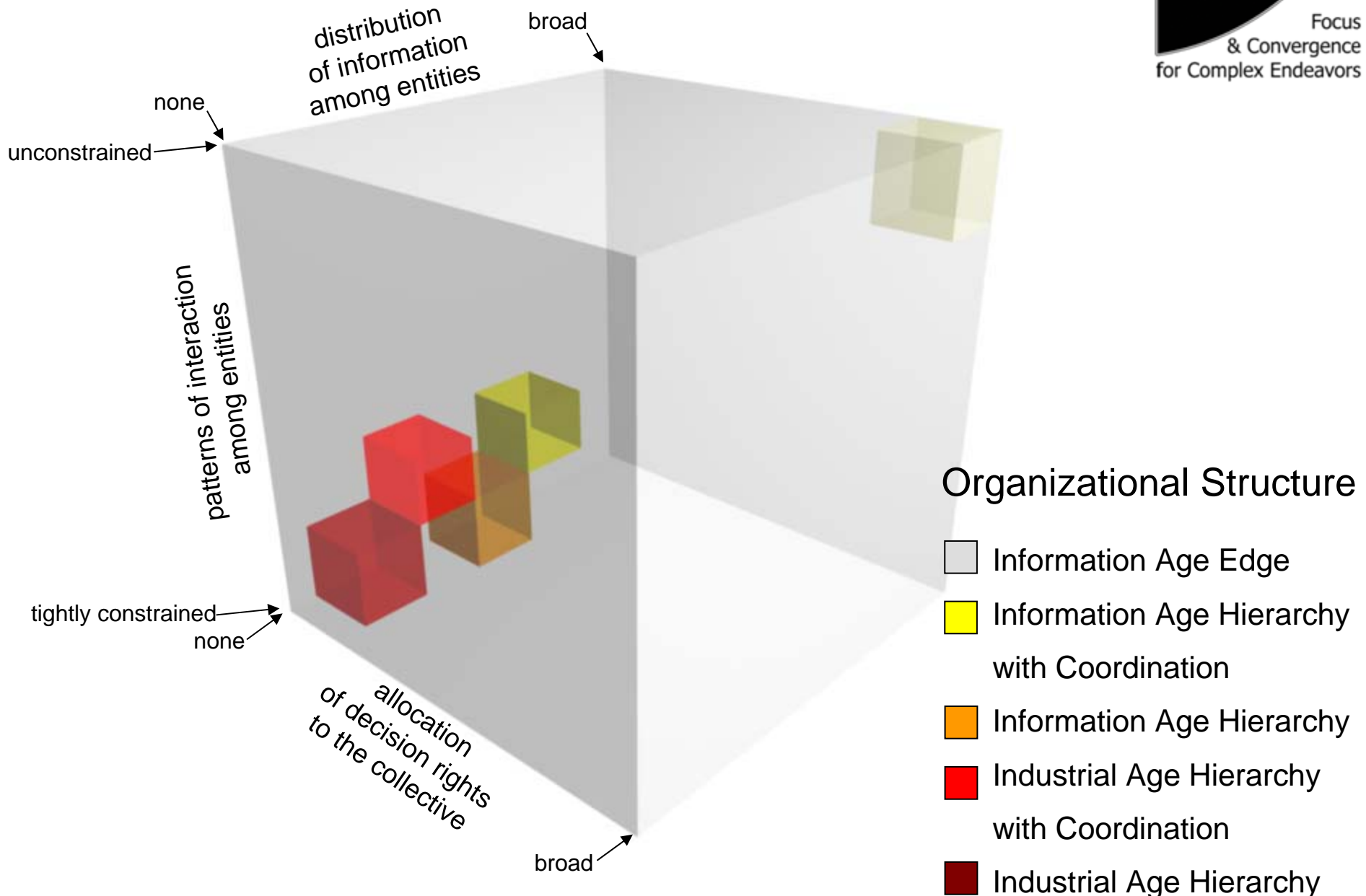
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# Information Age v Industrial Age Archetypes



- Research Questions
  - Do Information Age organizations outperform Industrial Age organizations?
  - Does coordination make a difference?
  - Do Edge organizations outperform Hierarchies?
- Measures of Metrics
  - Correct answers (surrogate for shared awareness)
  - Time to first correct answer (surrogate for responsiveness)
  - More access to information (surrogate for shared information)

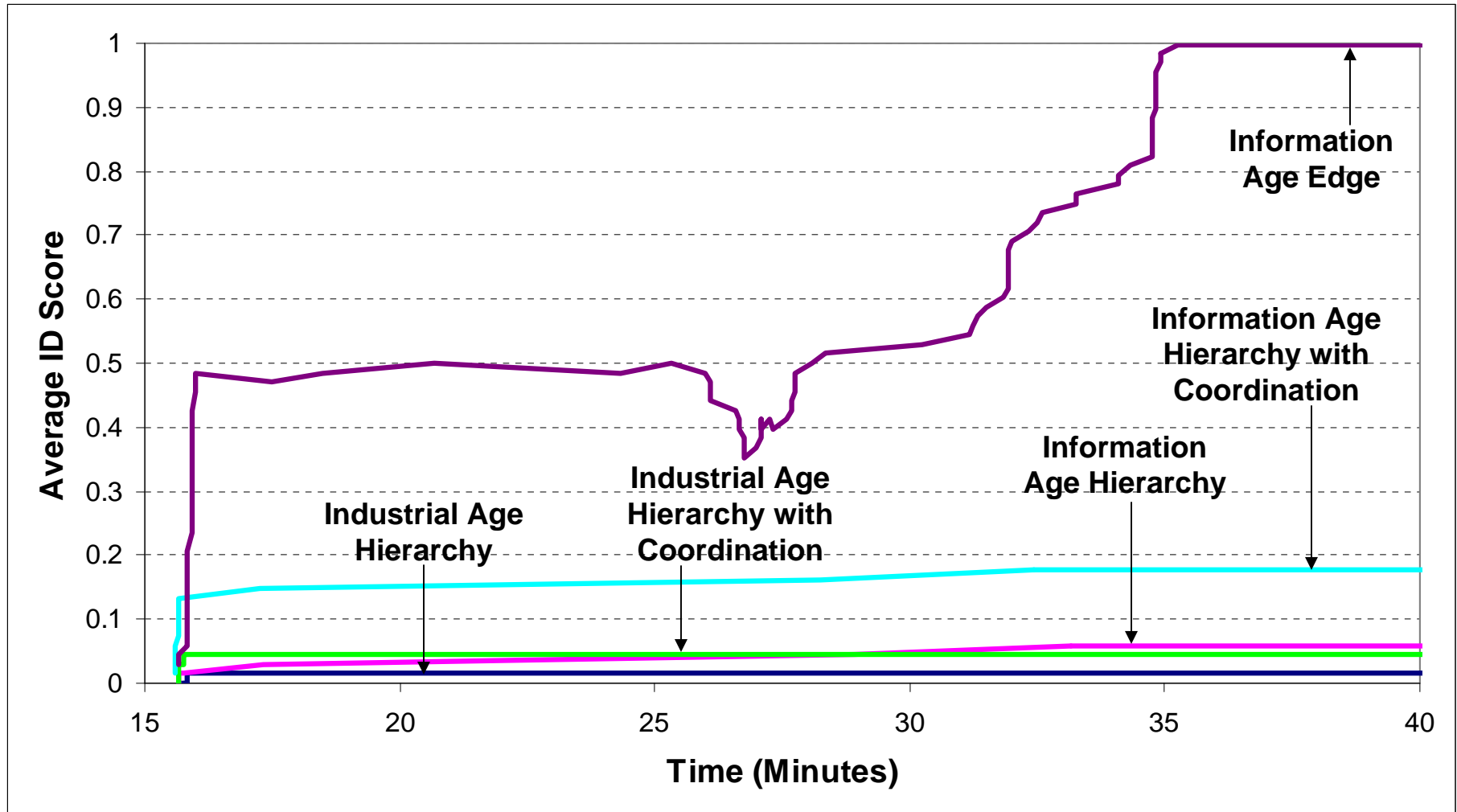
# Industrial Age/Information Age Archetype



# Information Age v Industrial Age Archetype Experiment Design

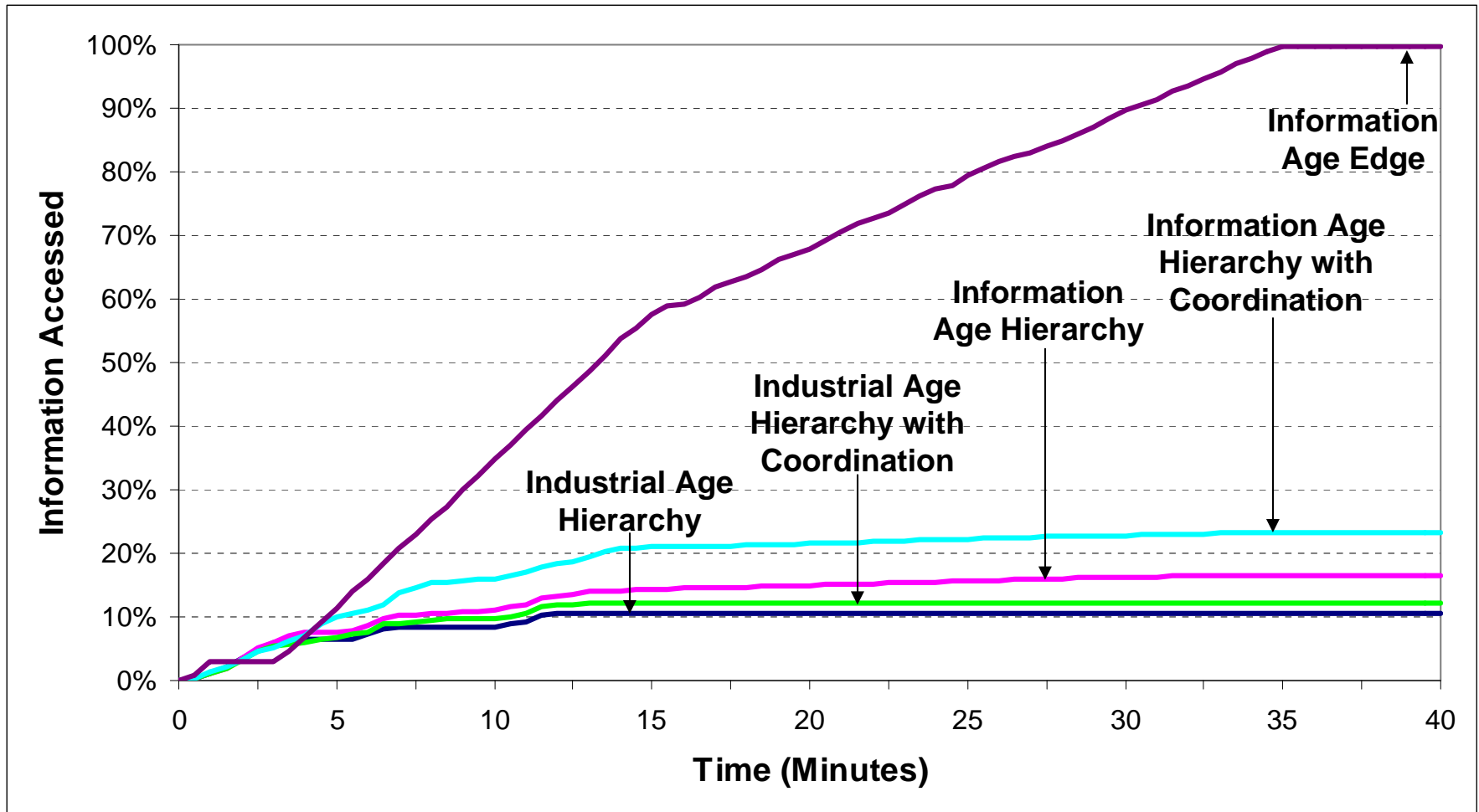
Organization Structure	Must Share	Must Share Websites	Sharing Modality	Propensity to Share
Industrial Age Hierarchy	<b>Members:</b> All team members, team leader	no websites	Share Only (Peer to Peer Only)	Low
	<b>Leader:</b> All team members, coordinator			
	<b>Coordinator:</b> All team leaders			
Industrial Age Hierarchy with Coordination	<b>Members:</b> All team members, team leader	no websites	Share Only (Peer to Peer Only)	Low
	<b>Leader:</b> All team members, all team leaders, coordinator			
	<b>Coordinator:</b> All team leaders			
Information Age Hierarchy	<b>Members:</b> All team members, team leader	<b>Members:</b> team website	Both	Low
	<b>Leader:</b> All team members, coordinator	<b>Leaders:</b> team website		
	<b>Coordinator:</b> All team leaders	<b>Coordinator:</b> all websites		
Information Age Hierarchy with Coordination	<b>Members:</b> All team members, team leader	<b>Members:</b> team website	Both	Low
	<b>Leader:</b> All team members, all team leaders, coordinator	<b>Leaders:</b> all websites		
	<b>Coordinator:</b> All team leaders	<b>Coordinator:</b> all websites		
Information Age Edge	Sharing Behavior Rules		Post Only	High

# Average ID Score Over Time





# Information Accessed Over Time



# ID Speed and Correctness

Organization Structure	Transactions to 1st Correct ID	Time (Minutes) to 1st Correct ID	Number of Solvers	Partial Solvers	Total Transactions	Ratio of Transactions to Correct IDs
Industrial Age Hierarchy	No Correct ID	No Correct ID	0	1	387	No Correct ID
Industrial Age Hierarchy with Coordination	No Correct ID	No Correct ID	0	3	429	No Correct ID
Information Age Hierarchy	540	33.17	1	1	560	560
Information Age Hierarchy with Coordination	629	32.42	1	9	649	649
Information Age Edge	312	33.25	17	17	444	26

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**Coordination makes a difference**

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**Coordination makes a difference**

**But coordination increases work load**

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**Edge outperforms with respect to Shared Awareness and Efficiency**

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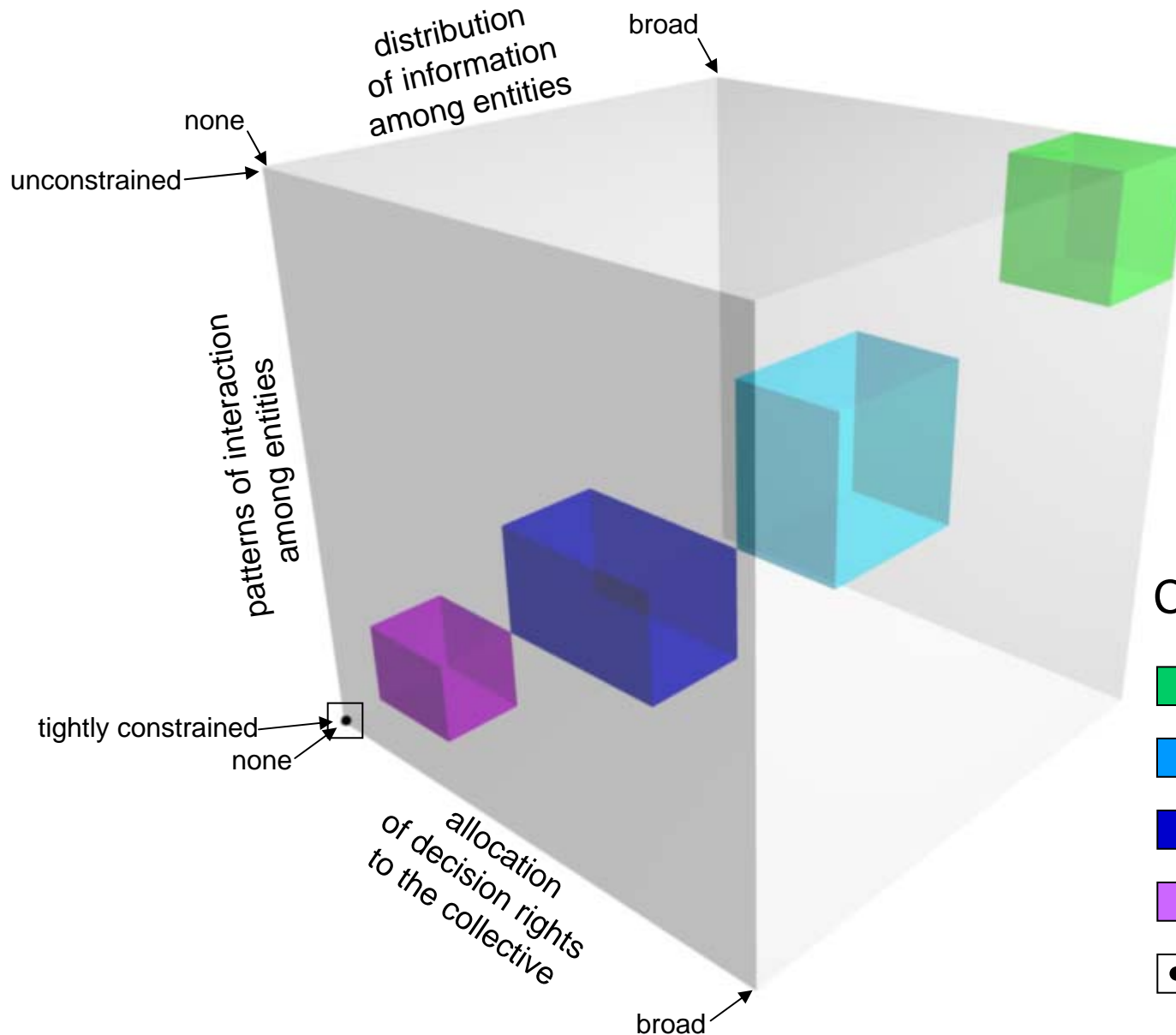
# C2 Approach Trials



- Do more network-centric C2 approaches outperform less network-centric C2 approaches?
  - Conflicted
  - De-Conflicted
  - Coordinated
  - Collaborative
  - Edge

For a full discussion of NEC C2 Approaches see NATO SAS C2 Maturity Model

# C2 Approach Space



## C2 Approaches

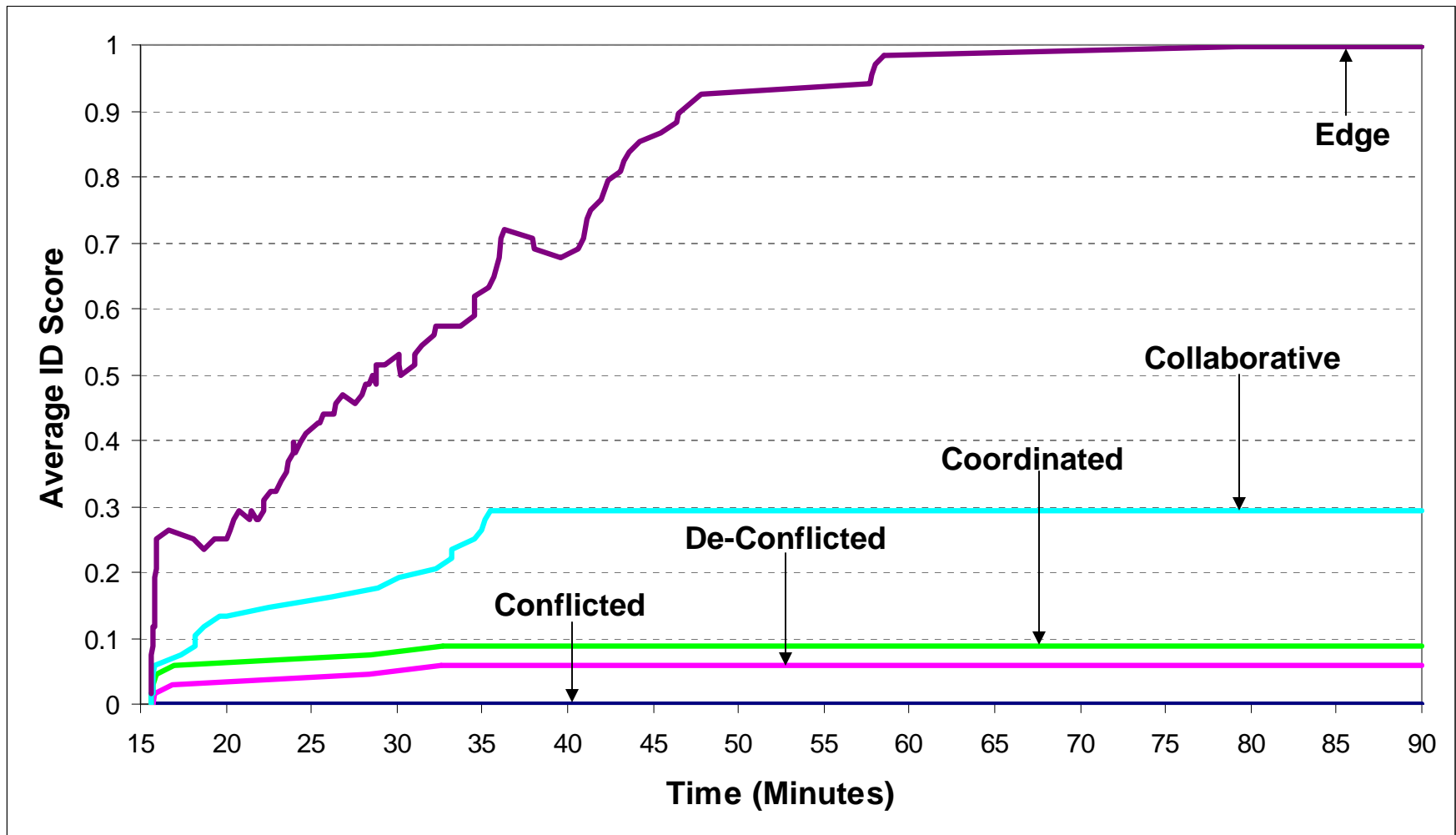
- Edge C2
- Collaborative C2
- Coordinated C2
- De-Conflicted C2
- Conflicted C2



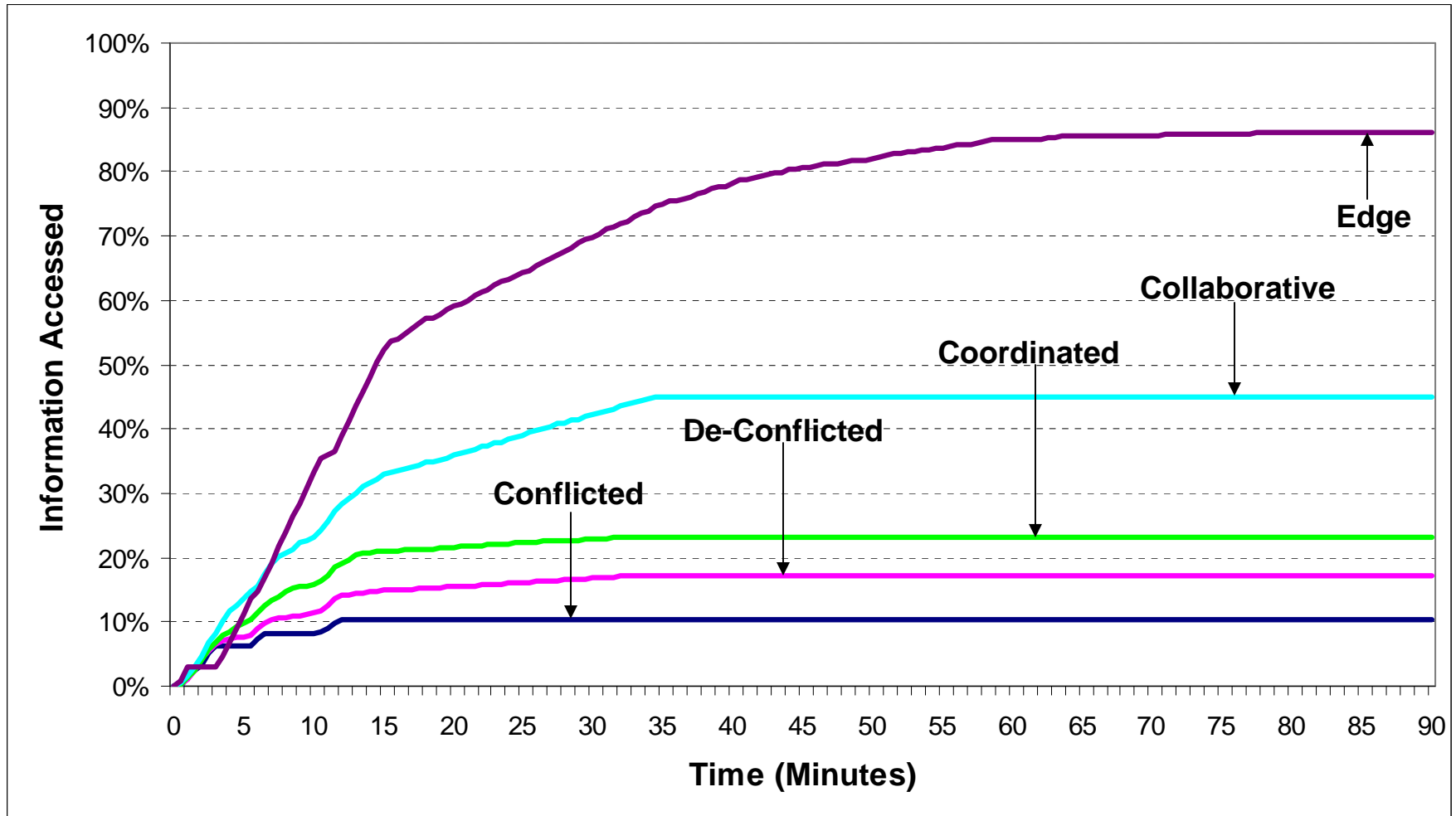
# C2 Approach Experiment Design

C2 Approaches	Must Share	Must Share Websites	Sharing Modality	Propensity to Share	Primary
Conflicted	<b>Members:</b> Team Members, Team Leader	<b>Members:</b> Team website	Both	Low	Team area
	<b>Leaders:</b> Team Members	<b>Leaders:</b> Team website			
	<b>No Coordinator</b>	<b>No Coordinator</b> ( <i>an additional fact is given to each of the Leaders</i> )			
De-Conflicted	<b>Members:</b> Team Members, Team Leaders	<b>Members:</b> Team website	Both	Low	Coordinator: all areas
	<b>Leaders:</b> Team Members, Coordinator	<b>Leaders:</b> Team Website			Leader: 2 areas
	<b>Coordinator:</b> Team Leaders	<b>Coordinator:</b> None			Members: team area
Coordinated	<b>Members:</b> Team Members, Team Leaders	<b>Members:</b> Team website	Both	Low	Coordinator: all areas
	<b>Leaders:</b> Team Members, Team Leaders, Coordinator	<b>Leaders:</b> Team Website			Leader: 2 areas
	<b>Coordinator:</b> Team Leaders	<b>Coordinator:</b> 2 Team Websites			Members: 1 area, except for Morgan, Robin, Taylor
Collaborative	<b>Members:</b> Team Members, Team Leaders (one member in a group must have a link to team member in another group)	<b>Members:</b> Team website	Both	Low	Coordinator: all
	<b>Leaders:</b> Team Members, Team Leaders, Coordinator	<b>Leaders:</b> Team Website			Leaders: 2 areas
	<b>Coordinator:</b> Team Leaders	<b>Coordinator:</b> All Team Websites			Members: 2 areas (1 member in a group must link to member in another group)
Edge			Both	Moderate	all areas

# Average ID Score Over Time



# Information Accessed by Time



# ID Speed and Correctness

C2 Approaches	Transactions to 1st Correct ID	Time (Minutes) to 1st Correct ID	Number of Solvers	Partial Solvers	Total Transactions	Ratio of Transactions to Correct IDs
Conflicted	No Correct ID	No Correct ID	0	0	418	No Correct ID
De-Conflicted	524	32.58	1	1	544	544
Coordinated	572	32.67	1	3	592	592
Collaborative	595	33.17	5	5	655	131
Edge	2069	31.08	17	17	4913	289

**Information Age Edge (post only) is far more efficient**

26

# Agenda



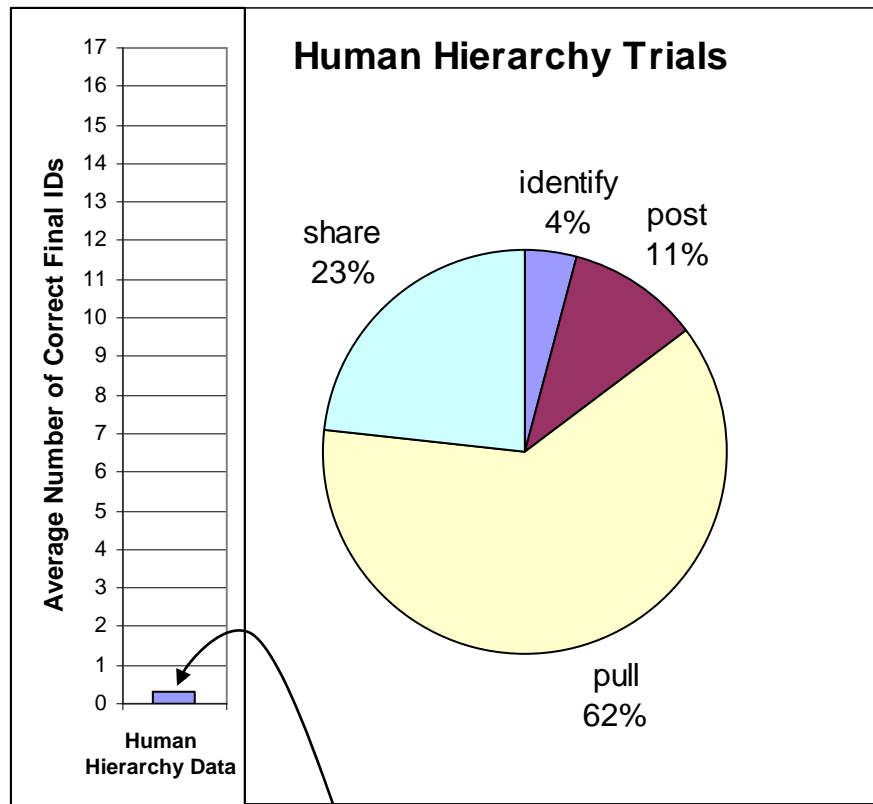
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# Comparison of Agent and Human Trial

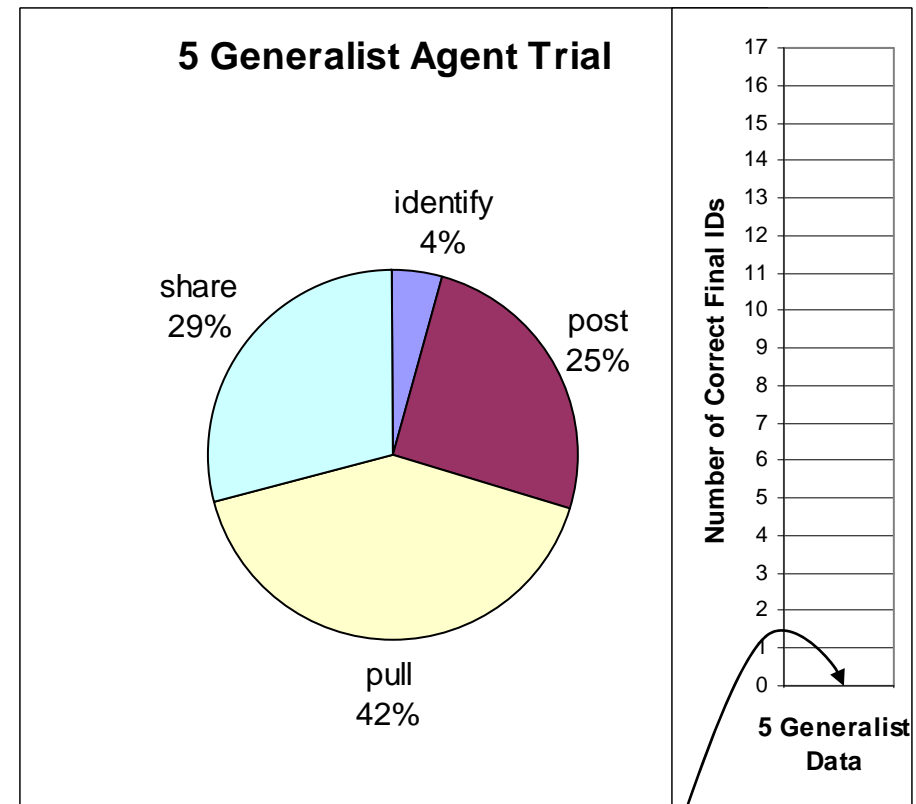


- Comparison 1: Human Hierarchy (5 runs) vs. Agent Run
  - 3 agents with Sharing Modality both
  - 14 agents with Sharing Modality Post Dominant
  - 5 agents with all areas and 12 agents with 1 area (as per Hierarchy)
  - All have Moderate Propensity to Share and Seek
- Comparison 2: Human Edge (5 runs) vs. Agent Run
  - 3 agents with Sharing Modality both
  - 14 agents with Sharing Modality Post Dominant
  - 17 agents with all areas
  - All have Moderate Propensity to Share and Seek

# Illustrative Activity Profiles (1)

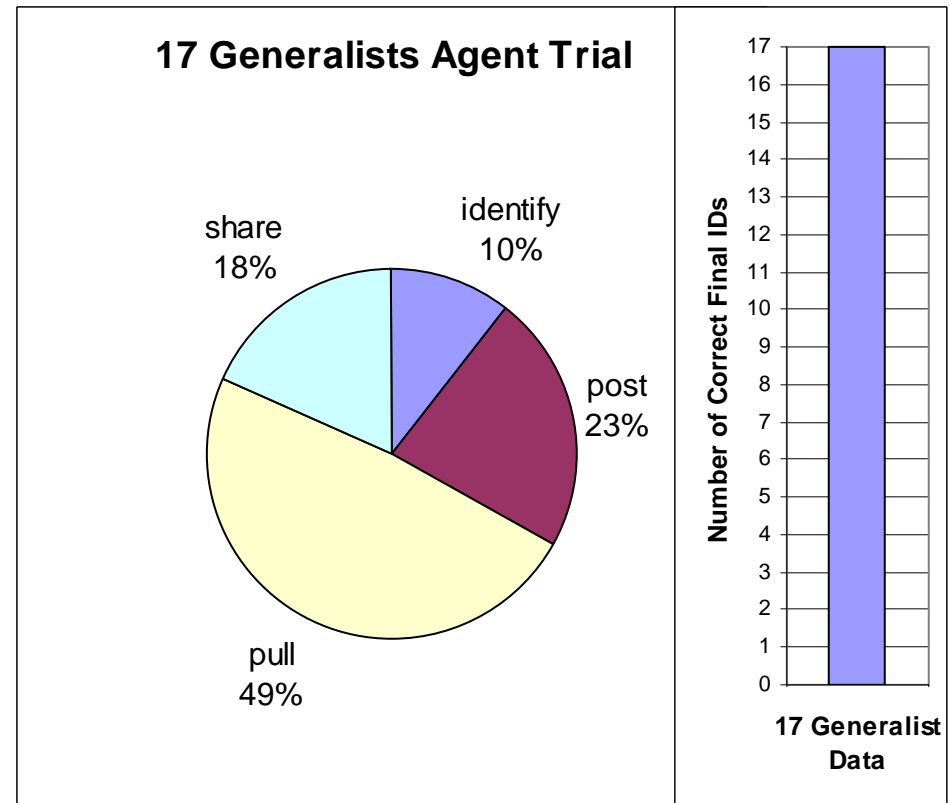
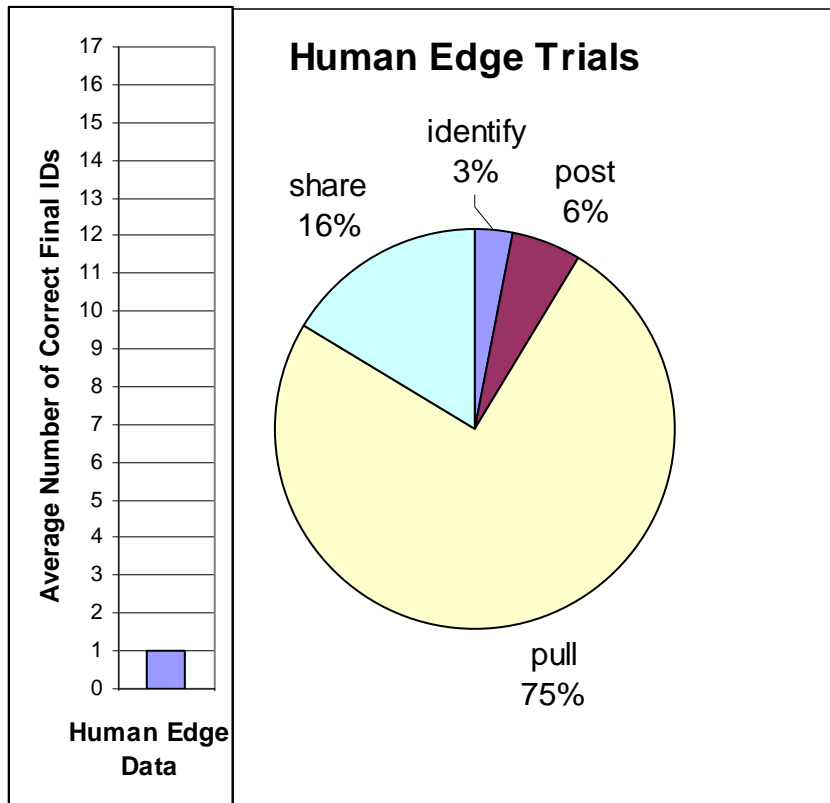


Value = 0.33



Value = 0

# Illustrative Activity Profiles (2)





# Conclusions

- abELICIT agent behaviors seem reasonable
- abELICIT findings mirror the results of human ELICIT trials
- abELICIT can be used to
  - cost effectively to explore the relative performance of a variety of points in the C2 Approach Space
  - suggest interesting human experiments
  - identify ways to improve human performance either by training or by decision support tools

# Interested in ELICIT?



**Next Meeting is Today, June 24, 2010 at 2pm in the  
Catalina Bungalow at the Fairmont Miramar.**

**Sign up at the ICCRTS registration desk!**

**We are Seeking Potential Collaborators!**

To join the ELICIT CoI, go to

[www.dodccrp.org/html4/elicit.html](http://www.dodccrp.org/html4/elicit.html)

# Questions ?



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