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

CCRP
Focus
& Convergence
for Complex Endeavors

N2C2M2 Experimentation and Validation

Understanding Its C2 Approaches and Implications

International Command and Control Research and Technology Symposium

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Outline

Part 1: Background

- N2C2M2 and theory of NCW
- ELICIT

Part 2: The Experiments

- Expectations, Model and Key-variables
- Experiment Design

Part 3: Analysis

- Analysis and (Main) Conclusions

Background

academia militar

EDI SOFT

SAS 065

CCRP

EBR

NPS

PARITY

N2C2M2 Experimentation

ELICIT Platform

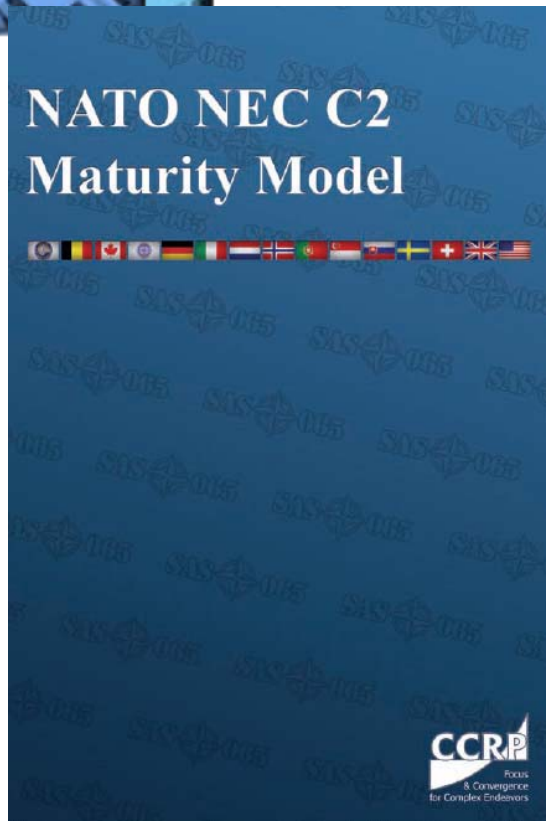
Paper 011
N2C2M2 Experimentation and Validation:
Understanding its C2 Approaches and Implications

Paper 010
Know The Network, Knit The Network:
Applying SNA to N2C2 Maturity Model Experiments

Part 1:

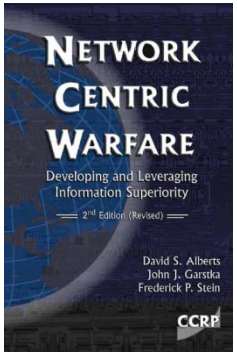
Background

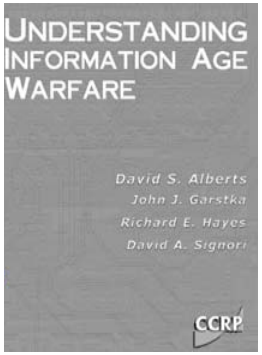
Background

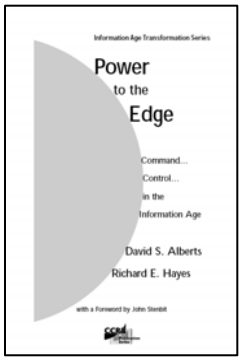


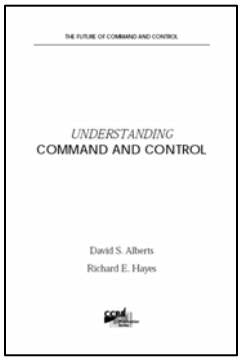
C2 in the Information Age:

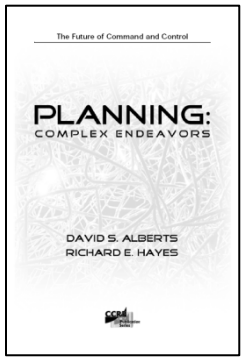
- Theory of NCW, including *NCW tenets*, *NCW Value Chain* and *C2 Approach Space* (CCRP, Alberts and Hayes)
- C2 models: C2 CRM (SAS-050)
- NATO NEC C2 Maturity Model (SAS-065)[1], recently developed and benefiting from multiple validation methods, including experimentation

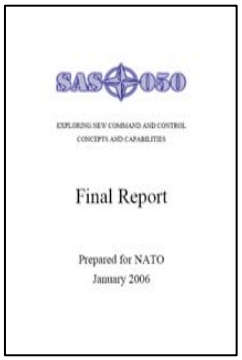


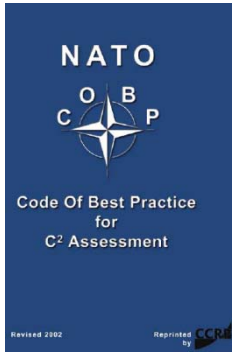








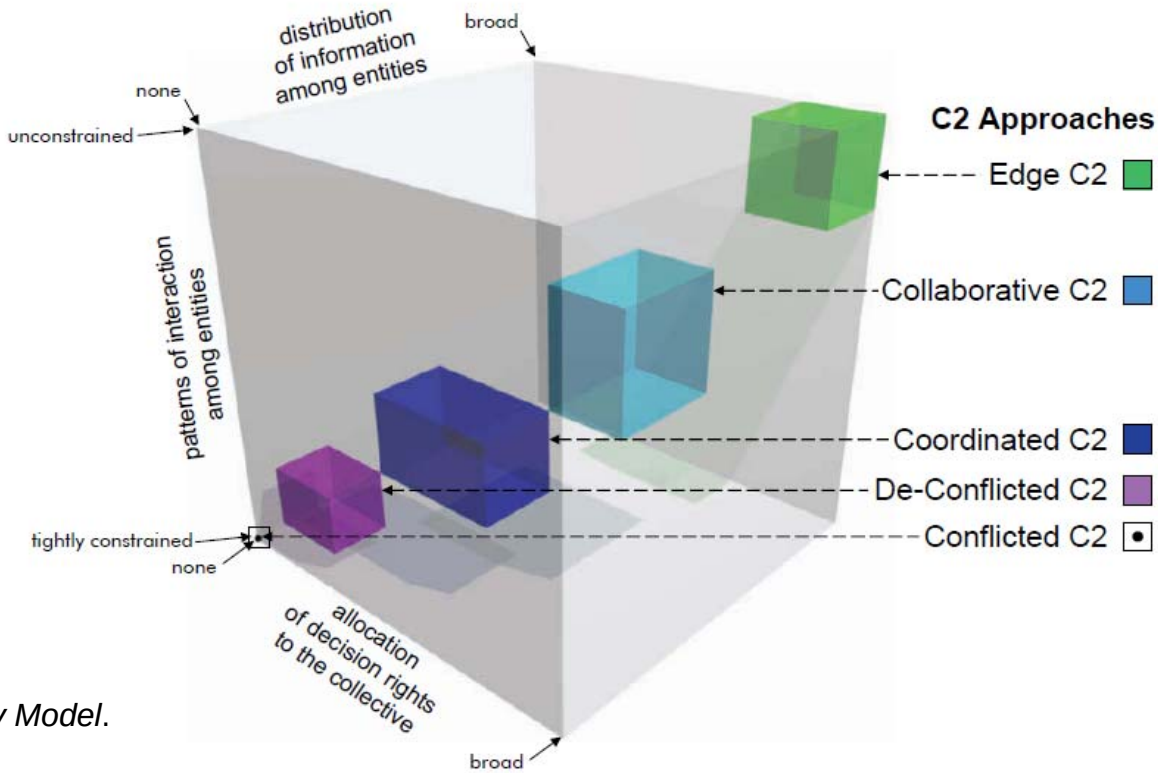




[1] NATO SAS-065. *NATO NEC C2 Maturity Model*. CCRP Publication Series, 2010.

Background: N2C2M2

- NATO NEC C2 Maturity Model
  - Defines 5 levels of NATO NEC operational capability: levels 1 (less mature) to level 5 (more mature).
  - Defines 5 approaches to C2 associated with each level.



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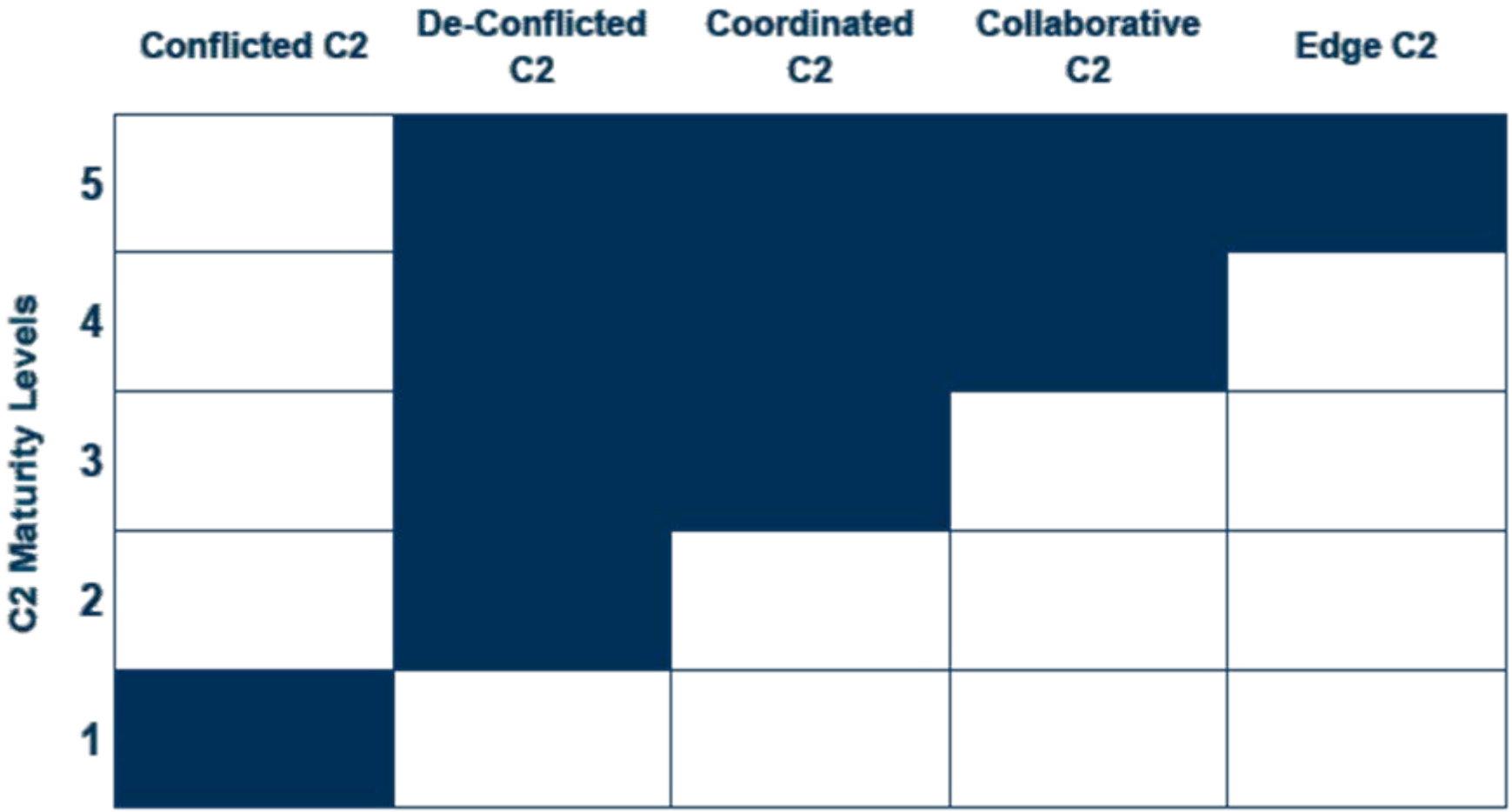

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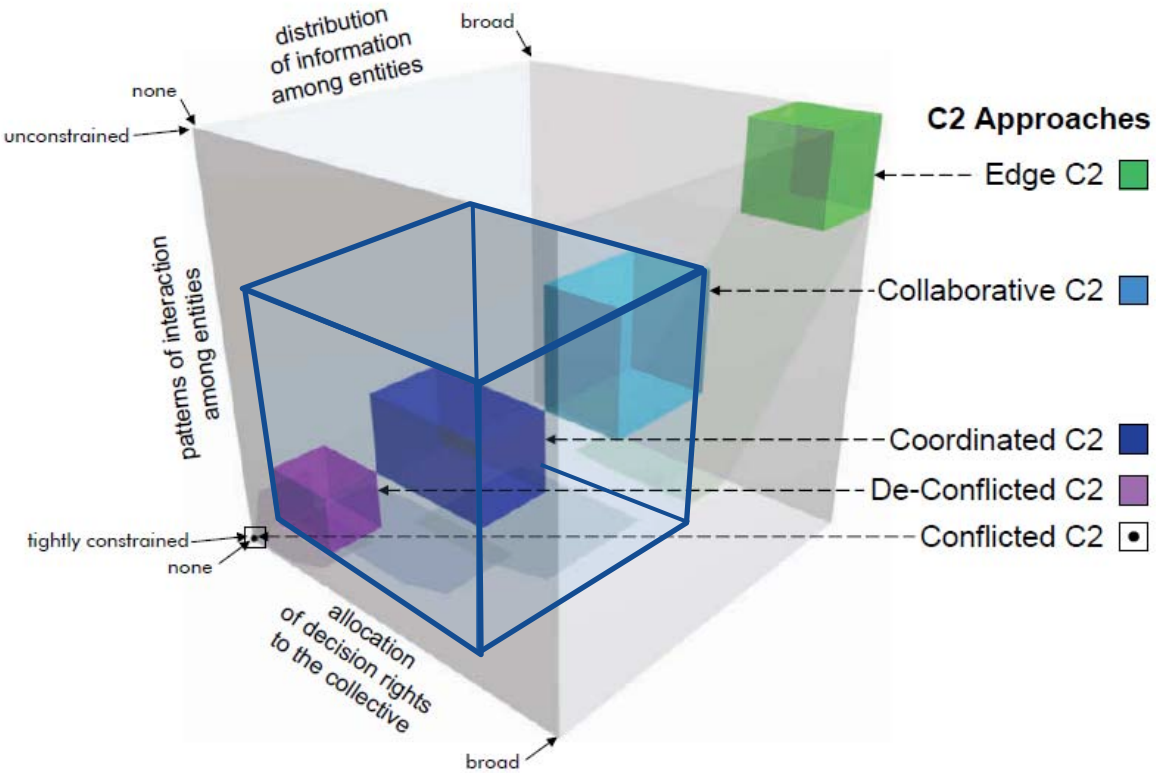
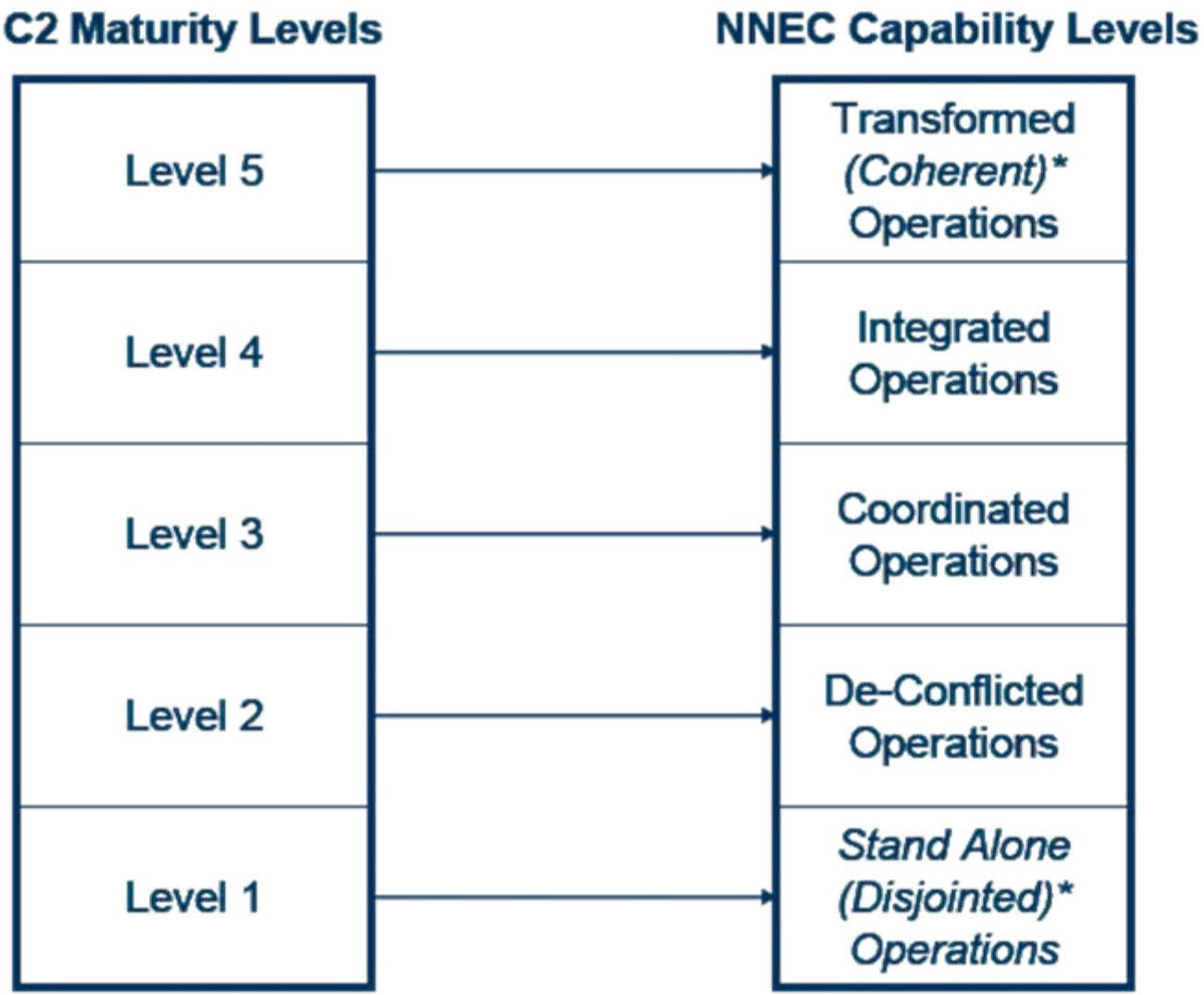


Level 4 Example

Background: N2C2M2



*The NNEC Feasibility Study used the terms *Coherent* and *Disjointed* rather than Transformed and Stand Alone

[1] NATO SAS-065. *NATO NEC C2 Maturity Model*. CCRP Publication Series, 2010.

Background: N2C2M2

- NATO NEC C2 Maturity Model (2):
  - More maturity delivers:
    - More effectiveness
    - More efficiency
    - More agility
    - Positive impact in intermediate NCW value-chain variables, such as, *Quality of Individual and Shared Information, Quality of Individual and Shared Awareness and Understanding* and *Self-Synchronization**

* *For detailed mapping between C2 CRM variables and ELICIT refer to:*
MANSO, Marco, and Paulo NUNES. *ELICIT and the Future C2: Theoretical Foundations for the Analysis of ELICIT Experiments*. Paper presented at the 13th ICCRTS, Seattle, USA, 2008

Background: ELICIT

- ELICIT: **E**xperimental **L**aboratory for the **I**nvestigation of **C**ollaboration, **I**nformation-sharing, and **T**rust.
  - An experimentation environment supported by software tools and instructions/procedures
  - Provides a simple (albeit rich) and collaborative network-centric environment for participating individuals
- Sponsor
  - U.S. DoD Command and Control Research Program (www.dodccrp.org)

Source: Alberts *et.al.* *"Assessing Network Centric Operations The Challenge of NEC C2, A Tutorial"*, presentation at the NCW-2009, Washington, DC, January 27, 2009.

Background: ELICIT

- ELICIT presents participants with an information-intensive situational awareness task:
  - Goal: Find Who, What, Where, When of a future terrorist attack
  - Pieces of information (factoids) are distributed to participants
  - No participant is given sufficient information to solve his/her assigned problem without receiving information from others
  - Information sharing is required for successful solution identification
- ELICIT environment can be tailored for various organizational and management C2 approaches

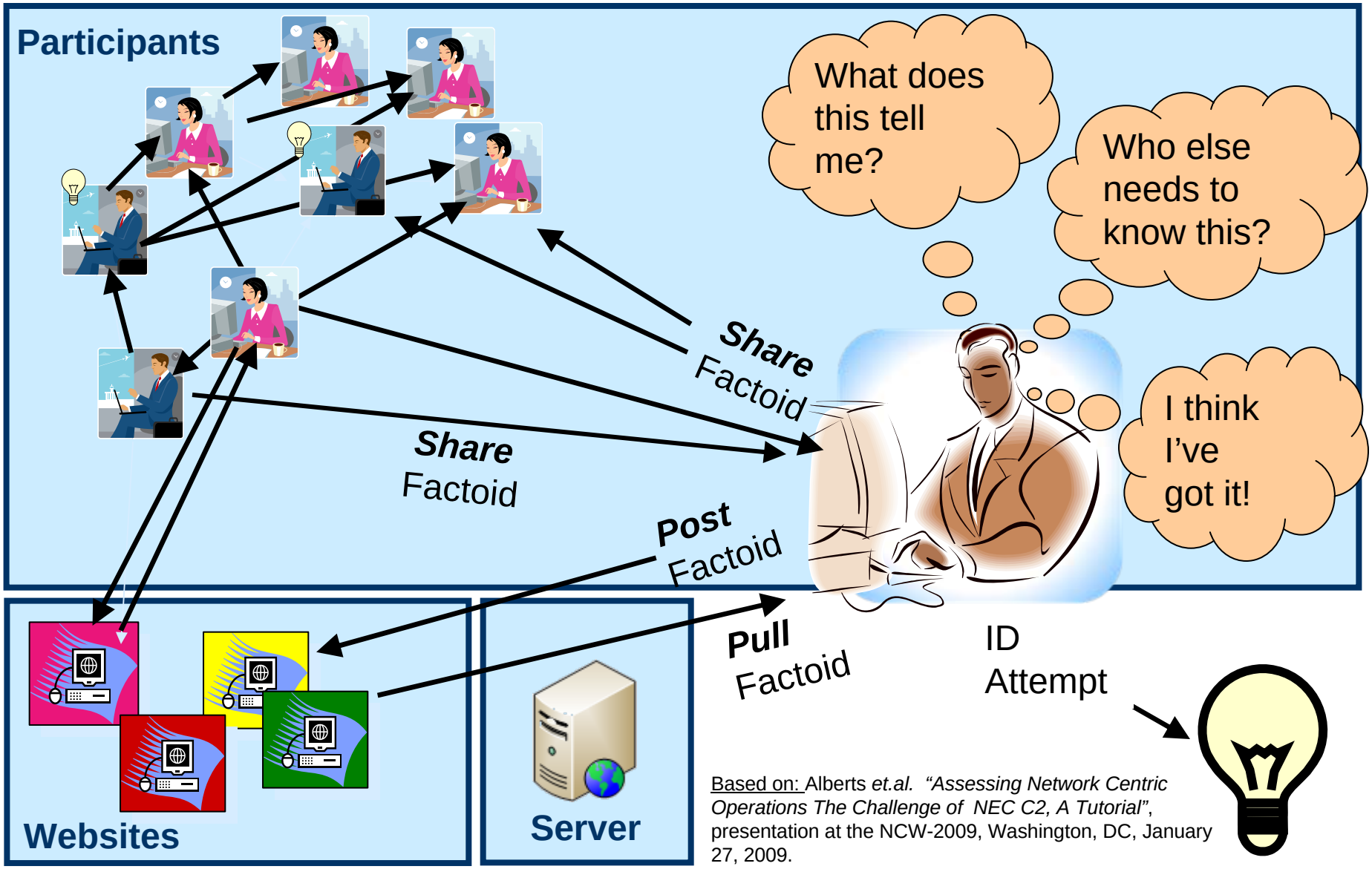
Source: Alberts *et.al.* *"Assessing Network Centric Operations The Challenge of NEC C2, A Tutorial"*, presentation at the NCW-2009, Washington, DC, January 27, 2009.

Background: ELICIT

- Factoids: the pieces of the puzzle
  - 68 pieces in total
  - Usually distributed as:
    - KEY/EXPERTISE (17)
    - SUPPORTIVE (17)
    - NOISE (34)
- Examples:

(KEY)	*Jupiter is involved*
(KEY)	*The attack will be at 3:00*
(SUP)	*There is a lot of activity involving the Aqua group*
(NOISE)	*Mars has been seen in Alphaland*
(NOISE)	*There is a major religious festival on the 14th*

Background: ELICIT

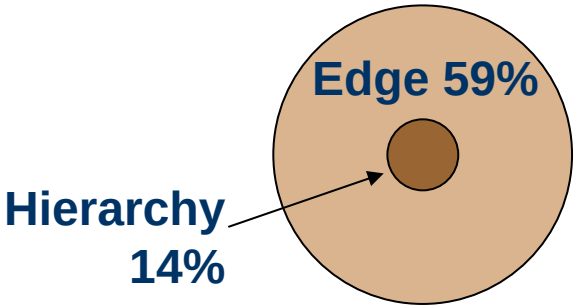


Based on: Alberts *et.al.* *"Assessing Network Centric Operations The Challenge of NEC C2, A Tutorial"*, presentation at the NCW-2009, Washington, DC, January 27, 2009.

First Findings: Hierarchy vs. Edge

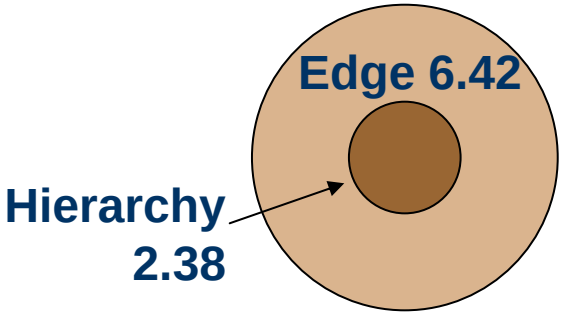
Effectiveness

Metric: Correctness
Fraction of Authorized Participants with Correct ID



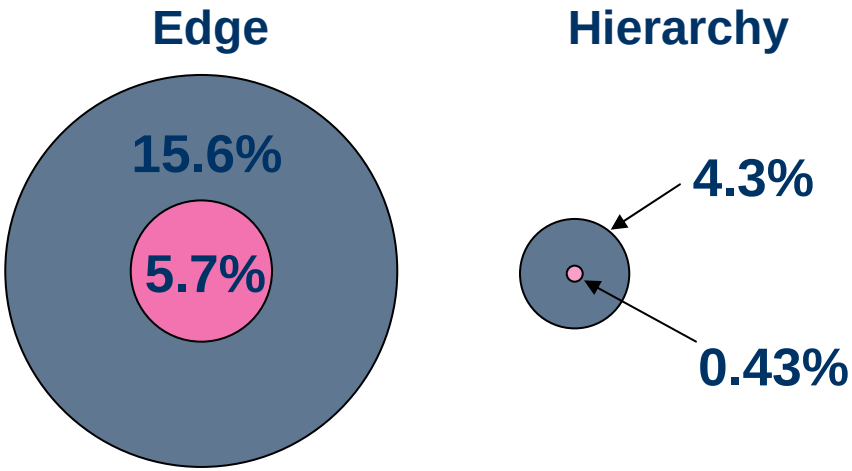
Efficiency

Metric: Productivity (Person-Minutes)
Correct IDs / Thousand Person-Minutes



Agility

Metric: Change in Timeliness
Fraction of person-minutes correct



Standard Factoid Sets	Difficult Factoid Sets

Source: Alberts *et.al.* *"Assessing Network Centric Operations The Challenge of NEC C2, A Tutorial"*, presentation at the NCW-2009, Washington, DC, January 27, 2009.

Part 2:

The Experiments

Experimentation: Early Expectations

Main hypotheses for validation:

- [1] For a complex endeavor , higher collective C2 maturity approaches are **more effective**.
- [2] For a given level of effectiveness, higher collective C2 maturity approaches are **more efficient**.
- [3] Higher collective C2 maturity approaches are **more agile**.

Experimentation: Early Expectations

Additional hypotheses:

- Higher collective C2 maturity approaches exhibit increased/better levels of:

  [4] Quality of Individual and Shared Information;

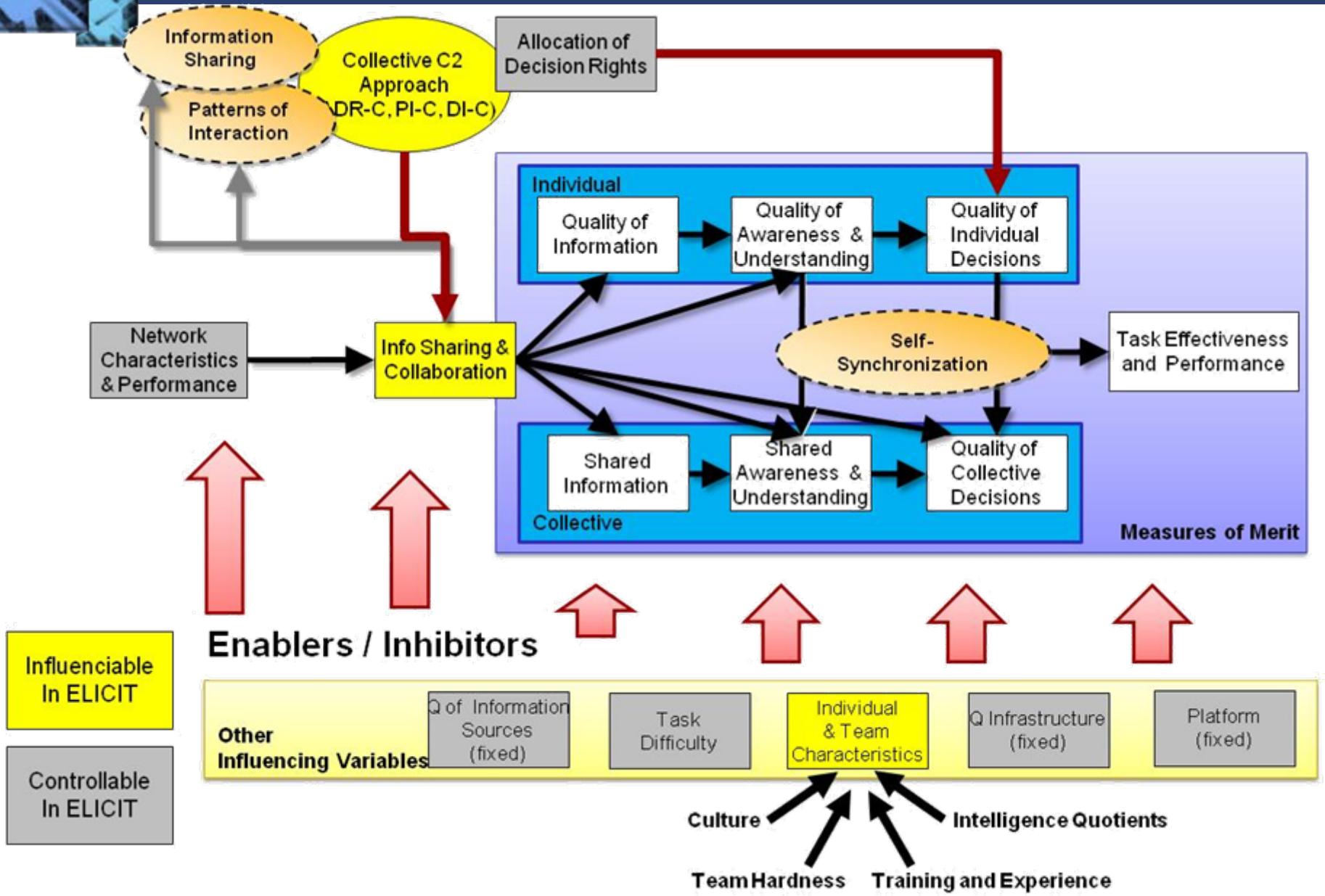
  [5] Quality of Individual and Shared Awareness and Understanding;

  [6] Self-Synchronization (at cognitive level);

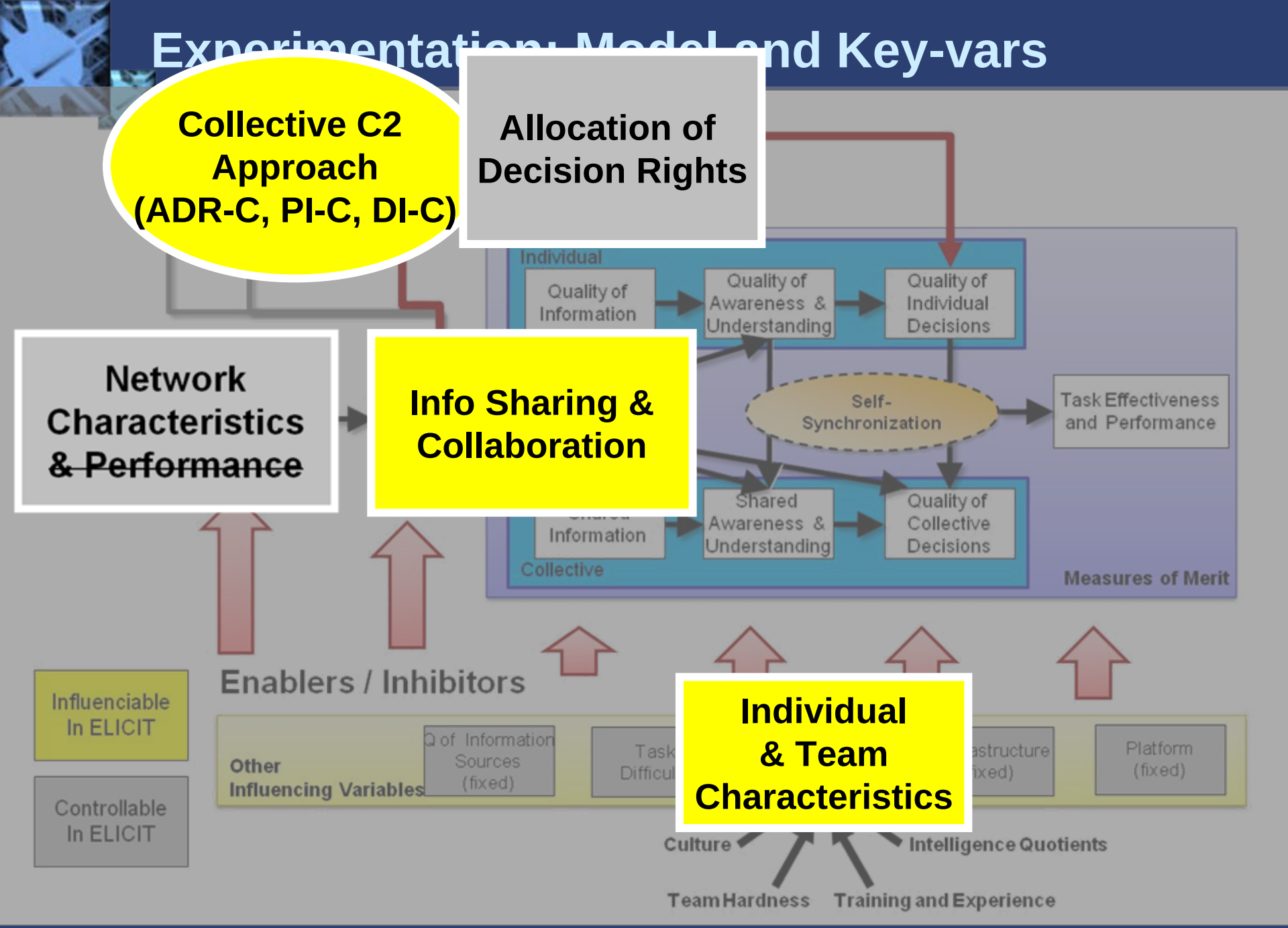
  Than: lower collective C2 maturity approaches.

- [7] Organizations require a minimum level of maturity to be effective in ELICIT.
- [8] Increasing the degree of difficulty in ELICIT require organizations to increase their level of maturity to maintain effectiveness in ELICIT.

Experimentation: Model and Key-vars



Experimentation: Model and Key-vars



Experimentation: Manipulations

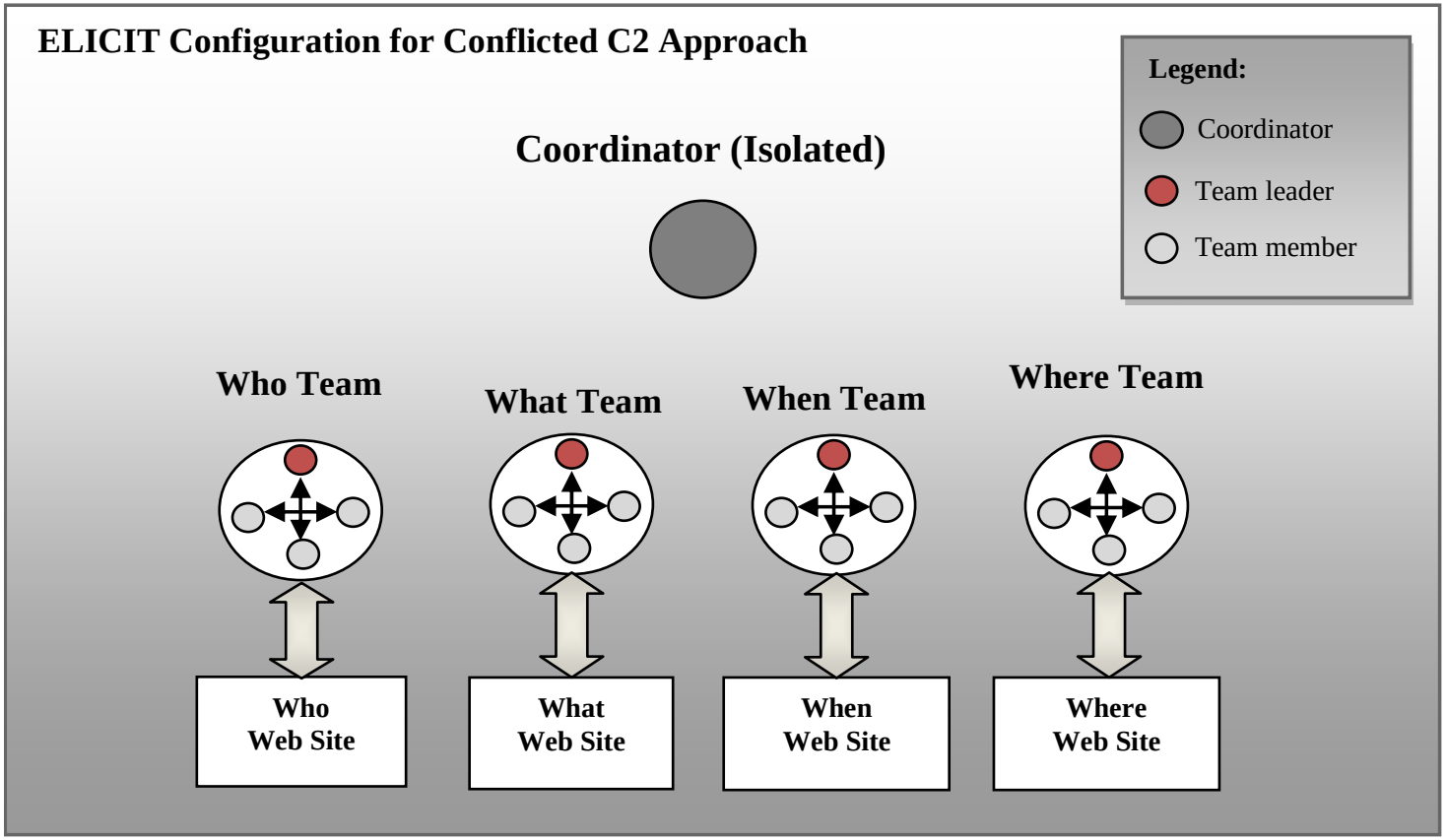
Name	Description
Network Characteristics and Performance	Allow or restrict interactions between: - subjects and teams. - subjects and websites. **This variable affects PI-C and DI-C**.
Information Sharing and (incentives for) Collaboration	Control: predefined server distributions of all factoids to subjects (in three waves). Influence: distribution of information as a result of human sharing and posting (human *will*) We will attempt to induce / influence collaborative behavior by: - defining collective or isolated goals - set individual and collective decision rights (see **ADR**) See paper for further notes on *Individual and Team Characteristics*. **This variable affects PI-C and DI-C**.
Allocation of Decision Rights	Decision rights will be allocated according to the C2 Approach to implement: - Distributed for higher maturity approaches; - None / (de)centralized for lower maturity approaches. **This variable is a C2 dimension**.

Experimentation: Design

Common aspects for all approaches:

- **Entities**: 4 TEAMS and 1 SINGLE ENTITY, except EDGE with 17 ENTITIES
- **Context**: complex endeavor with two or more force elements (entities) present with overlapping intents; operating in the same 'space' and time; and, an entity actions may conflict with those taken by another entities." (Alberts and Hayes 2007).
- **Scenario**: future terrorist attack
- **Task**: identify the "who", "what", "where" and "when" of the attack within a specific timeframe.
- **Information Sharing Capabilities**: *share*, *post* and *pull* actions. High maturity approaches will be enriched with more options (see next).
- **Collaborative Capabilities**: ability to provide "assessment" of importance (relevance) and/or trustworthiness of a factoid.
- **Resource Contention**: subject hoarding of relevant information is considered as a conflict. Cognitive efforts are required.

Experimentation: CONFLICTED model

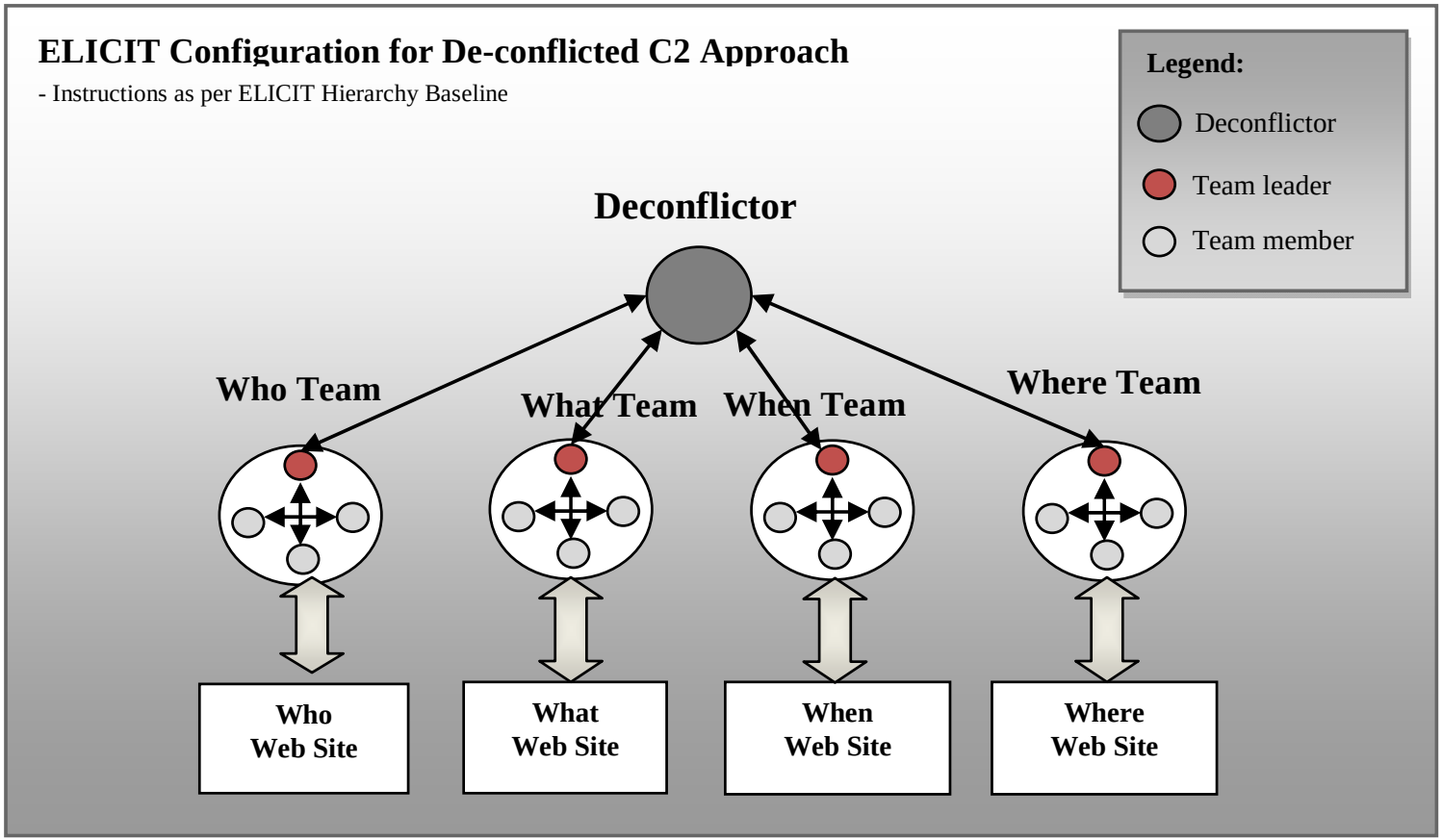


<u>SUCESS CRITERION</u>

Each Team pursues independent goals.

Success occurs if each Team leader finds the correct solution to his problem space.

Experimentation: DE-CONFLICTED model

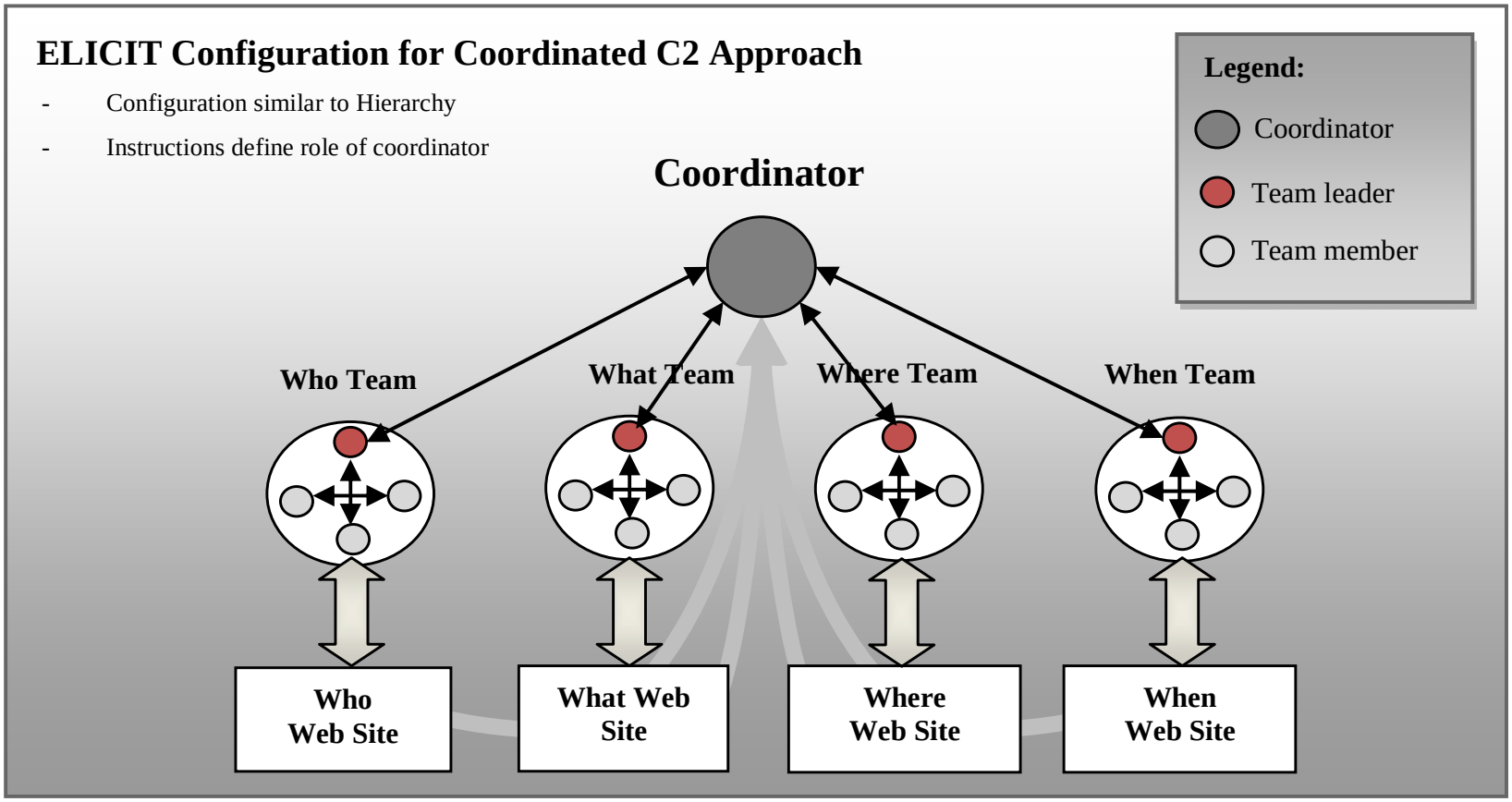


SUCESS CRITERION

Each Team pursues independent goals.

Success occurs if each Team leader finds the correct solution to his problem space.

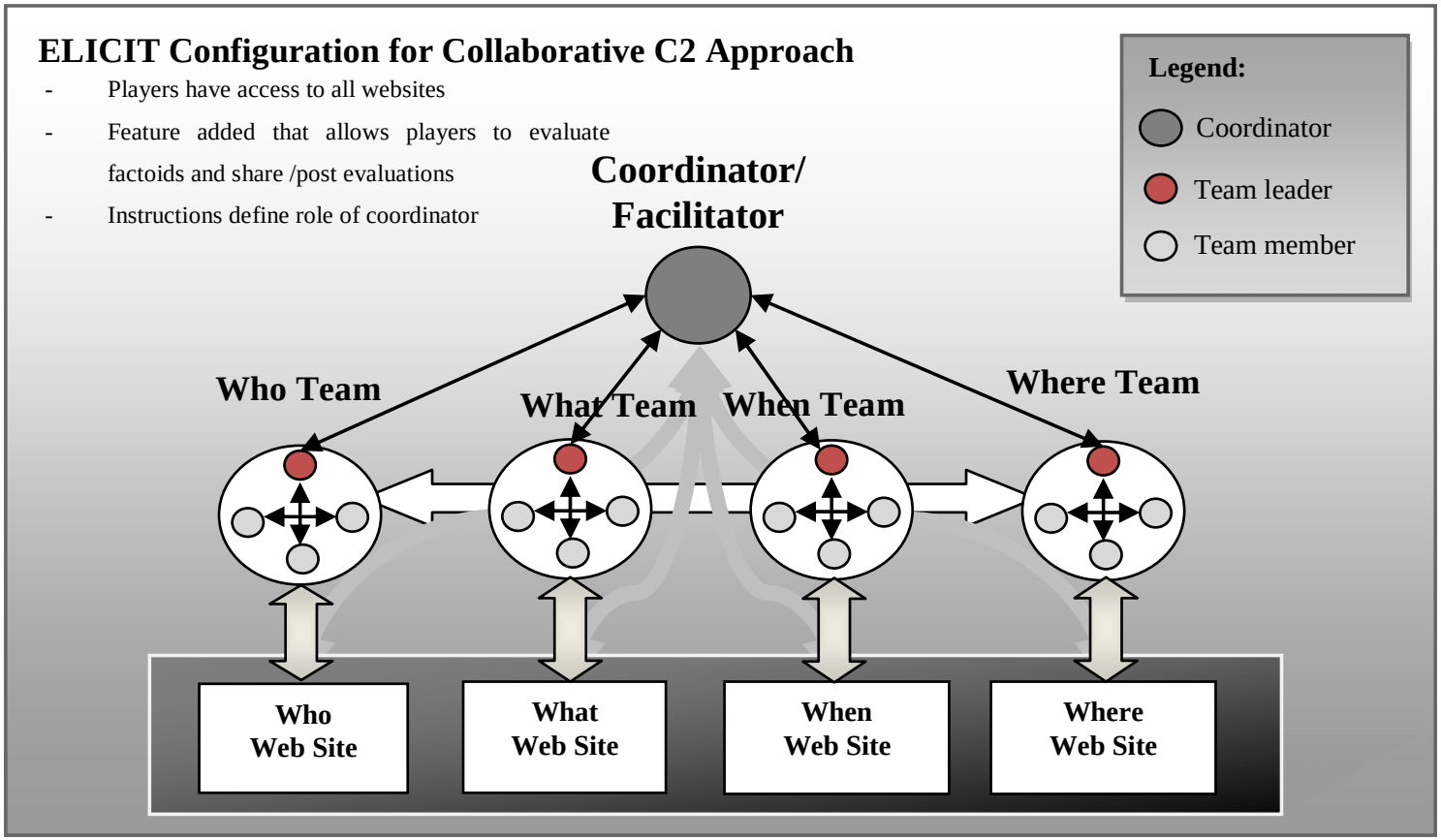
Experimentation: COORDINATED model



SUCESS CRITERION

Organization success depends on the Coordinator finding the correct solution.

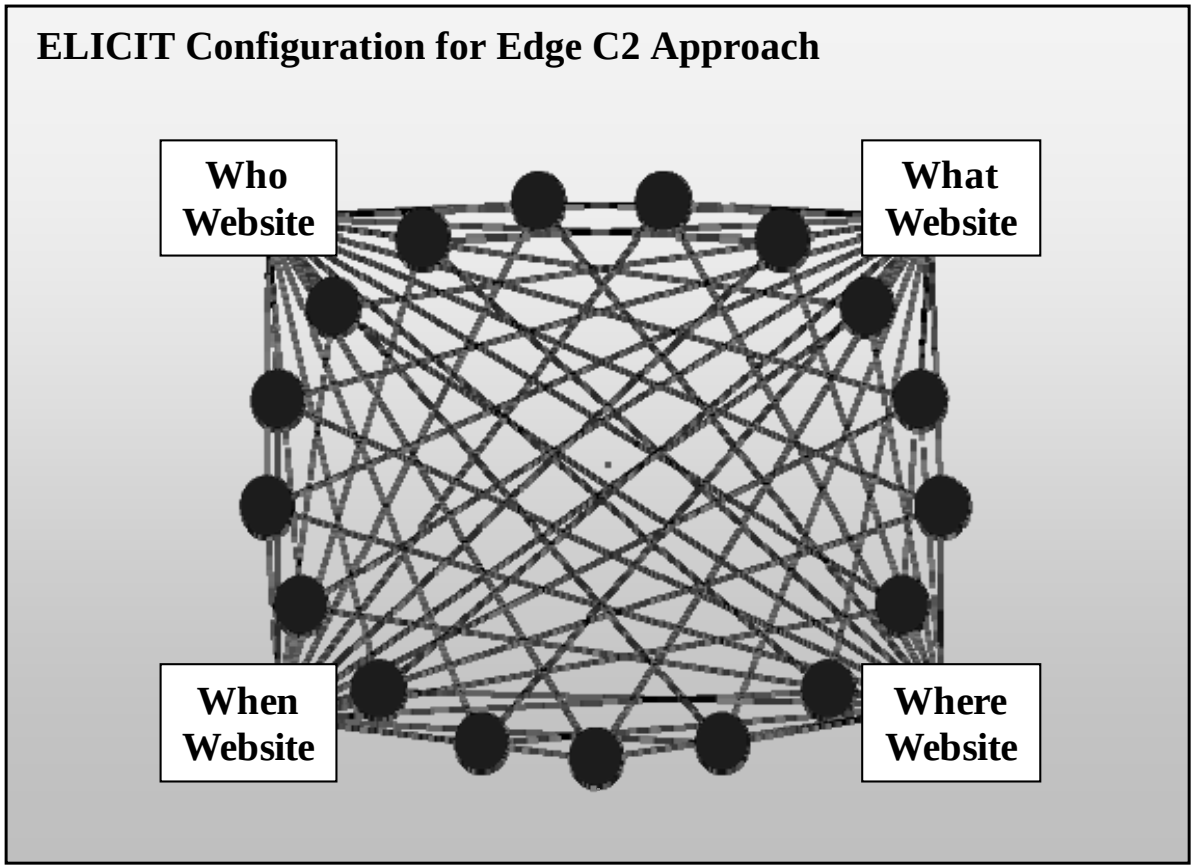
Experimentation: COLLABORATIVE model



<u>SUCESS CRITERION</u>

Coordinator finding the correct solution to all problem spaces OR Team leaders finding the correct solution to their problem space.

Experimentation: EDGE model



<u>SUCESS CRITERION</u>

Organization success depends on the individuals' IDs plurality being correct in each problem space.

Analysis: Experiments Baseline

18 valid runs performed with human subjects:

- 3 runs for CONFLICTED
- 4 runs for DE-CONFLICTED
- 4 runs for COORDINATED
- 4 runs for COLLABORATIVE
- 3 runs for EDGE

Usually, a group of 17 subjects was used to perform two runs. A *test* run (15 to 30 min) was always conducted prior to first *real* run.

This means:

- About 150 military cadets participated in ELICIT runs.
- About 10 hours of data to analyze
- 9 979 actions, comprising:
  2 290 shares, 1 880 posts, 4 979 pulls and 712 IDs
- Software Analysis Tool: more than 50K SLOC

Part 3:

Analysis

Analysis: Overview

- Information Domain
- Interactions and Social Domain
- Cognitive Domain
- Measures of Merit

Analysis: Information Domain

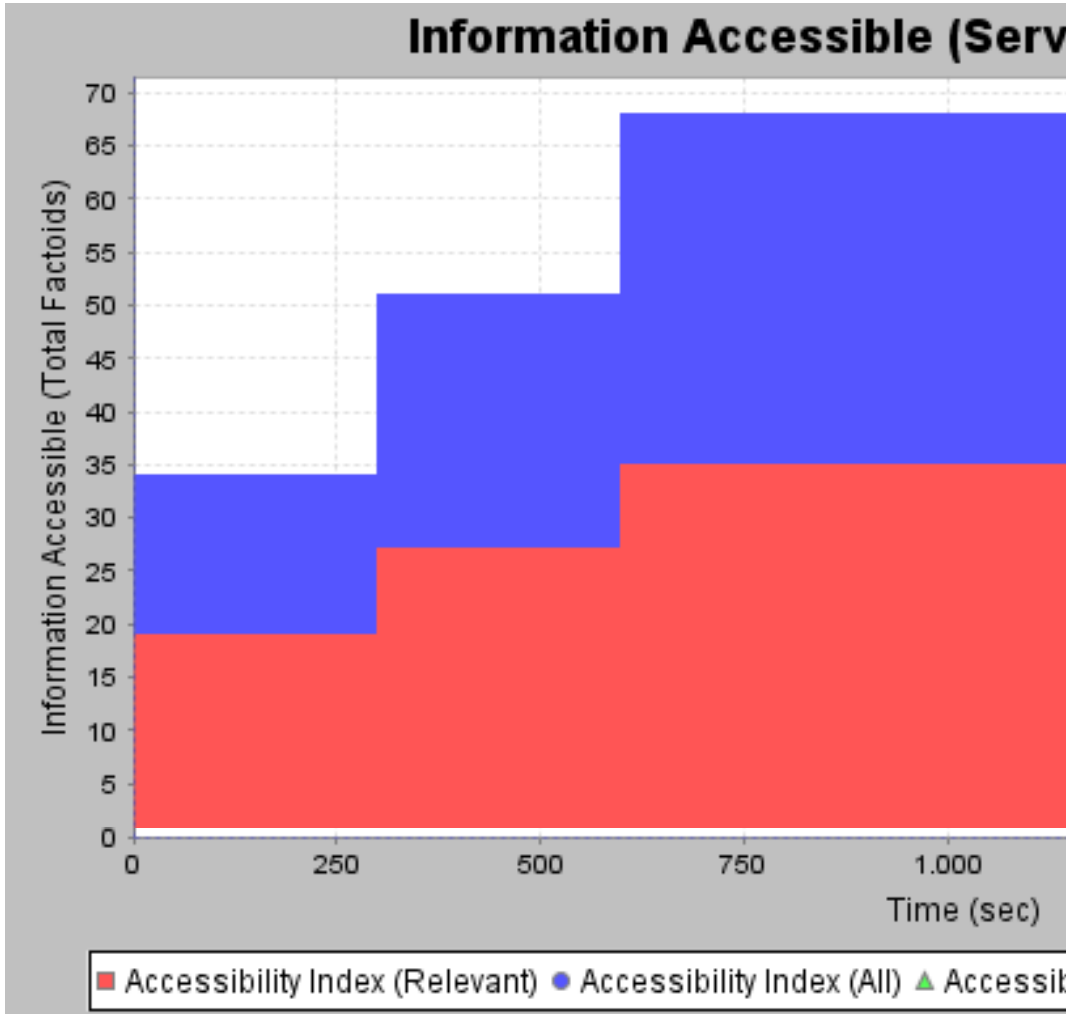
- Question:

Are there significant differences between the C2 approaches in the Information Domain?

e.g., (Percentage of) Shared Information accessible and Critical Information Missing.

Analysis: Information Domain

Information Accessible (factoids distributed by server)



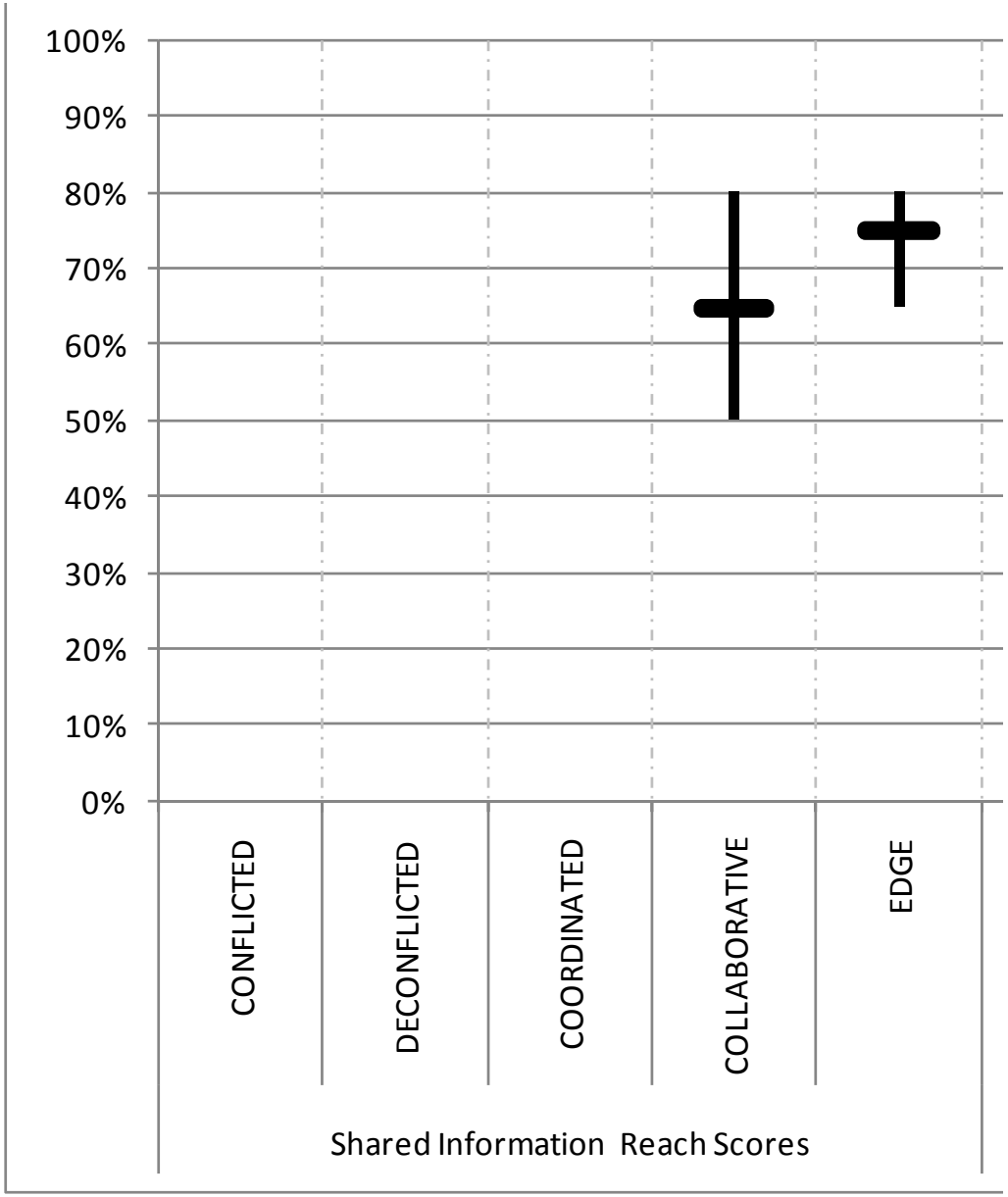
50% @ 0 seconds
75% @ 300 seconds (5 minutes)
100% @ 600 seconds (10 minutes)

Analysis: Information Domain

Shared

Information

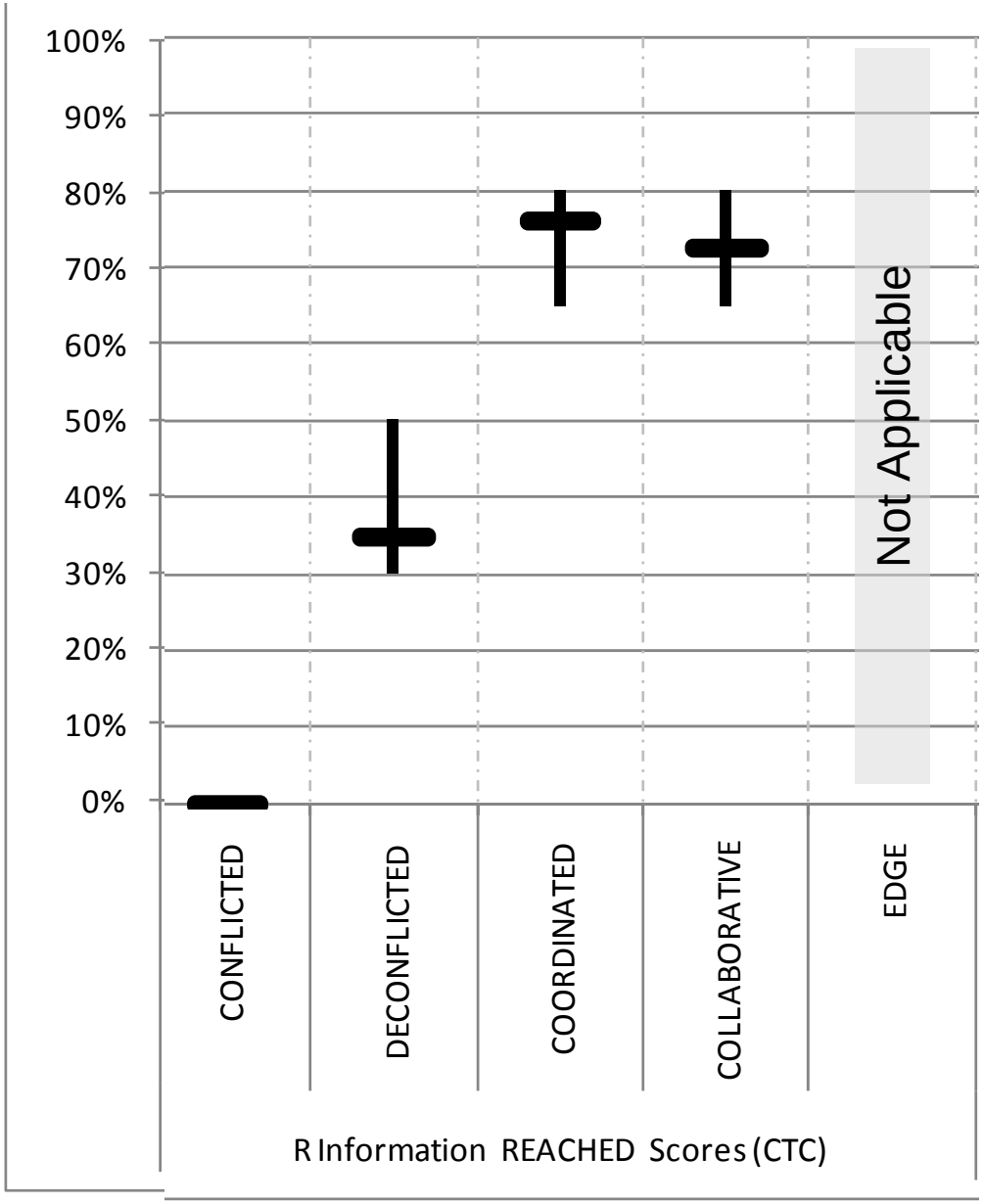
(in percentage)



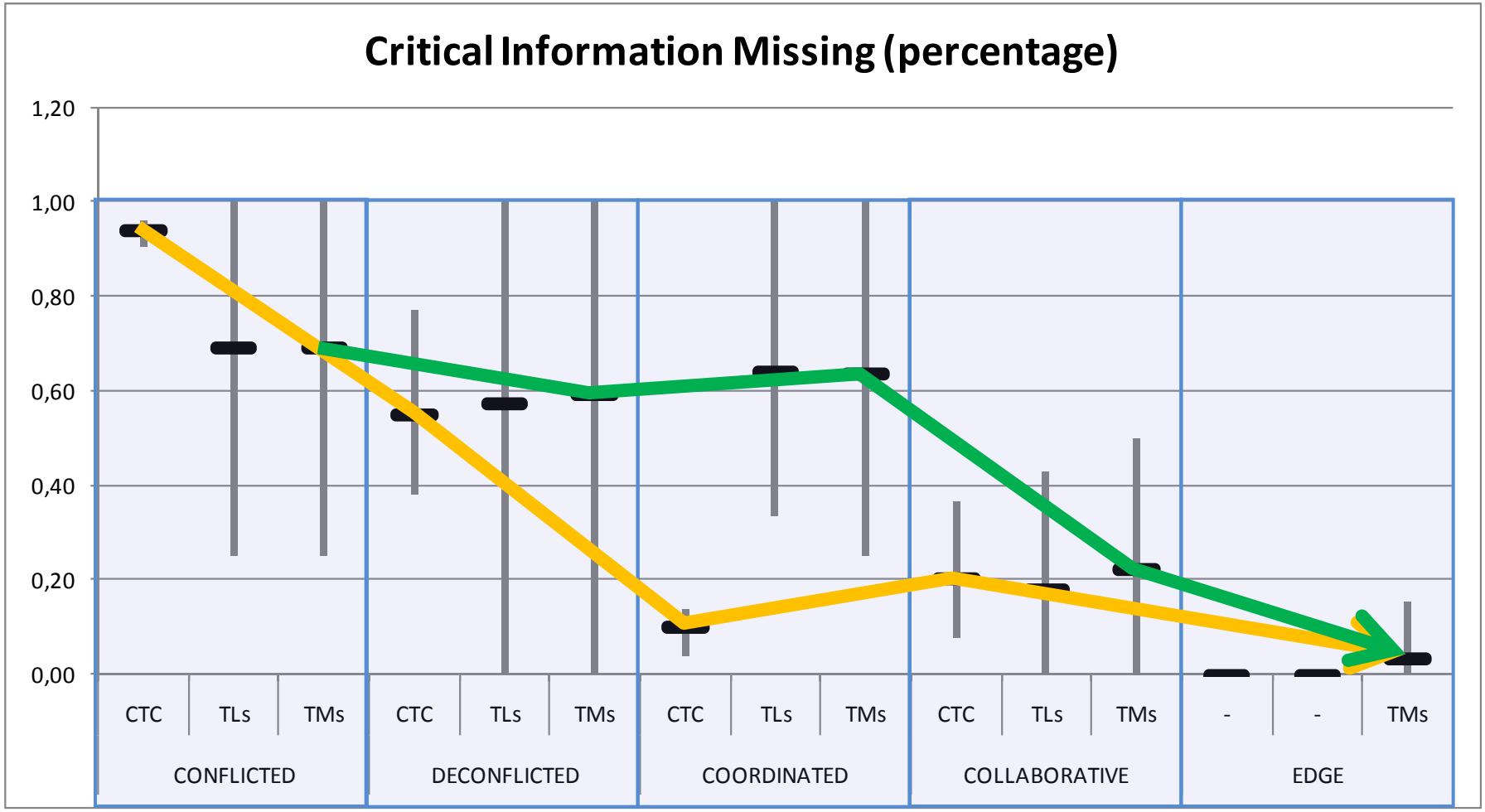
Analysis: Information Domain

Relevant information reached by CTC

(in percentage)



Analysis: Information Domain

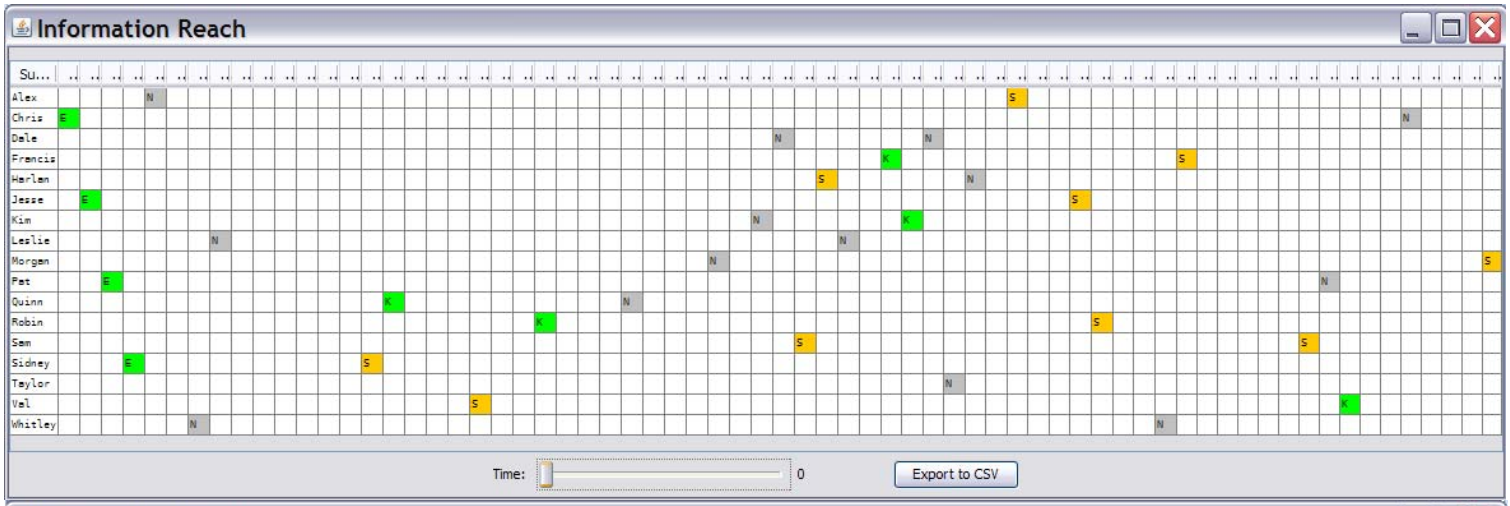


CTC TMs

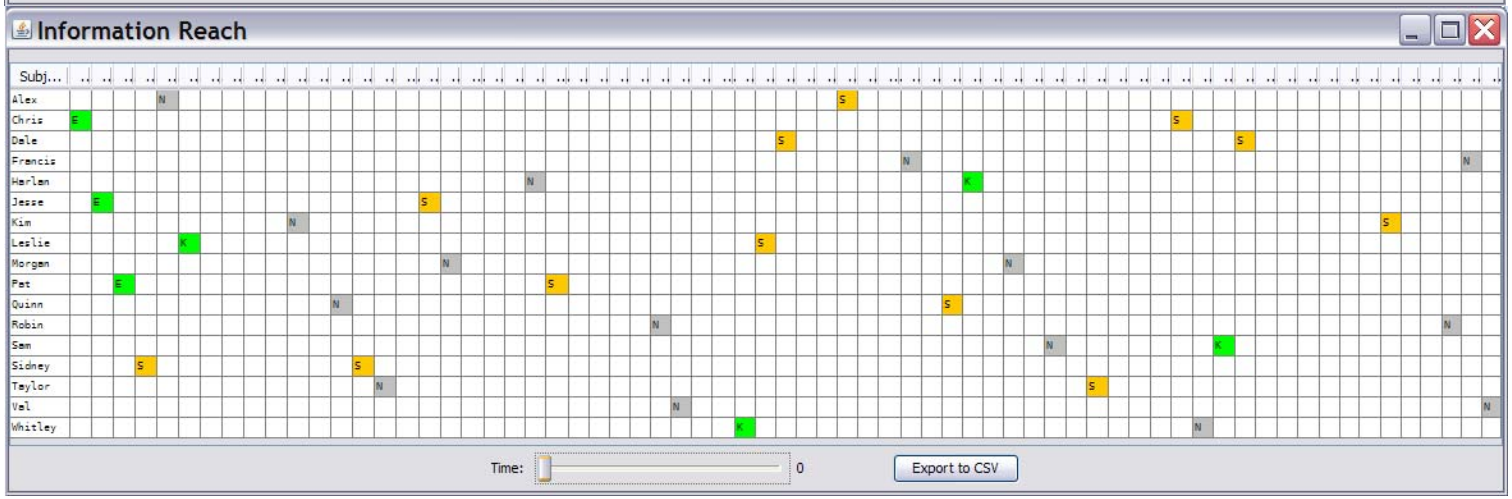
Analysis: Information Domain

- Information Accessible::Reach (example)

DECONFLICTED



EDGE

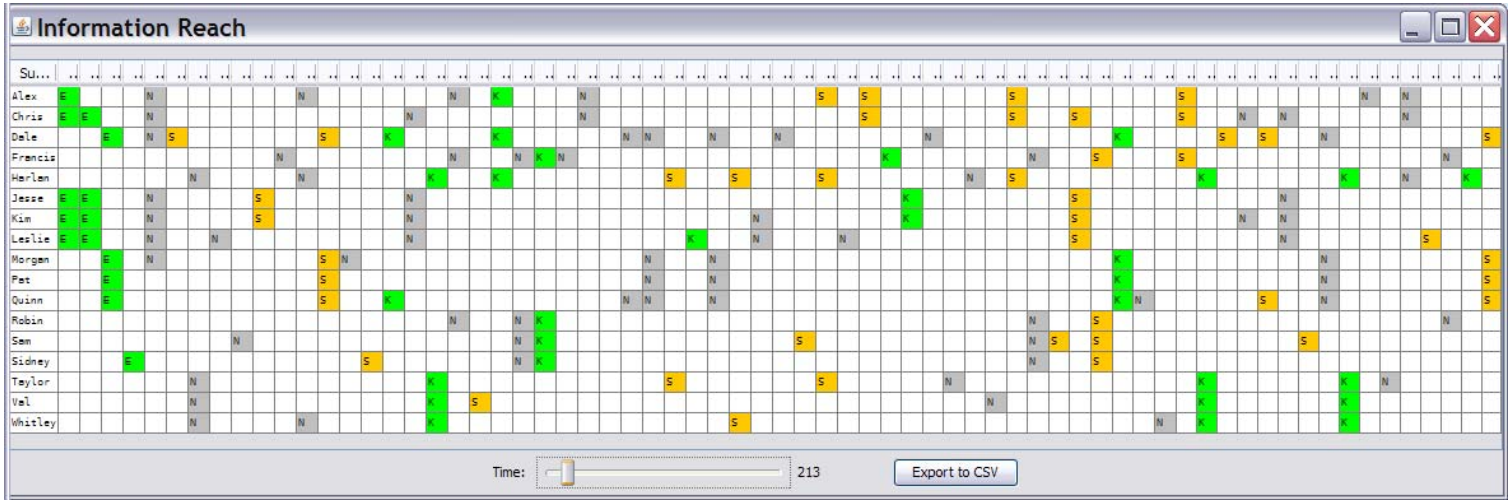


start → time

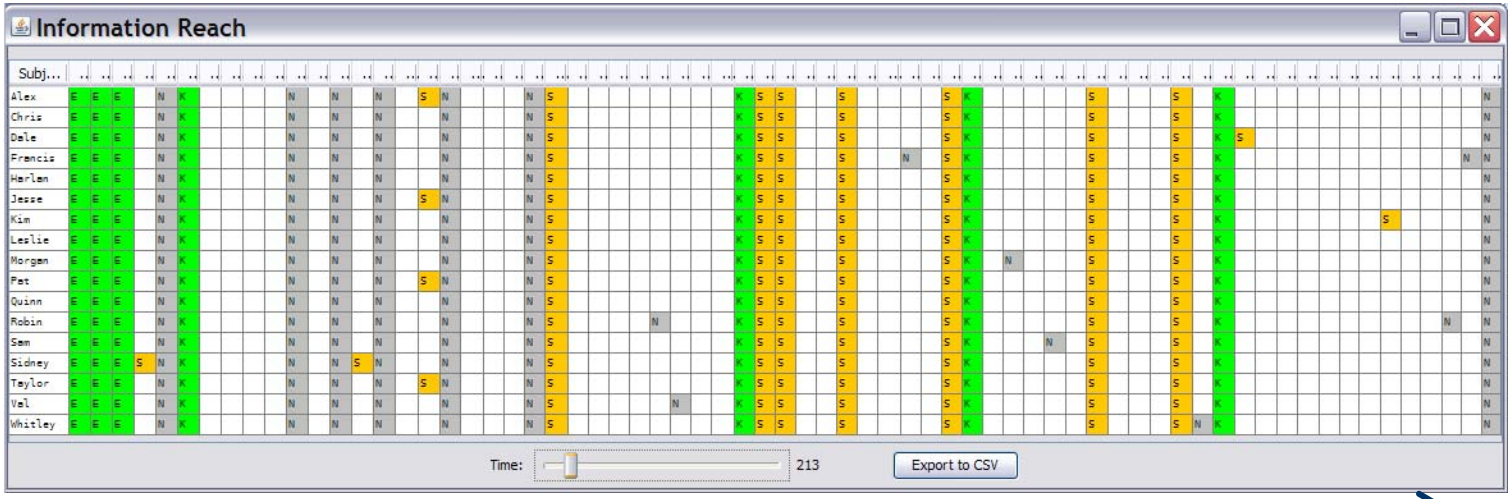
Analysis: Information Domain

- Information Accessible::Reach (example)

DECONFLICTED



EDGE



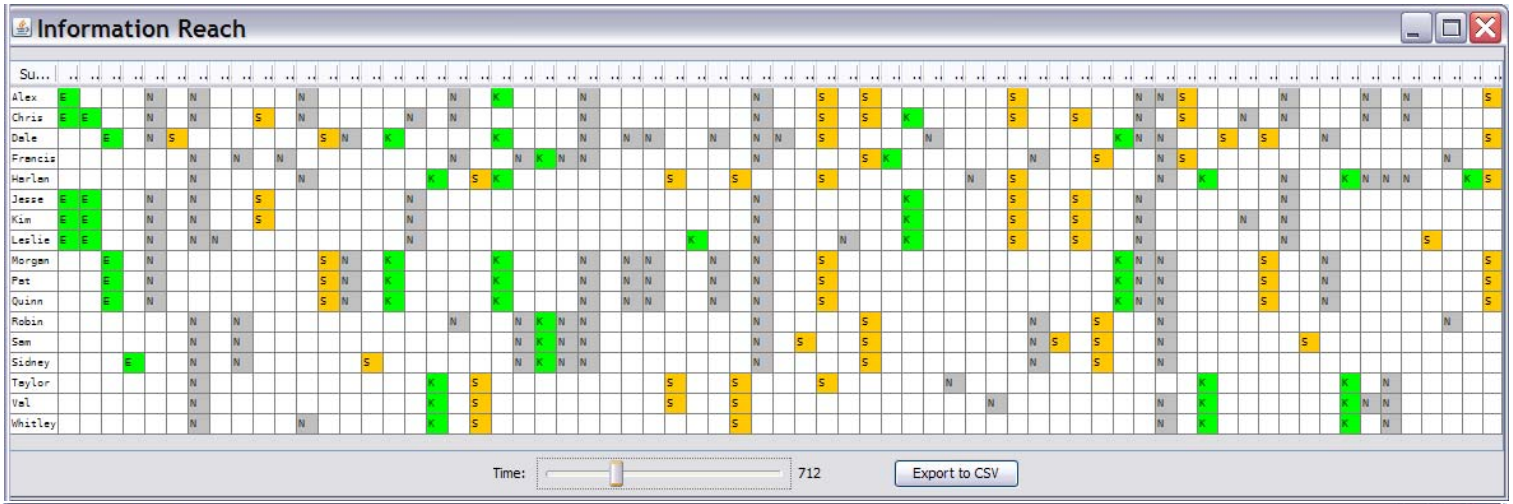
t = 230 sec

time

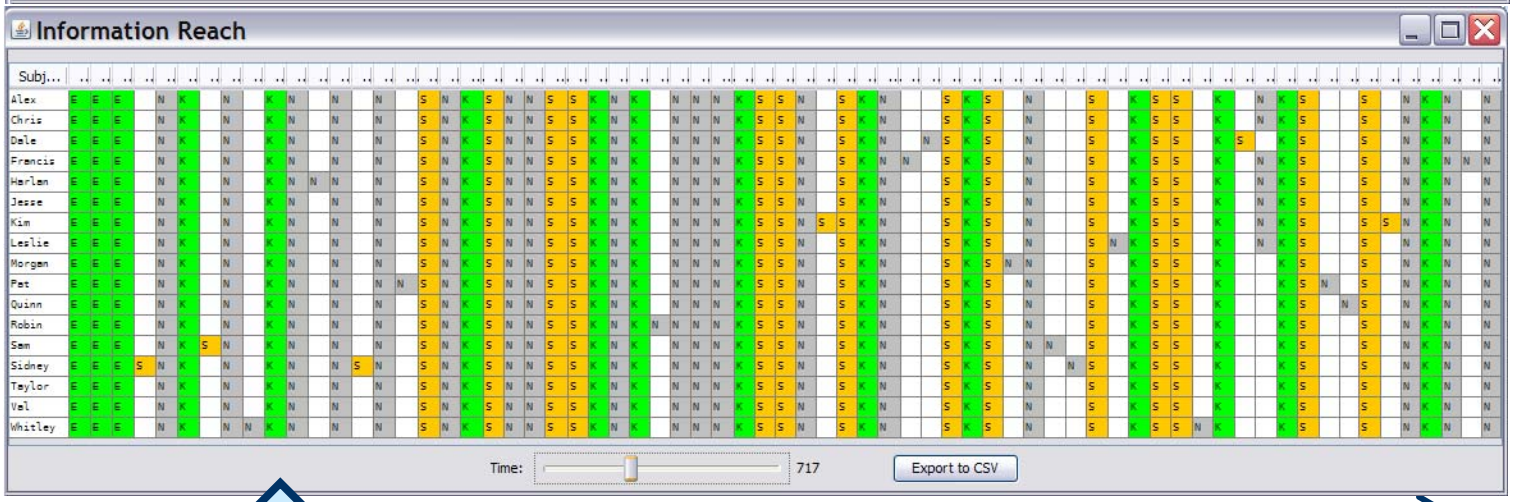
Analysis: Information Domain

- Information Accessible::Reach (example)

DECONFLICTED



EDGE



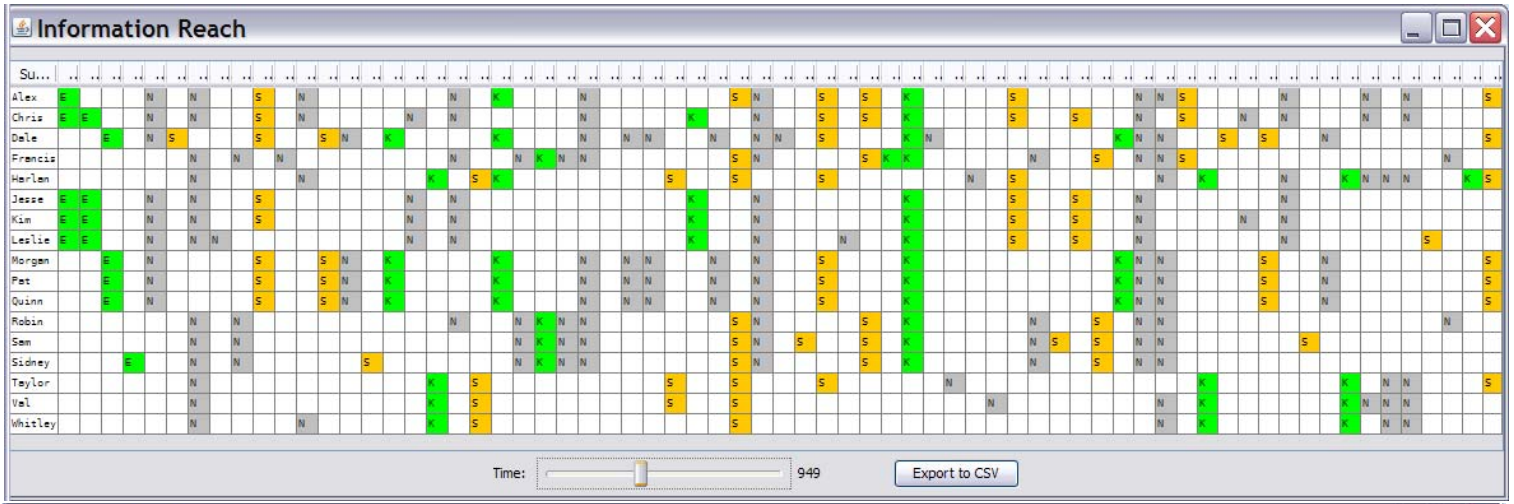
t = 712 - 717 sec

time

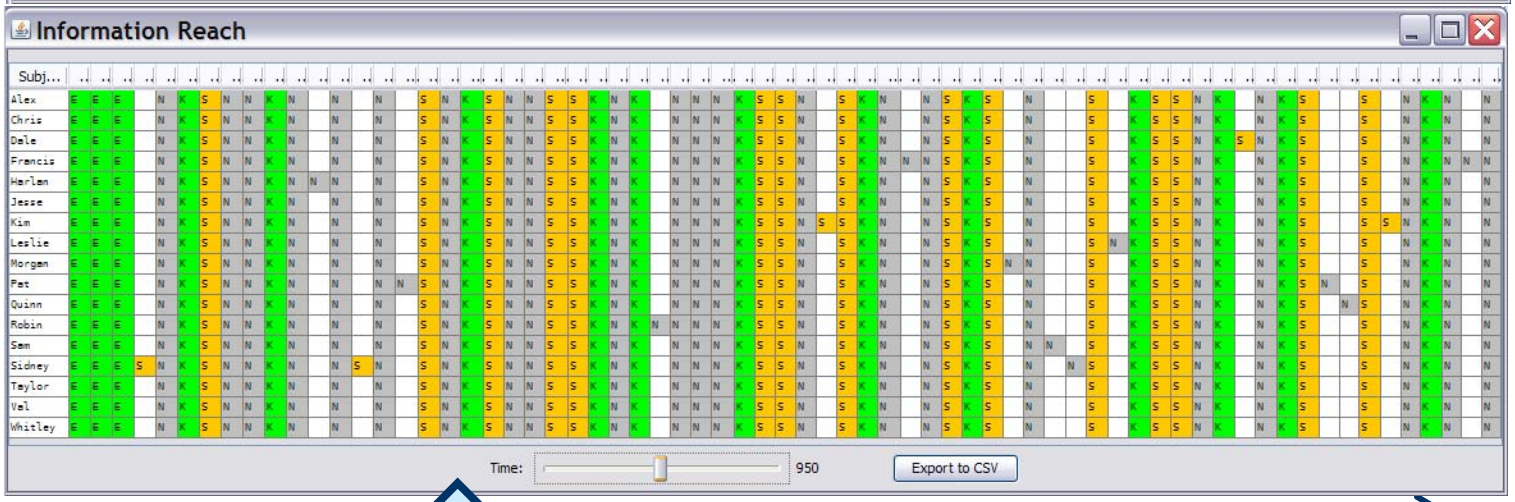
Analysis: Information Domain

- Information Accessible::Reach (example)

DECONFLICTED



EDGE



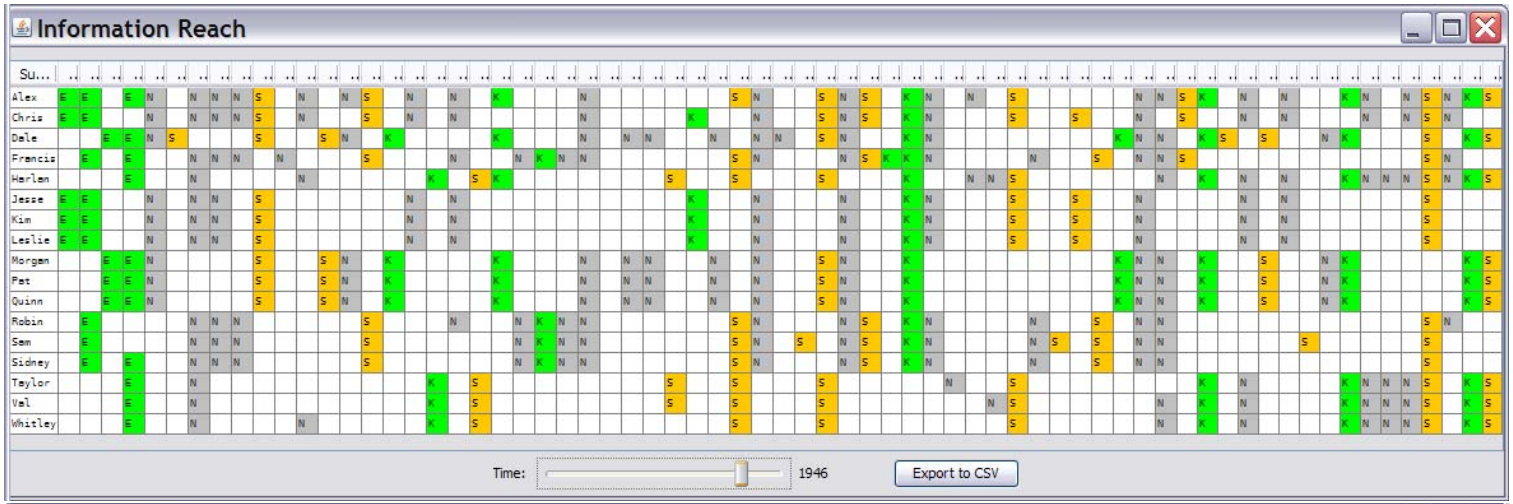
t = 950 sec

time

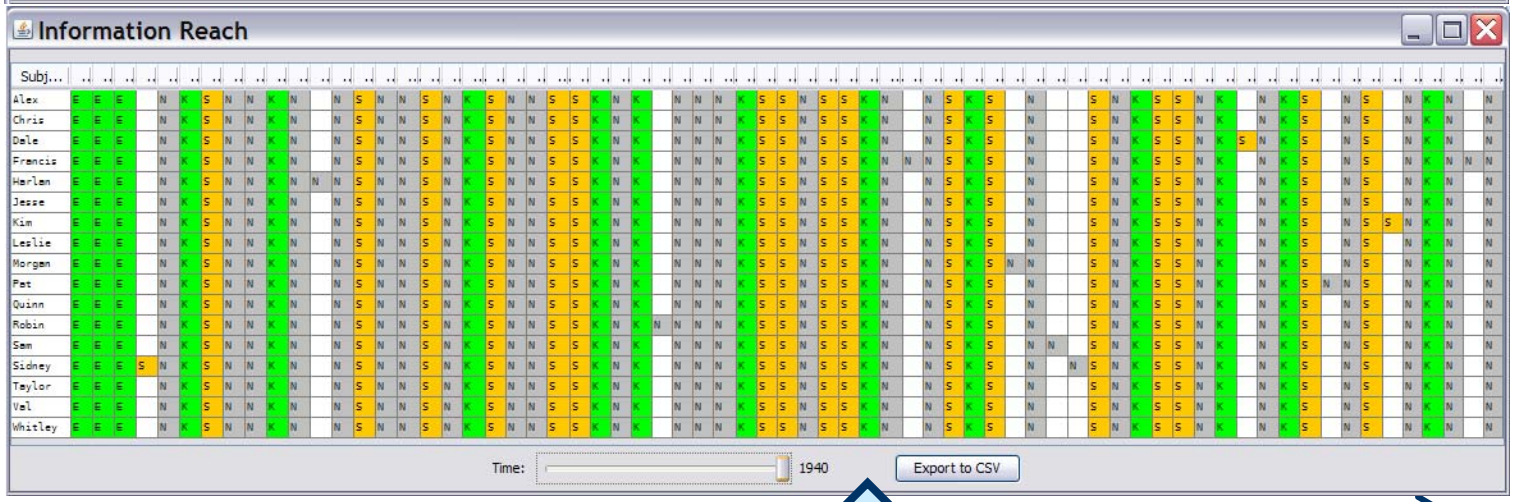
Analysis: Information Domain

- Information Accessible::Reach (example)

DECONFLICTED



EDGE



t = 1940 sec

time

Analysis: Information Domain

- Answer:

Yes - there are significant differences.

EDGE and COLLAB achieved high levels of shared information and all other approaches have none.

COORD achieved high levels of information reached by CTC (and low levels for TLs).

	CONF	DECONF	COORD	COLLAB	EDGE
Sh Info	NONE	NONE	NONE	MED-HIGH	HIGH
Info R (CTC)	NONE	LOW	HIGH	HIGH	N/A

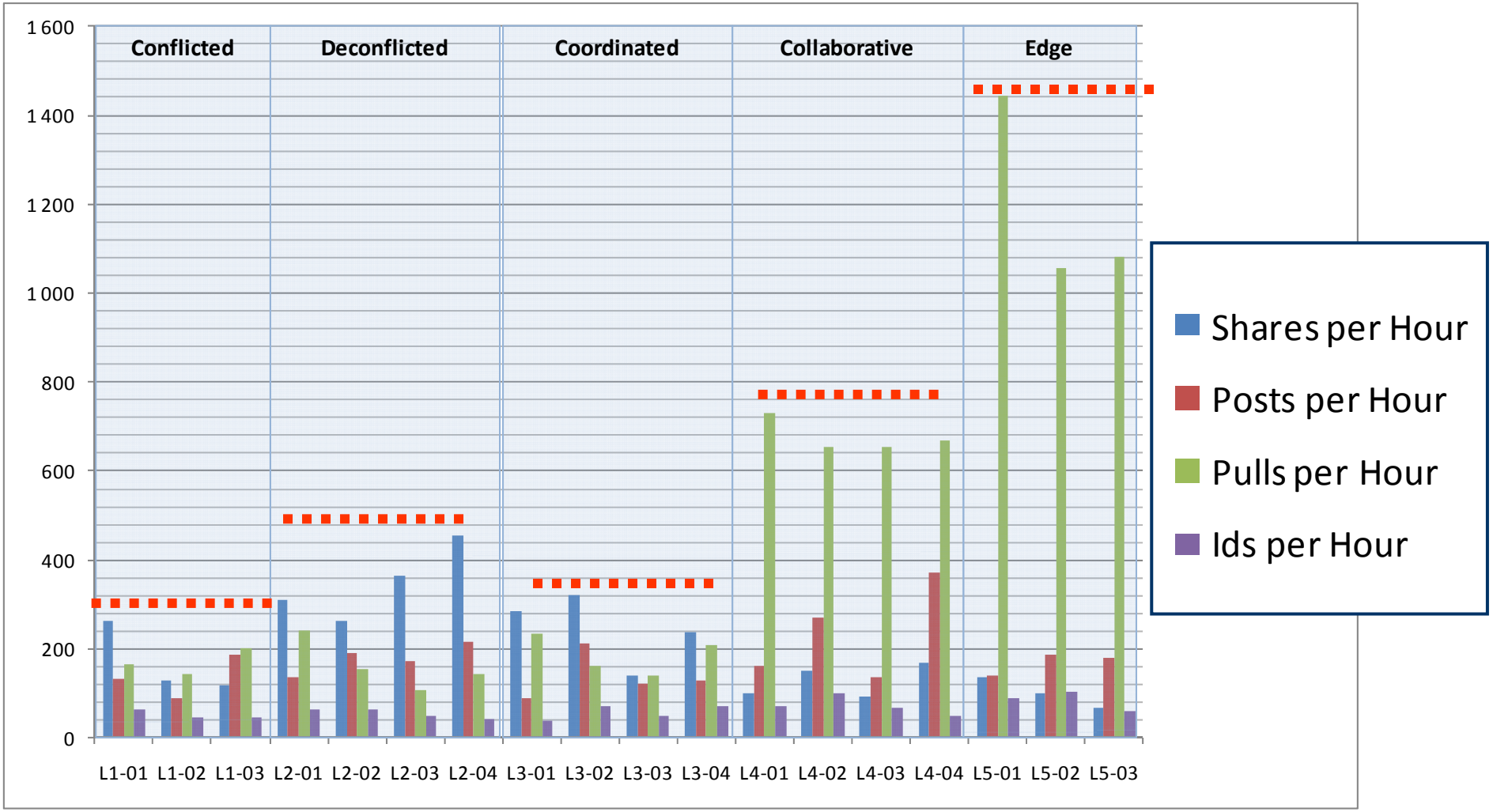
Analysis: Interactions and Social Domain

- Question:

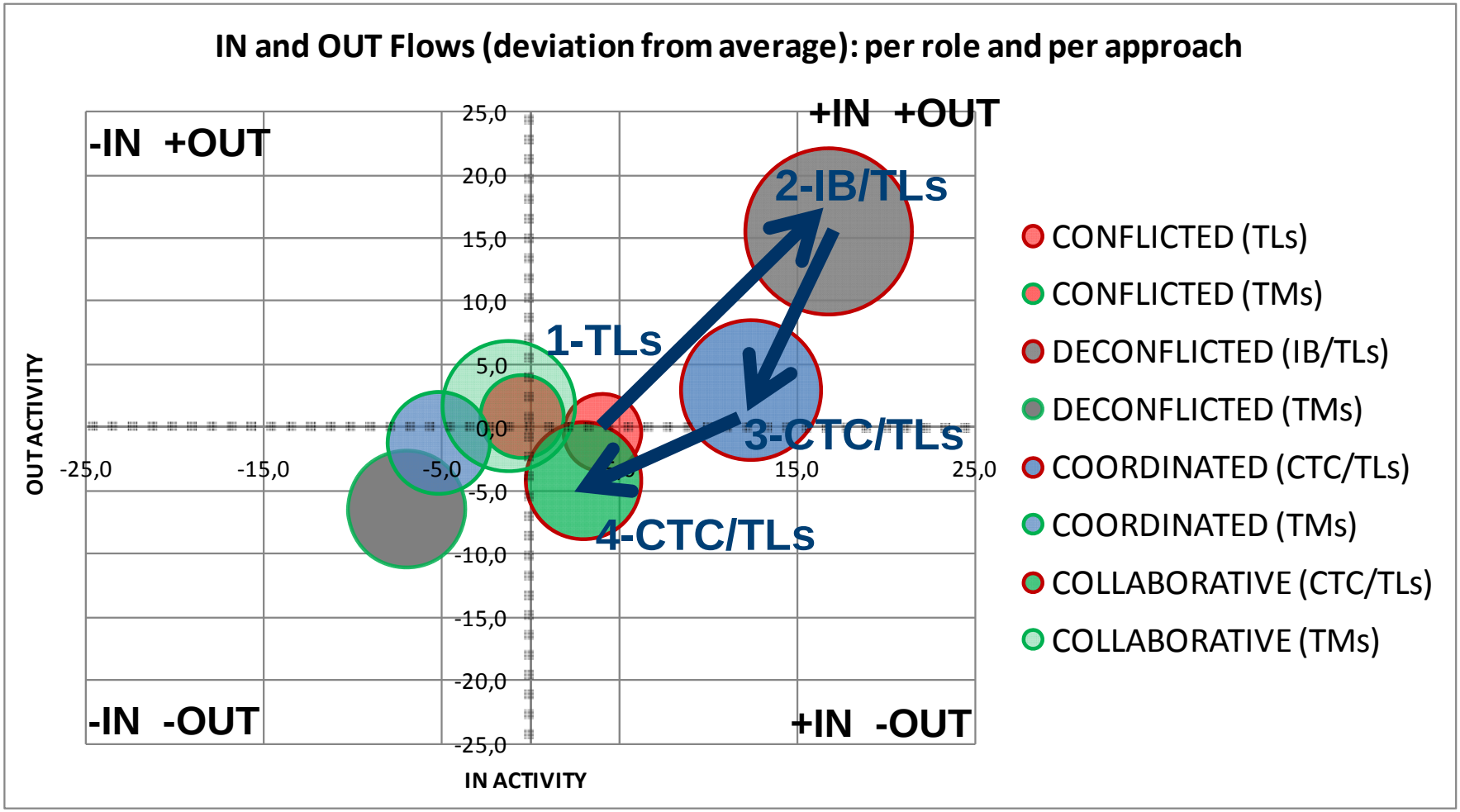
Are there significant differences between the C2 approaches regarding social interactions and nature of interactions?

Analysis: Interactions and Social Domain

Nature and quantity of Interactions:



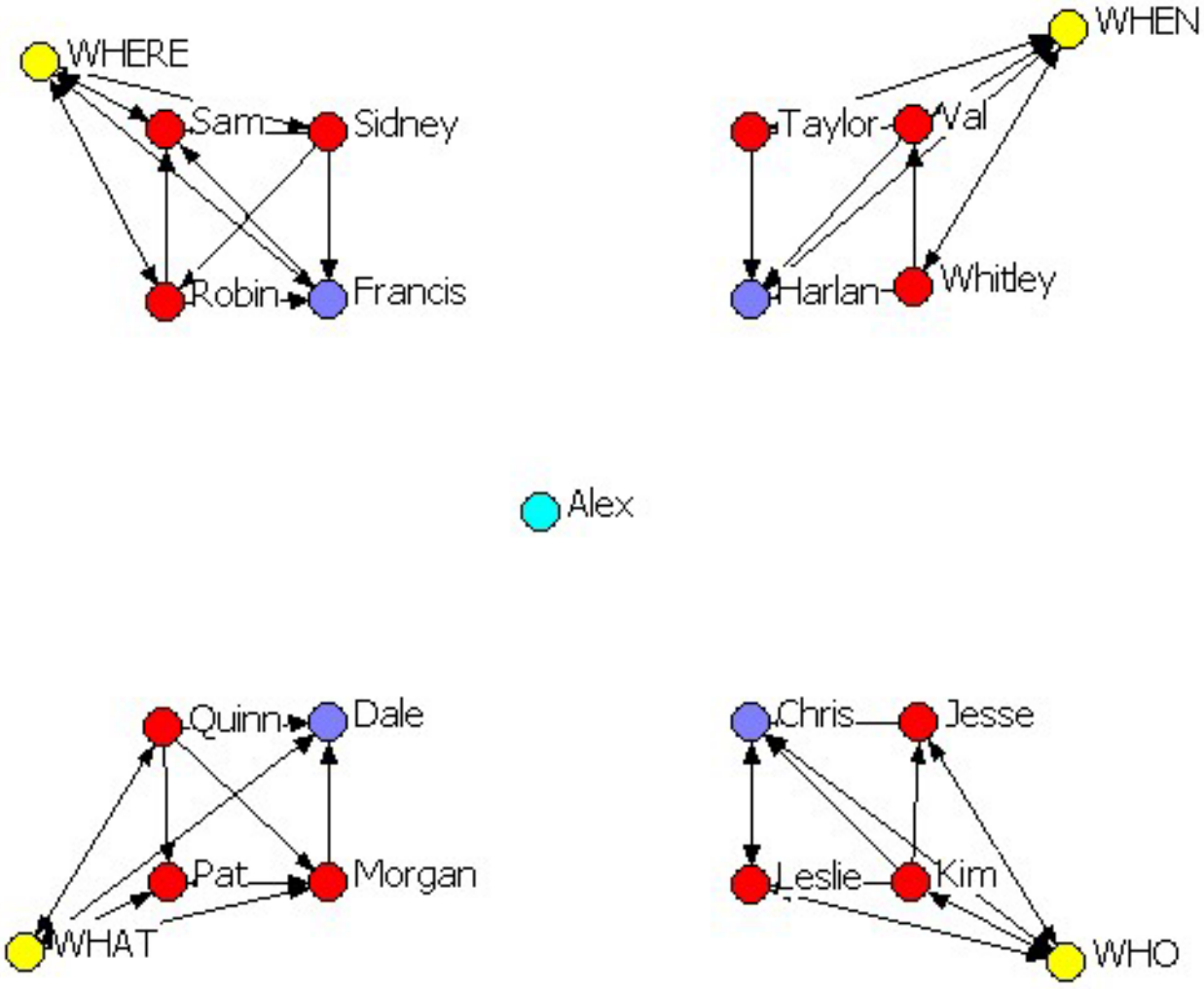
Analysis: Interactions and Social Domain



$$IN_DEV_{S_i} = (nbr_shares_received_{S_i} + nbr_pulls_{S_i}) - (Average_nbr_shares_received + Average_nbr_pulls)$$

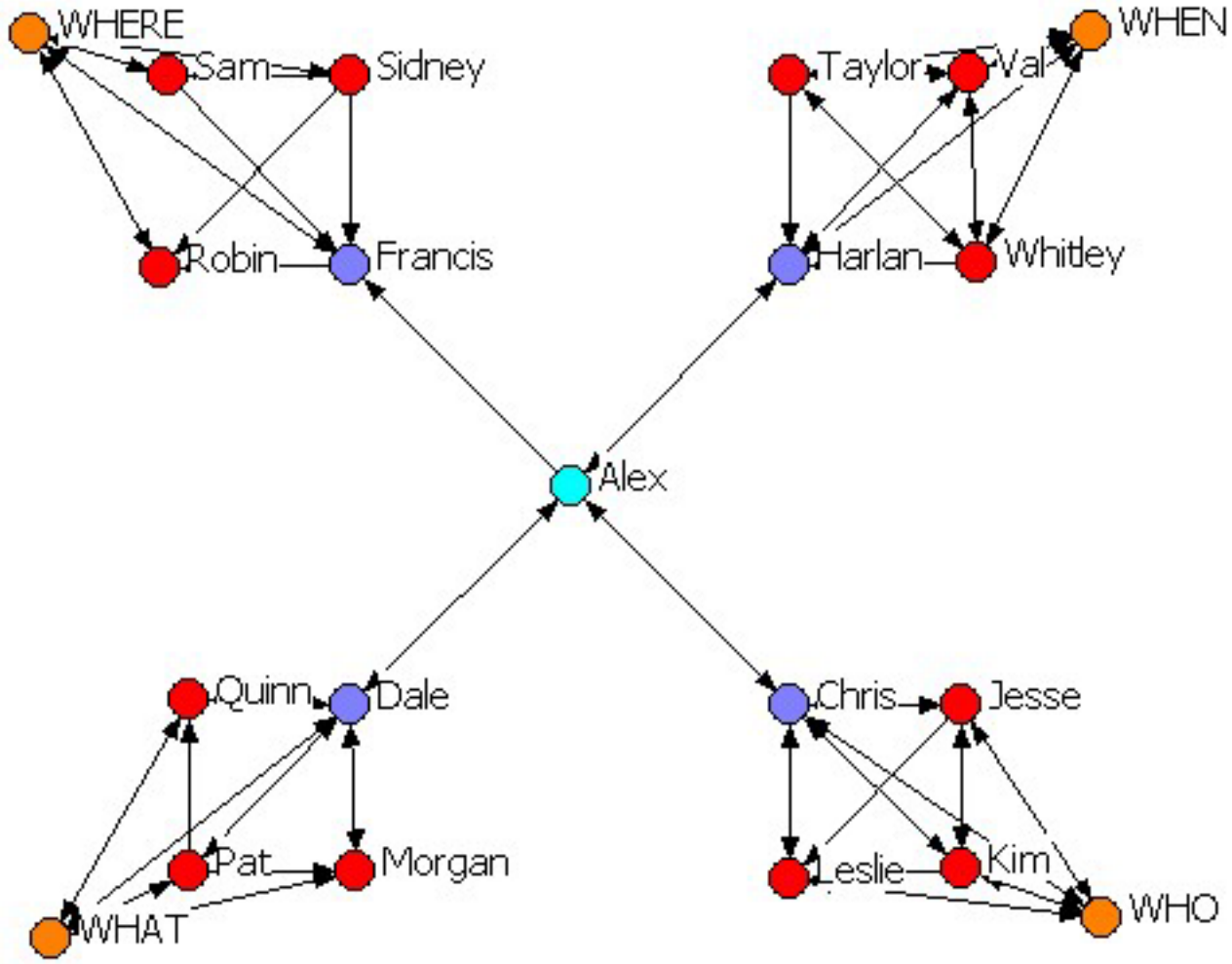
$$OUT_DEV_{S_i} = (nbr_shares_sent_{S_i} + nbr_posts_{S_i}) - (Average_nbr_shares_sent + Average_nbr_posts)$$

Analysis: Interactions and Social Domain



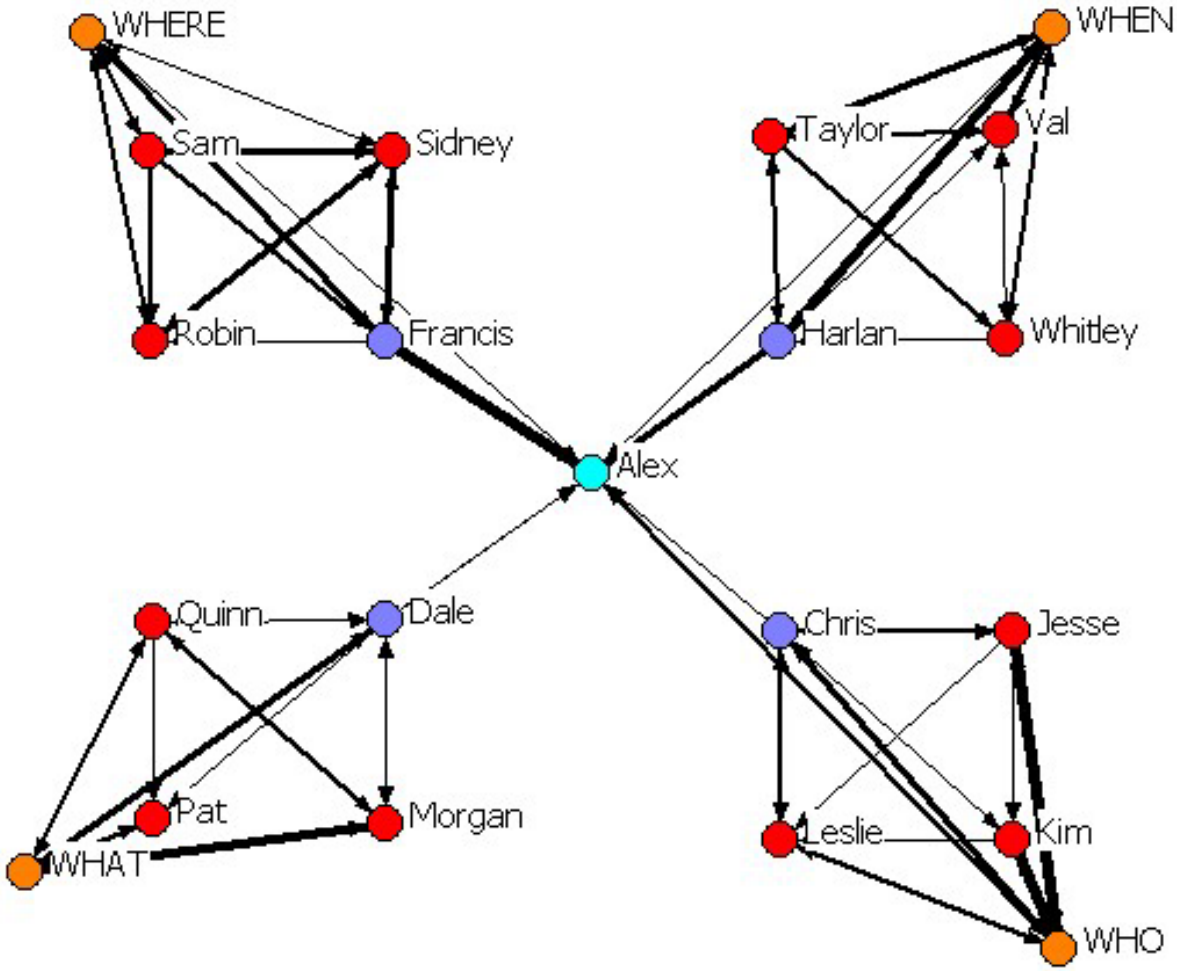
L1 03 Sociogram with websites

Analysis: Interactions and Social Domain



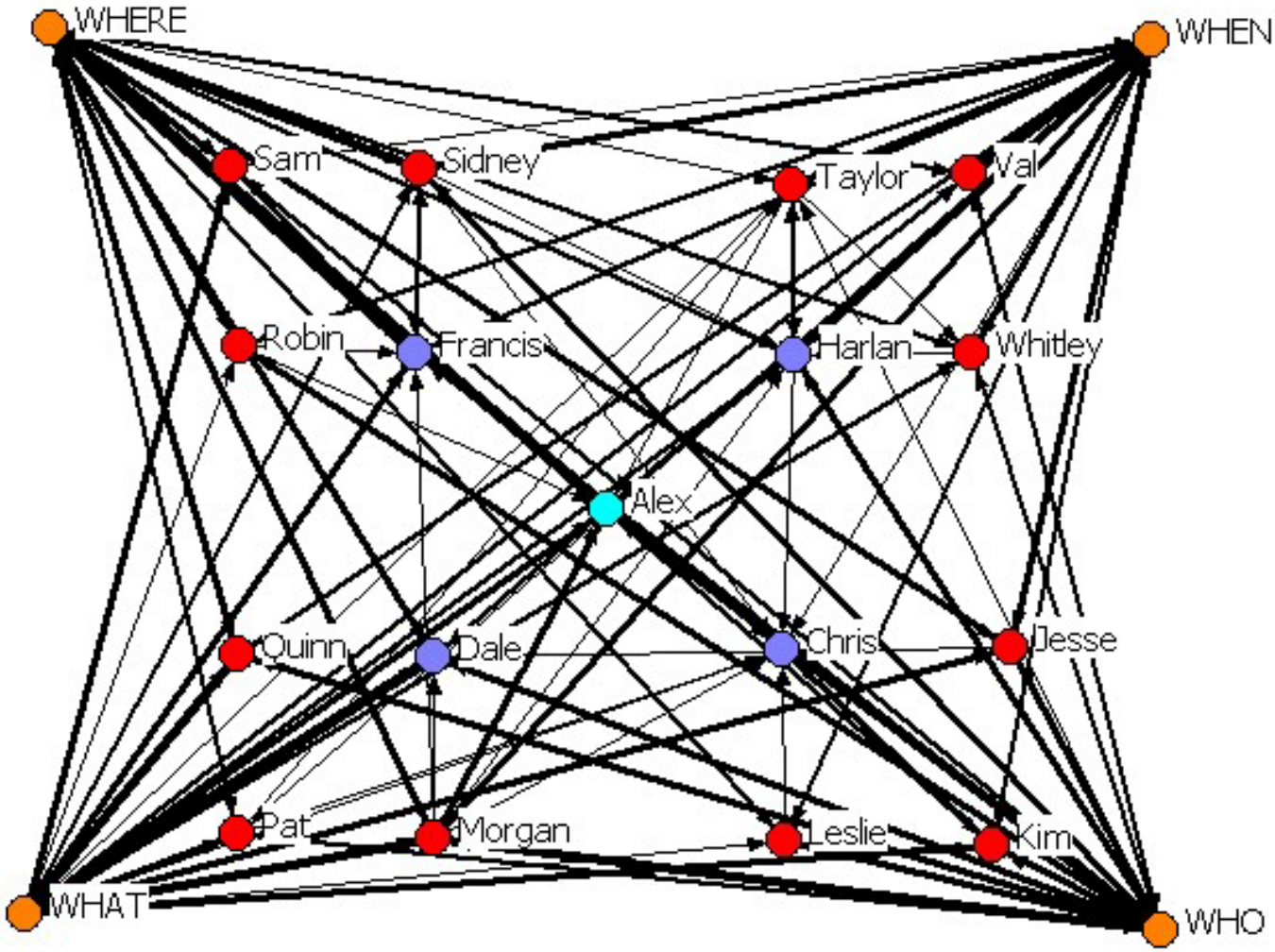
L2 01 Sociogram with websites

Analysis: Interactions and Social Domain



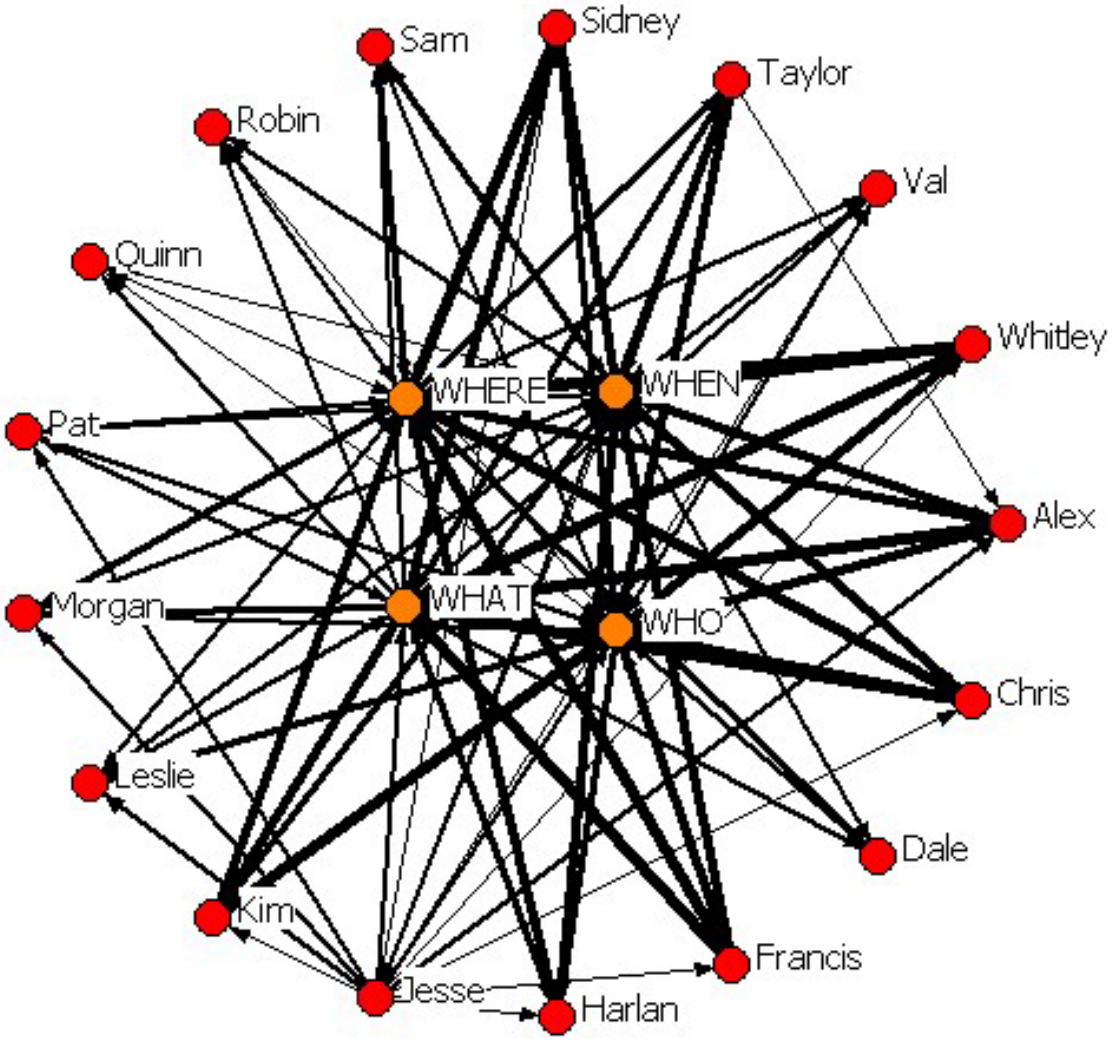
L3 04 Sociogram with websites

Analysis: Interactions and Social Domain



L4 01 Sociogram with websites

Analysis: Interactions and Social Domain



L5 03 Sociogram with websites

Analysis: Interactions and Social Domain

	Node Centrality			Node Embeddedness			Network Activity	Network Average Path Length	Network Structural Cohesion
	Betweenness	Degree	Closeness	Link Density	Link Strength	Link Flow			
Average L1	0,196	2,529	2,627	0,196	2,529	2,627	291	0,138	3
Average L2	16,157	2,667	6,903	0,536	6,941	22,725	490	0,950	7
Average L3	16,182	2,824	7,010	0,614	5,863	17,373	400	0,616	5
Average L4	2,852	2,098	8,098	0,154	1,627	6,314	704	0,471	3
Average L5	5,059	2,745	6,363	0,208	1,392	7,176	981	0,561	7

SNA Variable	CONF	DECONF	COORD	COLLAB	EDGE
node centrality	-	High	Highest	Low	Medium
node embeddedness	-	Highest	High	Low	Medium
network activity	-	Enlarged	Medium	High	Higest
path lengths	-	Largest	Large	Smallest	Small
network diameter	-	Widest	Wide	Small	Large
network structural cohesion	-	High	Medium	Low	High

Analysis: Interactions and Social Domain

- Answer:

Yes – there are significant differences.

- Nature of interactions (share/push approach to pull/information-seekers approach)
- Network nodes asymmetry: from more asymmetric to less asymmetric networks
- (SNA variables)

Analysis: Cognitive Domain

- Question:

Are there significant differences between the C2 approaches in the Cognitive Domain?

e.g., (Extent of) Correct Understanding.

Analysis: Cognitive Domain

DECONFLICTED

/ ID ...	WHO	WHAT	WHERE
Alex	MAGENTA		
Chris	BEIGE		
Dale		TERMINAL DE OL...	
Francis			THETALAND
Harlan	MAGENTA	TERMINAL DE OL...	
Jesse	BEIGE	ESTACOES DE CO...	LAMBDALAND
Kim	BEIGE	EDIFICIOS	LAMBDALAND
Leslie	BEIGE		
Morgan	MAGENTA	TERMINAL DE OL...	LAMBDALAND
Pat		CENTRAL ELECTRICA	ZETALAND
Quinn		ESTACAO CENTRA...	
Robin			ZETALAND
Sam			
Sidney			THETALAND
Taylor	MAGENTA	TERMINAL DE OL...	THETALAND
Val			
Whitley	HYENA	TERMINAL DE OL...	ZETALAND

COORDINATED

IO	WHAT	WHERE
Alex	MAGENTA	ESTACAO DE COM...	LAMBDALAND
Chris	MAGENTA		
Dale	MAGENTA	CENTRAL ELECTRICA	ZETALAND
Francis	BEIGE E IVORY	ATACAR ESTACOE...	LAMBDALAND
Harlan			
Jesse	FOX	ATAQUE A INTER...	KAPPALAND
Kim	FOX - BEIGE		
Leslie	CYAN		
Morgan		CENTRAL ELECTRICA	ZETALAND
Pat		CENTRAL ELECTRICA	
Quinn		CENTRAL ELECTRICA	ZETALAND
Robin	MAGENTA	ESTACAO DE COM...	LAMBDALAND
Sam			LAMBDALAND
Sidney			
Taylor	MAGENTA	TERMINAL DE OL...	ZETALAND
Val			
Whitley	GREEN	CENTRAIS ELECT...	IOTALAND

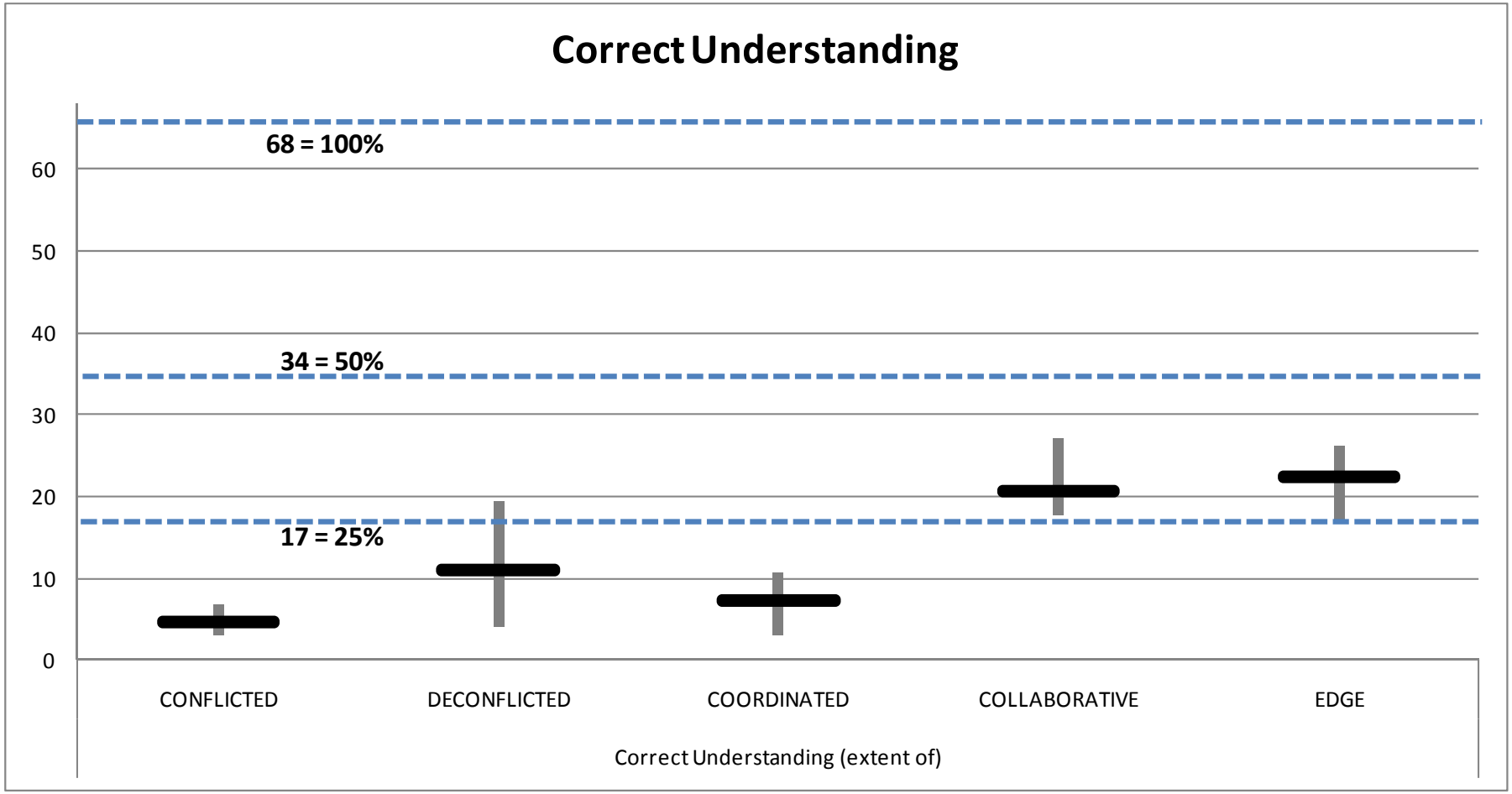
COLLABORATIVE

cts / ID ...	WHO	WHAT	WHERE
Alex	MAGENTA	ESTACAO DE COM...	THETALAND
Chris			THETALAND
Dale		TERMINAL DE OL...	
Francis			THETALAND
Harlan	FOX	TERMINAL DE OL...	THETALAND
Jesse	MAGENTA		THETALAND
Kim	MAGENTA, CYAN ...		THETALAND
Leslie	MAGENTA		
Morgan	FOX	TERMINAL DE OL...	KAPPALAND
Pat	FOX	CENTRAL ELECTRICA	LAMBDALAND
Quinn			THETALAND
Robin			LAMBDALAND
Sam		ESTACOES DE CO...	LAMBDALAND
Sidney			IOTALAND
Taylor			
Val	MAGENTA	TERMINAL DE OL...	THETALAND
Whitley	CYAN	ESTACAO DE COM...	THETALAND

EDGE

cts / ID ...	WHO	WHAT	WHERE
Alex	SILVER	ESCOLA SECULAR	OMICRONLAND
Chris	BLUE	ESCOLA	PILAND
Dale	GRAY	ESCOLA SECULAR	PILAND
Francis	SILVER	ESCOLA SECULAR	OMICRONLAND
Harlan	BLUE	ATAQUE BOMBIST...	MULAND
Jesse	BLUE	ESCOLA	
Kim	TURQUOISE	ESCOLA	XILAND
Leslie			SIGMALAND
Morgan	SILVER	ATAQUE BOMBISTA	XILAND
Pat	SILVER	ESCOLA	OMICRONLAND
Quinn	SILVER	ESCOLA	OMICRONLAND
Robin		ESCOLA	
Sam	TEAL	ESCOLA	OMICRONLAND
Sidney	BLUE	ATAQUE BOMBIST...	PILAND
Taylor			
Val	SILVER		
Whitley	SILVER	ESCOLA	OMICRONLAND

Analysis: Cognitive Domain



Analysis: Cognitive Domain

- How to measure level of convergence / order regarding IDs ?
  - Information Entropy
    (source used: Atkinson and Moffat, *The Agile Organization*, CCRP2005)
  - Cognitive Entropy and Cognitive Self-Synchronization

Cognitive Self-Synchronization (CSSync): measures the amount of disorder (or entropy) of an organization towards determining the problem (i.e., finding *who*, *what*, *where* and *when*).

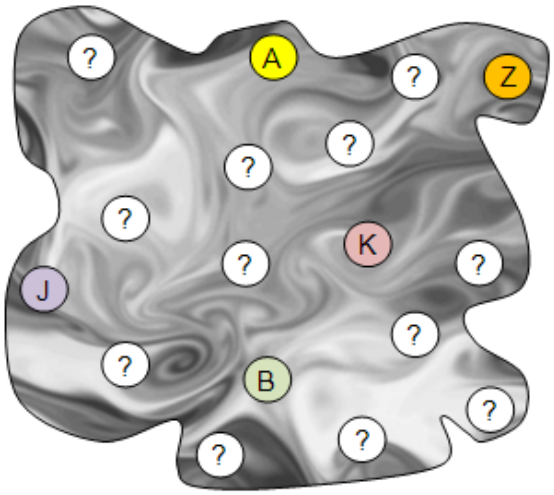
$$\text{CSSync}_{problemSpace} = 1 - \sum_{i=1}^{N} P(S_i) * \ln(P(S_i)) / Max_Disorder_{problemSpace}$$

$$Max_Disorder_{problemSpace} = -\sum_{i=1}^{N} \frac{1}{N} * \ln(\frac{1}{N}) = \ln(N)$$

CSSync=0 means system is fully disordered.

CSSync=1 means system is fully synchronized.

Analysis: Cognitive Domain



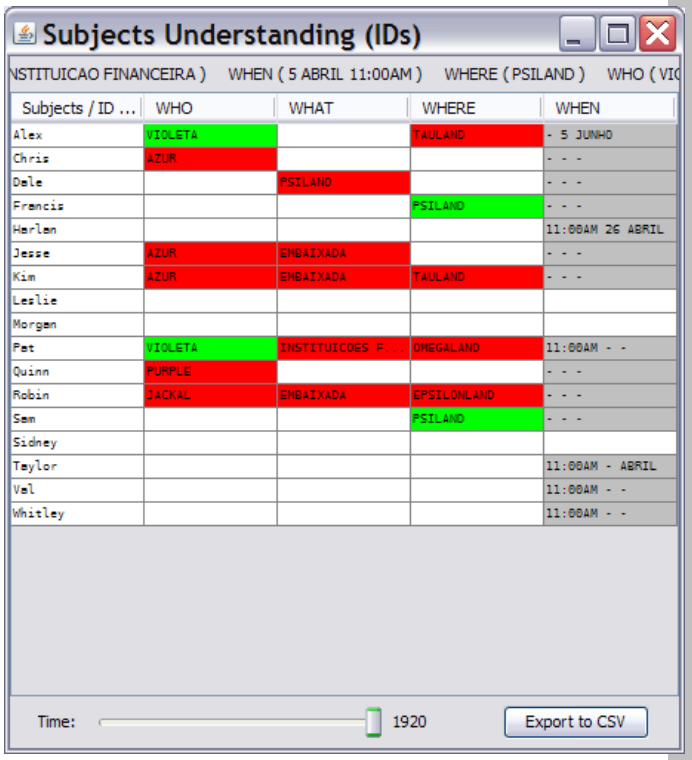
Fully-disordered system[1]

$P_? = 1/17$, 17 times
(17 perceived outcomes)

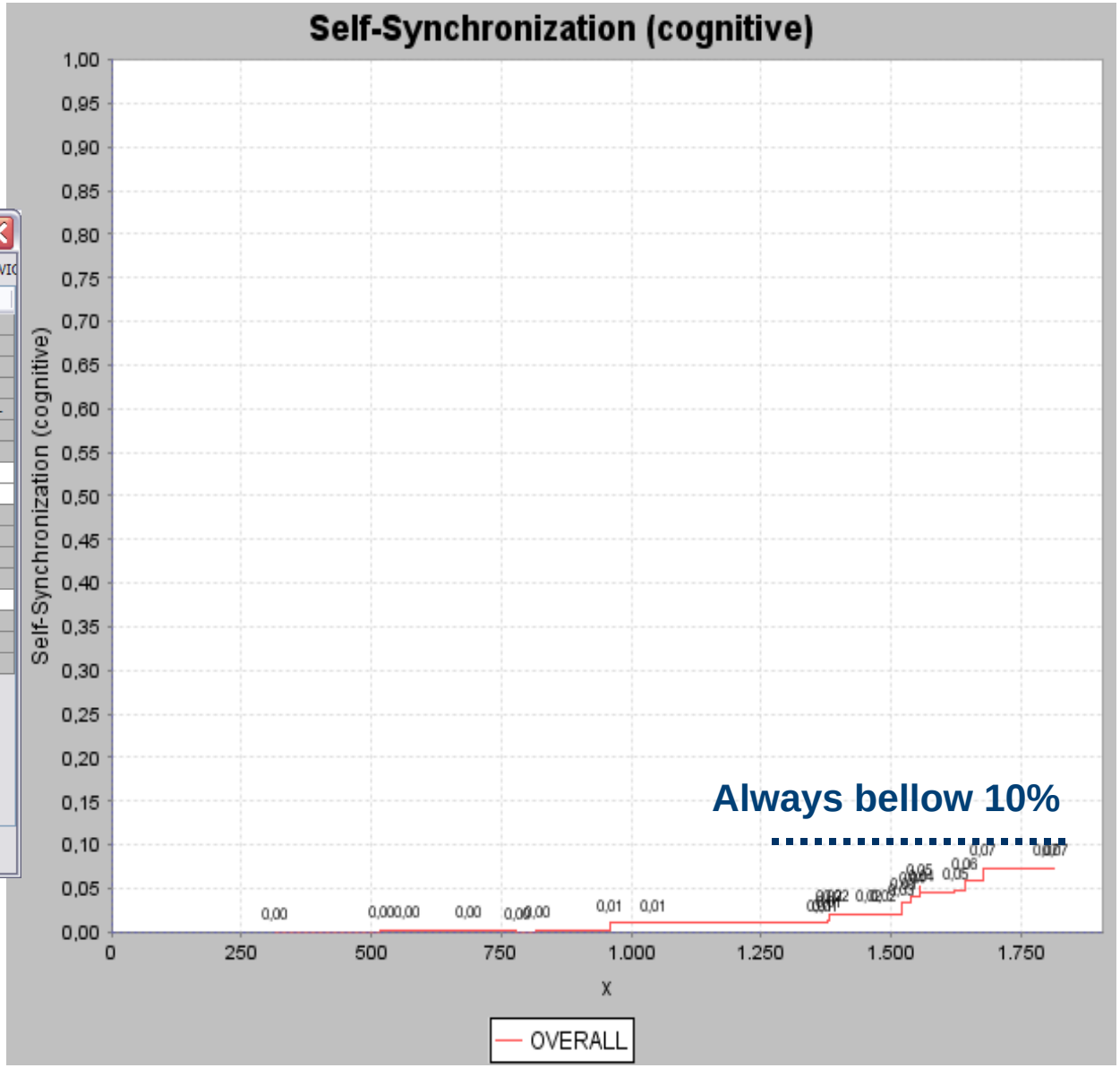
CSSync = 1 - 17*1/17 * ln (1/17)/Max_dis
= 0

Analysis: Cognitive Domain

CONFLICTED:
(L1-02 RUN)

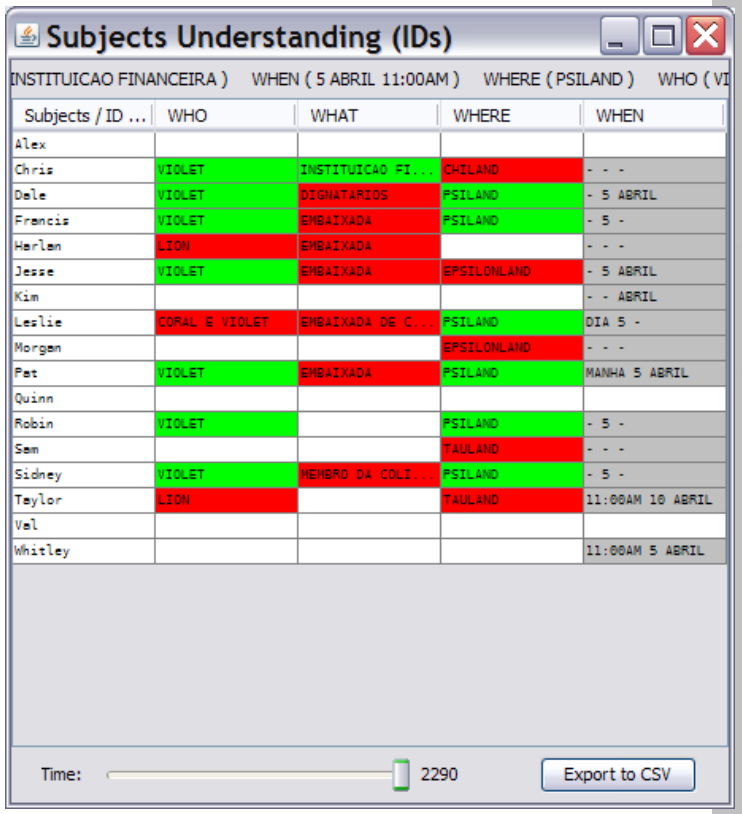


Subjects / ID ...	WHO	WHAT	WHERE	WHEN
Alex	VIOLETA		TAULAND	- 5 JUNHO
Chris	AZUR			- - -
Dale		PSILAND		- - -
Francis			PSILAND	- - -
Harlem				11:00AM 26 ABRIL
Jesse	AZUR	EMBAIXADA		- - -
Kim	AZUR	EMBAIXADA	TAULAND	- - -
Leslie				
Morgan				
Pat	VIOLETA	INSTITUICOES F...	OMEGALAND	11:00AM - -
Quinn	PURPLE			- - -
Robin	JACKAL	EMBAIXADA	EPSILONLAND	- - -
Sam			PSILAND	- - -
Sidney				
Taylor				11:00AM - ABRIL
Val				11:00AM - -
Whitley				11:00AM - -

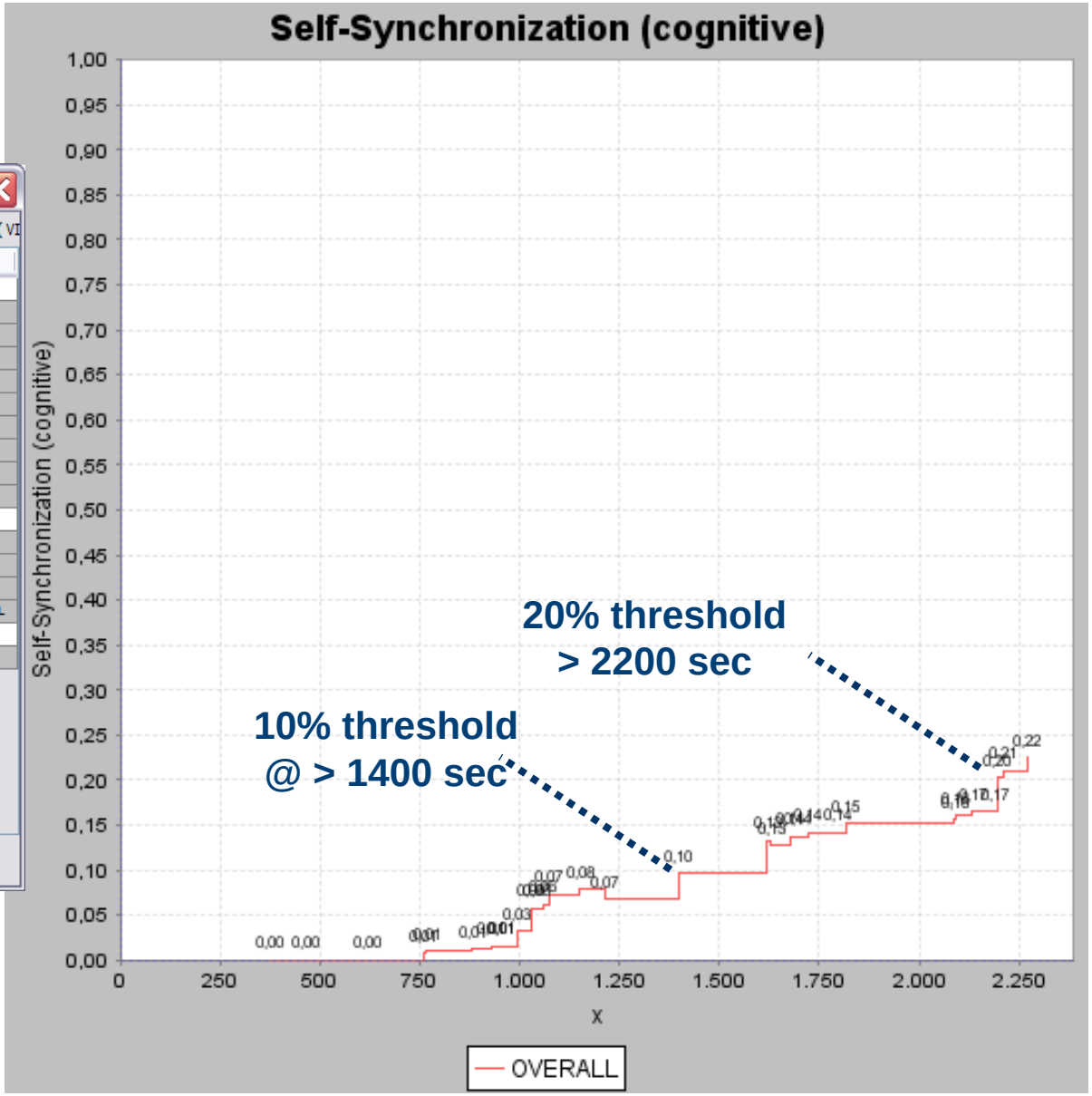


Analysis: Cognitive Domain

DE-CONFLICTED:
(L2-03 RUN)

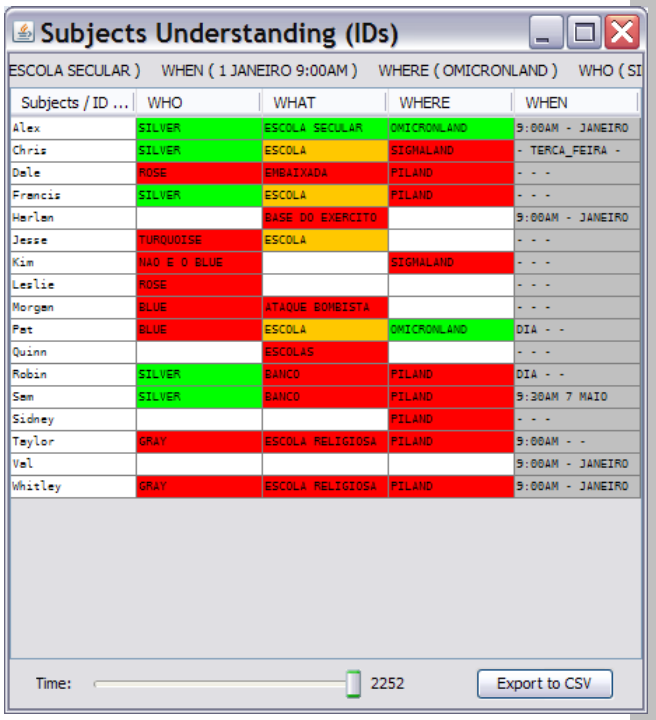


Subjects / ID ...	WHO	WHAT	WHERE	WHEN
Alex				
Chris	VIOLET	INSTITUICAO FI...	CHILAND	- - -
Dele	VIOLET	DIGNATARIOS	PSILAND	- 5 ABRIL
Francis	VIOLET	EMBAIXADA	PSILAND	- 5 -
Harlan	LION	EMBAIXADA		- - -
Jesse	VIOLET	EMBAIXADA	EPSILONLAND	- 5 ABRIL
Kim				- - ABRIL
Leslie	CORAL E VIOLET	EMBAIXADA DE C...	PSILAND	DIA 5 -
Morgan			EPSILONLAND	- - -
Pat	VIOLET	EMBAIXADA	PSILAND	MANHA 5 ABRIL
Quinn				
Robin	VIOLET		PSILAND	- 5 -
Sam			TAULAND	- - -
Sidney	VIOLET	MEMBRO DA COLI...	PSILAND	- 5 -
Taylor	LION		TAULAND	11:00AM 10 ABRIL
Val				
Whitley				11:00AM 5 ABRIL

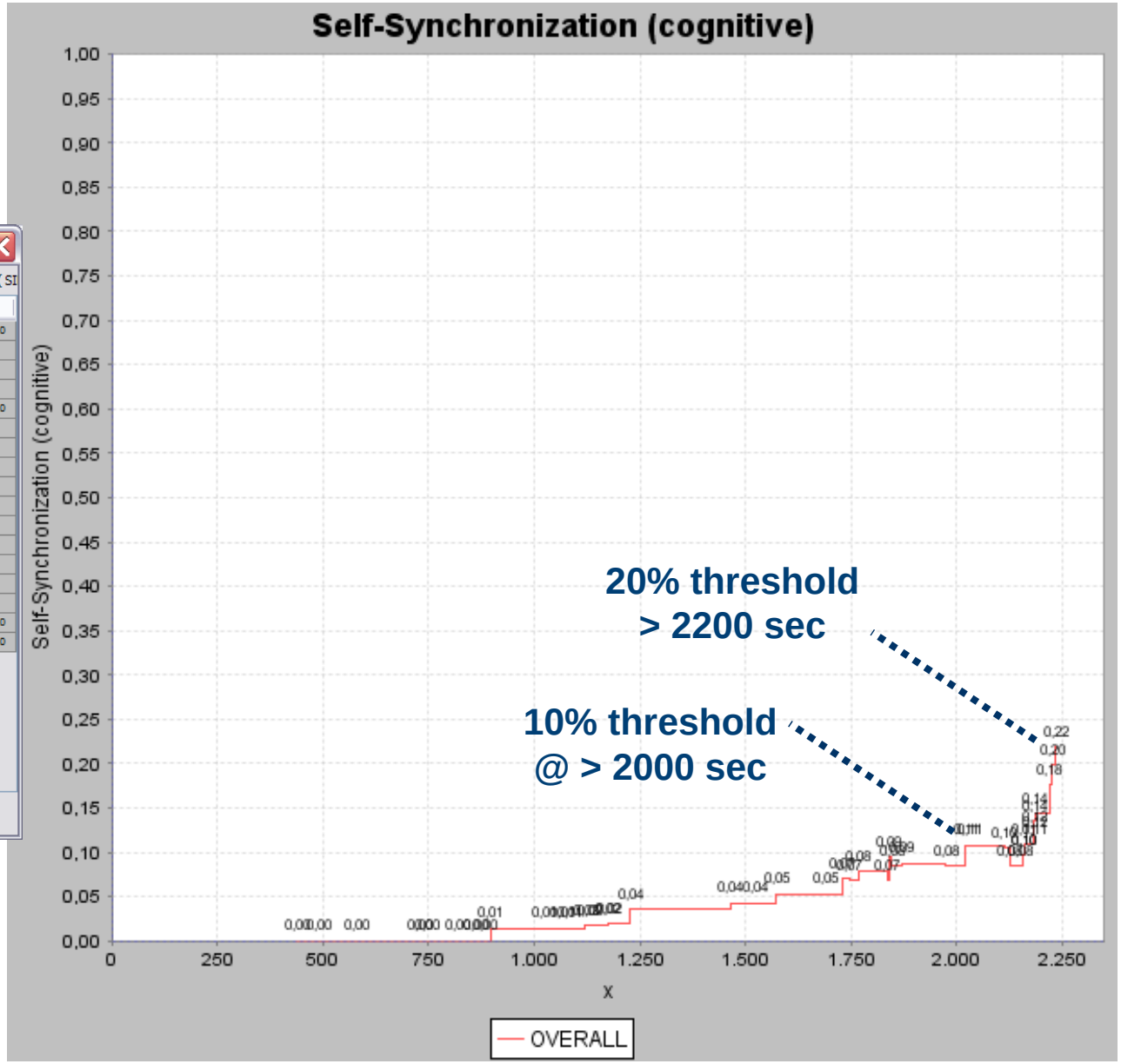


Analysis: Cognitive Domain

COORDINATED:
(L3-04 RUN)

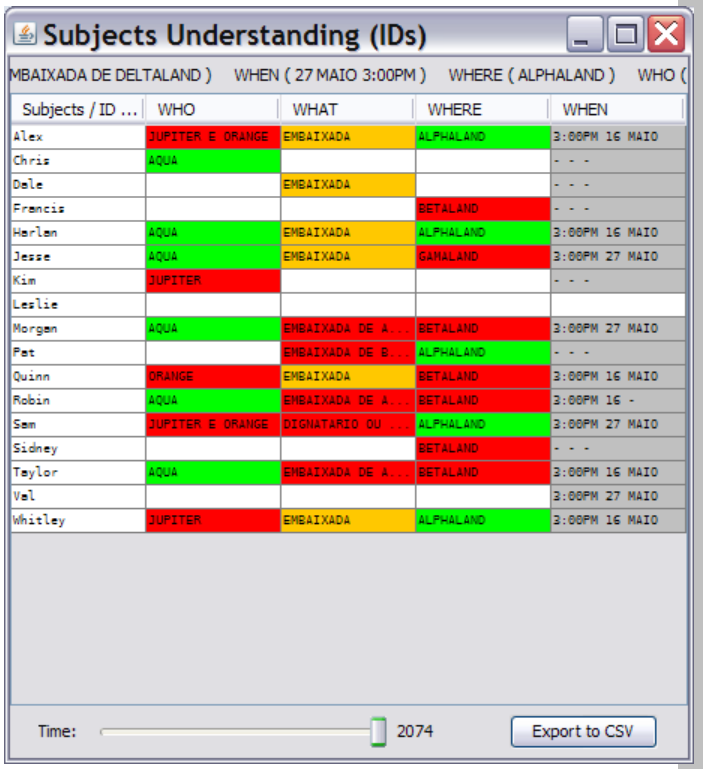


Subjects / ID ...	WHO	WHAT	WHERE	WHEN
Alex	SILVER	ESCOLA SECULAR	OMICRONLAND	9:00AM - JANEIRO
Chris	SILVER	ESCOLA	SIGMALAND	- TERCA_FEIRA -
Dale	ROSE	EMBAIXADA	PILAND	- - -
Francis	SILVER	ESCOLA	PILAND	- - -
Harlan		BASE DO EXERCITO		9:00AM - JANEIRO
Jesse	TURQUOISE	ESCOLA		- - -
Kim	NAO E O BLUE		SIGMALAND	- - -
Leslie	ROSE			- - -
Morgan	BLUE	ATAQUE BOMBISTA		- - -
Pat	BLUE	ESCOLA	OMICRONLAND	DIA - -
Quinn		ESCOLAS		- - -
Robin	SILVER	BANCO	PILAND	DIA - -
Sam	SILVER	BANCO	PILAND	9:30AM 7 MAIO
Sidney			PILAND	- - -
Taylor	GRAY	ESCOLA RELIGIOSA	PILAND	9:00AM - -
Val				9:00AM - JANEIRO
Whitley	GRAY	ESCOLA RELIGIOSA	PILAND	9:00AM - JANEIRO

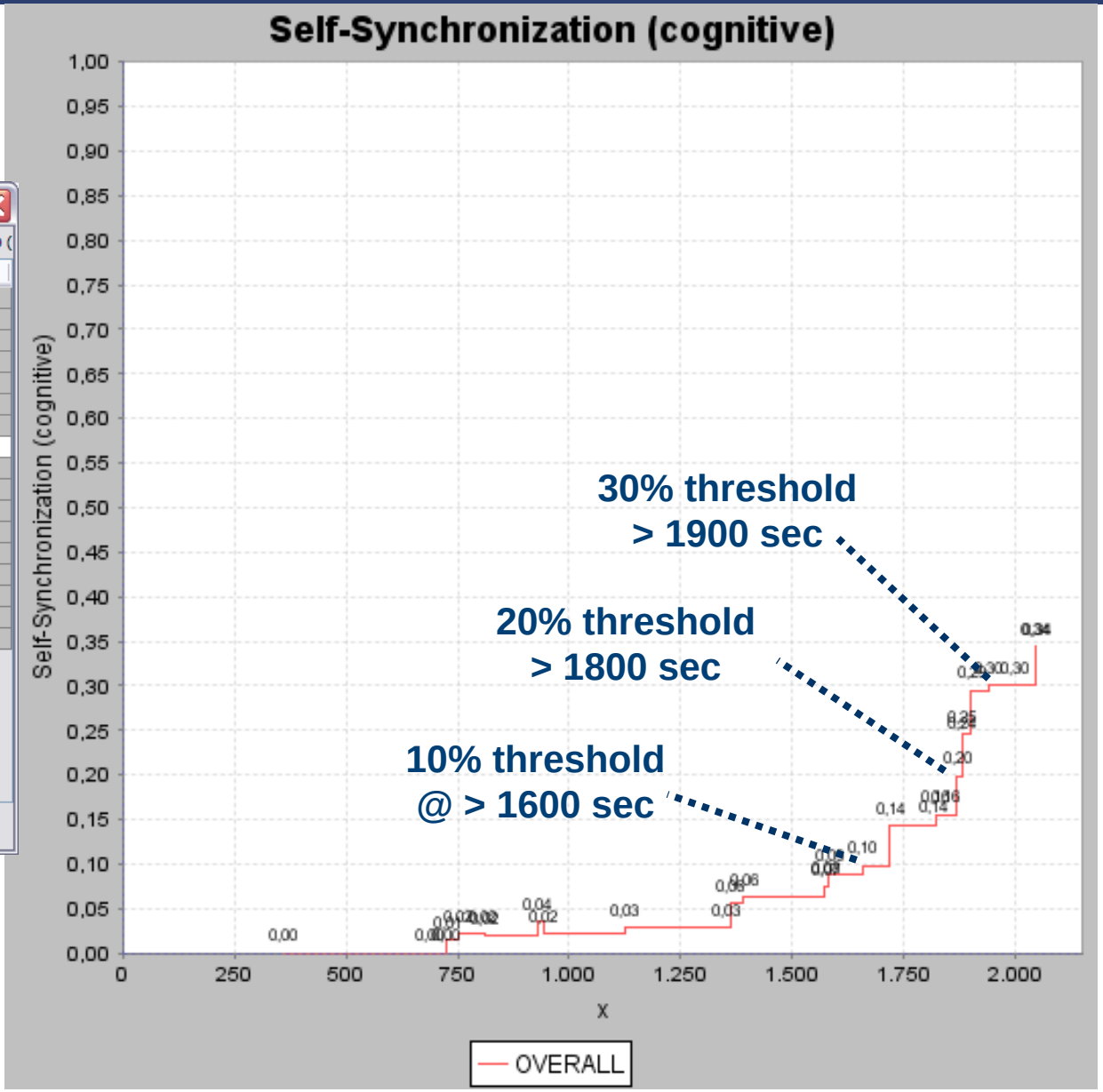


Analysis: Cognitive Domain

COLLABORATIVE:
(L4-04 RUN)

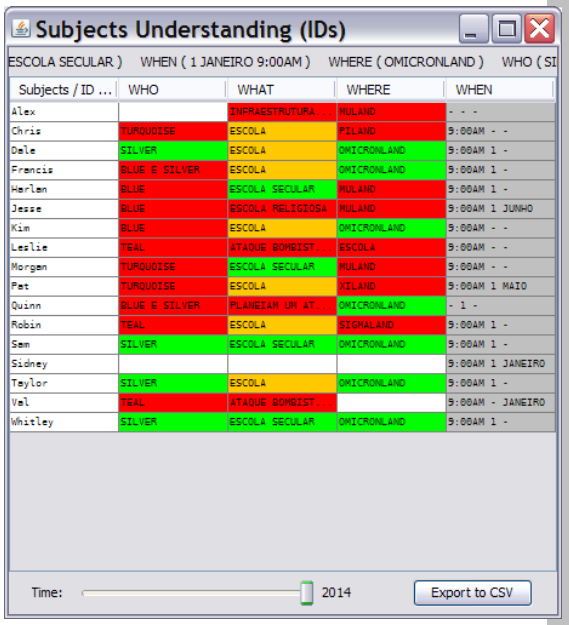


Subjects / ID ...	WHO	WHAT	WHERE	WHEN
Alex	JUPITER E ORANGE	EMBAIXADA	ALPHALAND	3:00PM 16 MAIO
Chris	AQUA			- - -
Dale		EMBAIXADA		- - -
Francis			BETALAND	- - -
Harlan	AQUA	EMBAIXADA	ALPHALAND	3:00PM 16 MAIO
Jesse	AQUA	EMBAIXADA	GAMALAND	3:00PM 27 MAIO
Kim	JUPITER			- - -
Leslie				
Morgan	AQUA	EMBAIXADA DE A...	BETALAND	3:00PM 27 MAIO
Pat		EMBAIXADA DE B...	ALPHALAND	- - -
Quinn	ORANGE	EMBAIXADA	BETALAND	3:00PM 16 MAIO
Robin	AQUA	EMBAIXADA DE A...	BETALAND	3:00PM 16 -
Sam	JUPITER E ORANGE	DIGNATARIO OU ...	ALPHALAND	3:00PM 27 MAIO
Sidney			BETALAND	- - -
Taylor	AQUA	EMBAIXADA DE A...	BETALAND	3:00PM 16 MAIO
Val				3:00PM 27 MAIO
Whitley	JUPITER	EMBAIXADA	ALPHALAND	3:00PM 16 MAIO

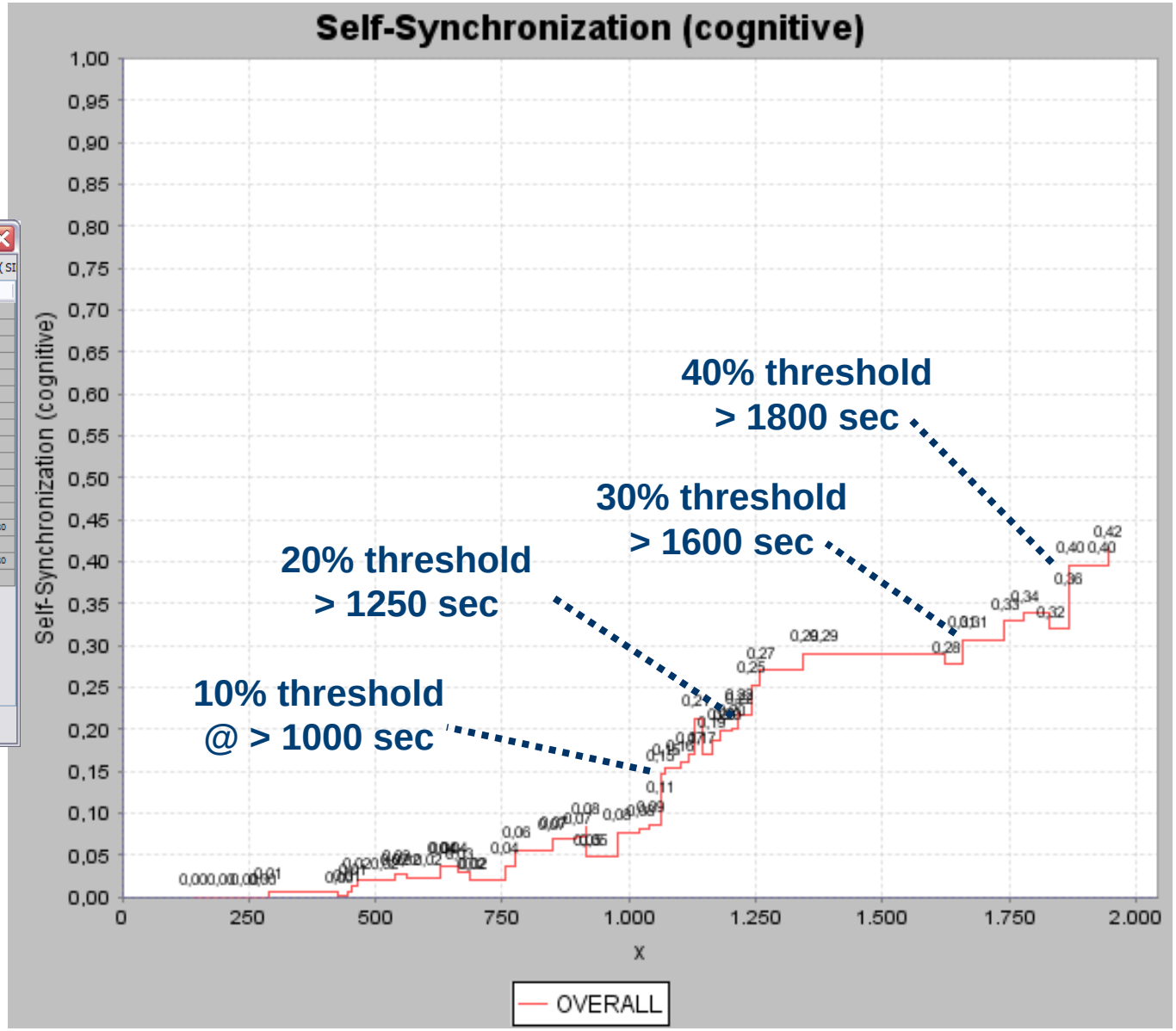


Analysis: Cognitive Domain

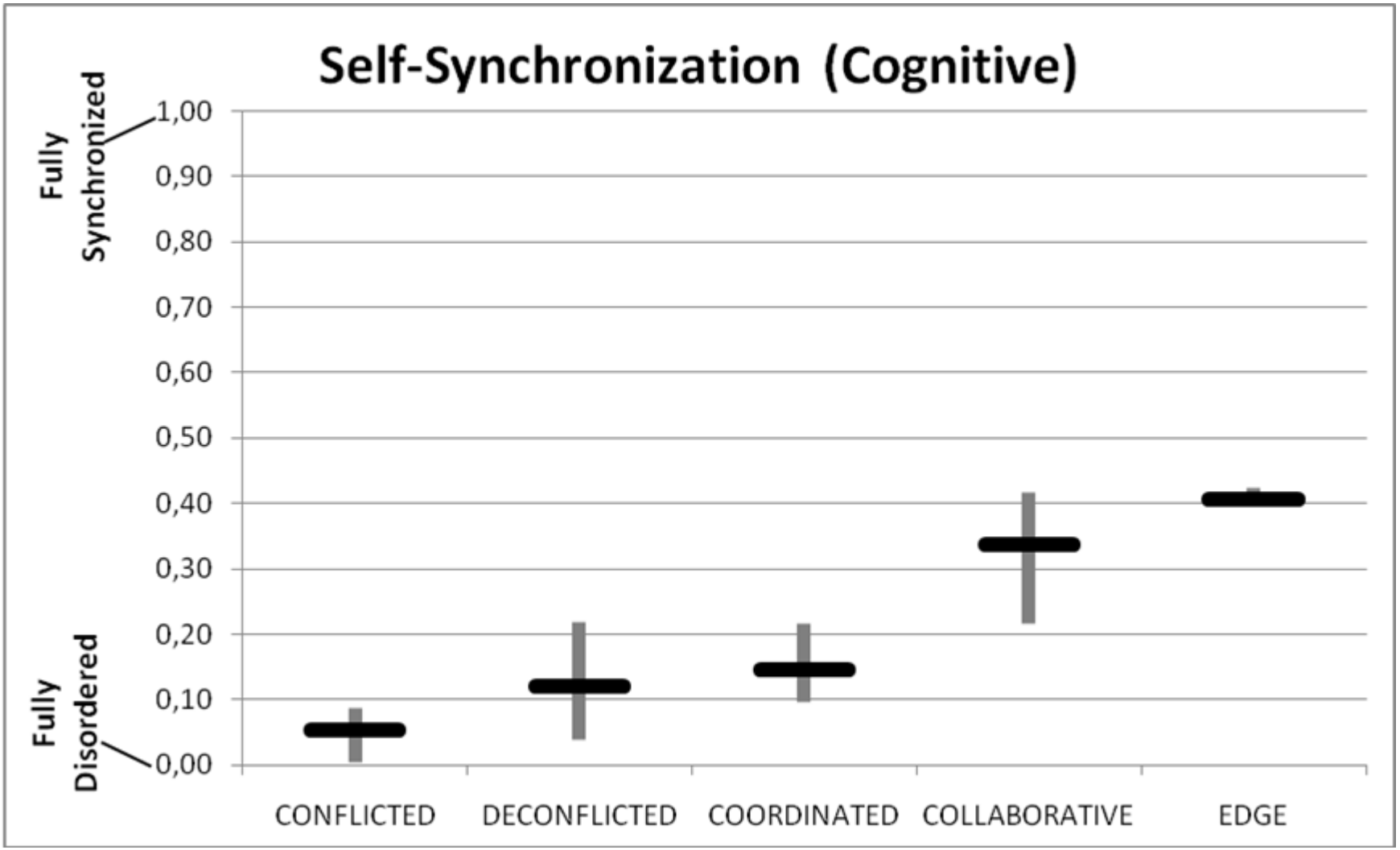
EDGE:
(L5-02 RUN)



Subjects / ID ...	WHO	WHAT	WHERE	WHEN
Alex		INFRAESTRUTURA...	MULAND	- - -
Chris	TURQUOISE	ESCOLA	PILAND	9:00AM - -
Dale	SILVER	ESCOLA	OMICRONLAND	9:00AM 1 -
Francis	BLUE E SILVER	ESCOLA	OMICRONLAND	5:00AM 1 -
Harlan	BLUE	ESCOLA SECULAR	MULAND	9:00AM 1 -
Jesse	BLUE	ESCOLA RELIGIOSA	MULAND	9:00AM 1 JUNHO
Kim	BLUE	ESCOLA	OMICRONLAND	9:00AM - -
Leslie	TEAL	ATAQUE BOMBIST...	ESCOLA	9:00AM - -
Morgan	TURQUOISE	ESCOLA SECULAR	MULAND	9:00AM - -
Pat	TURQUOISE	ESCOLA	XILAND	9:00AM 1 MAIO
Quinn	BLUE E SILVER	PLANEIAM UM AT...	OMICRONLAND	- 1 -
Robin	TEAL	ESCOLA	SIGMALAND	9:00AM 1 -
Sam	SILVER	ESCOLA SECULAR	OMICRONLAND	9:00AM 1 -
Sidney				9:00AM 1 JANEIRO
Taylor	SILVER	ESCOLA	OMICRONLAND	9:00AM 1 -
Val	TEAL	ATAQUE BOMBIST...		9:00AM - JANEIRO
Whitley	SILVER	ESCOLA SECULAR	OMICRONLAND	5:00AM 1 -



Analysis: Cognitive Domain



$$\text{CSSync}_{problemSpace} = 1 - \sum_{i=1}^{N} P(S_i) * \ln(P(S_i)) / Max_Disorder_{problemSpace}$$

$$Max_Disorder_{problemSpace} = -\sum_{i=1}^{N} \frac{1}{N} * \ln(\frac{1}{N}) = \ln(N)$$

Analysis: Cognitive Domain

- Answer:

Yes - there are significant differences.

EDGE and COLLAB achieved the best cognitive performances (correct ID and CCSync).

All other approaches achieved low levels.

	CONF	DECONF	COORD	COLLAB	EDGE
Correct ID	VERY-LOW	LOW	LOW	LOW-MED	LOW-MED
CSSync	VERY-LOW	LOW	LOW	LOW-MED	MED

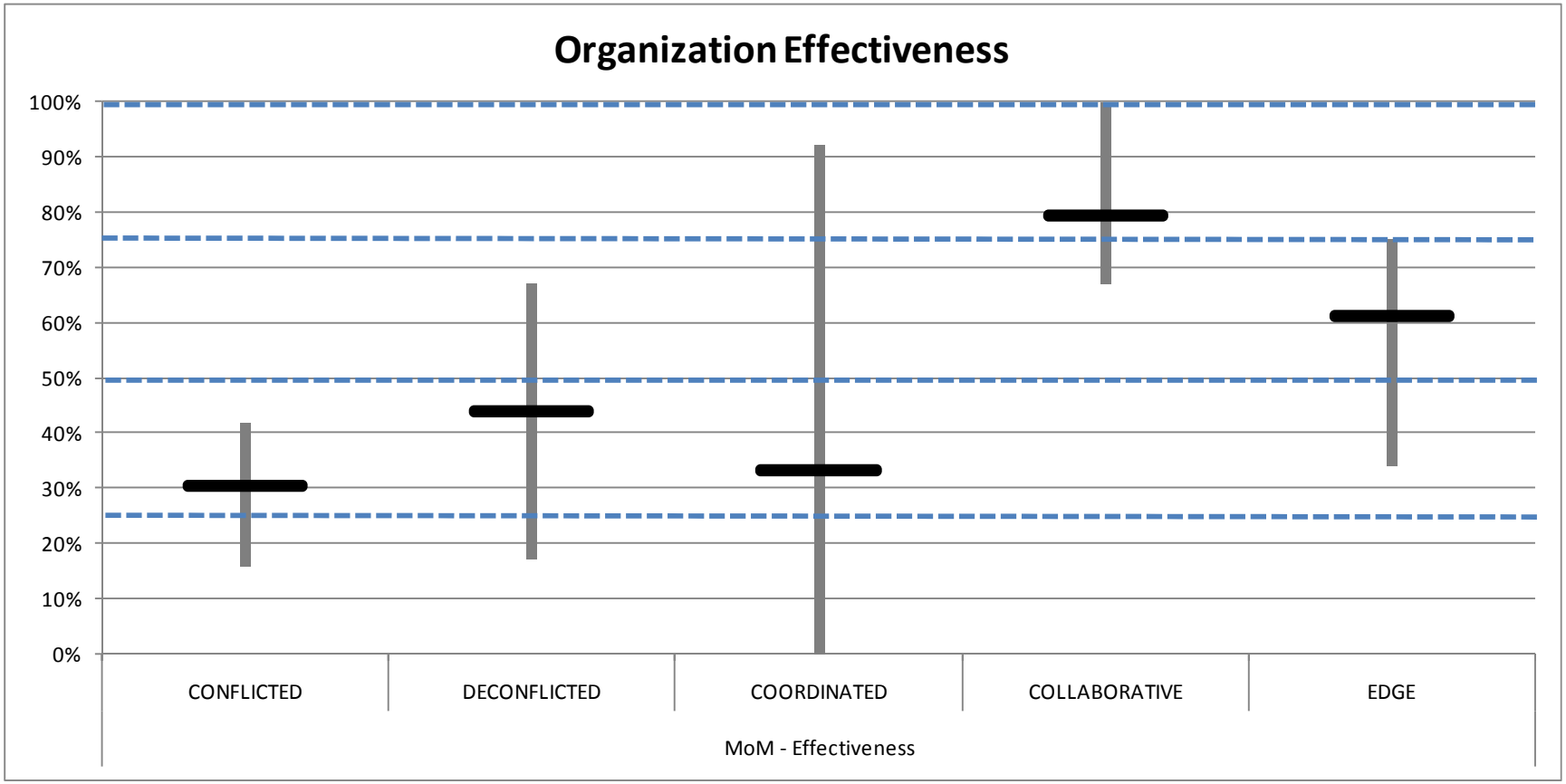
Analysis: MoM

- Question:

Are there significant differences between the C2 approaches in terms of end-results ?

e.g., Effectiveness and Efficiency.

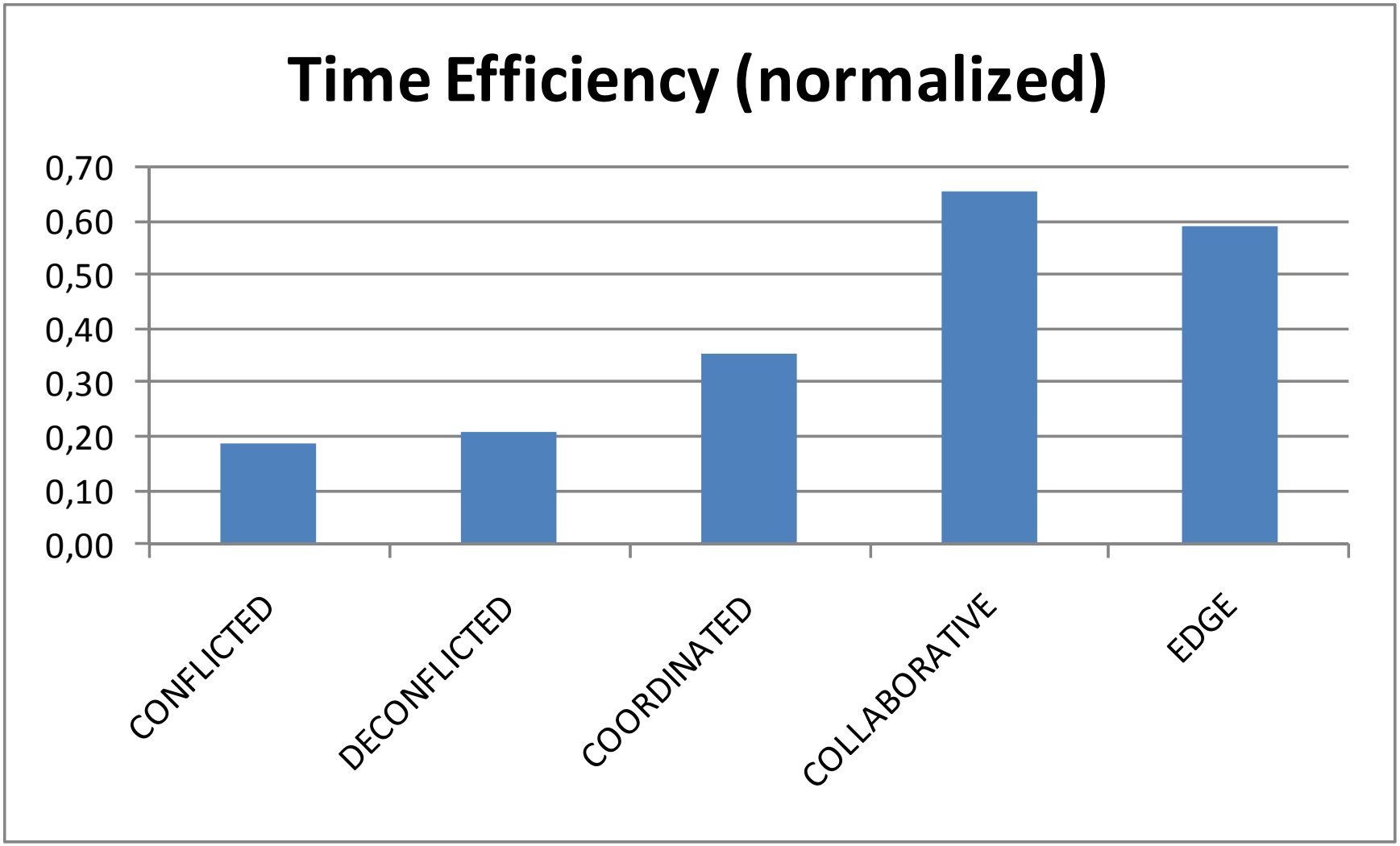
Analysis: MoM



$$Effectiveness = \sum_i 0.25 * Correct_ans_i$$ afterwards normalized to [0,1] and expressed as percentage.

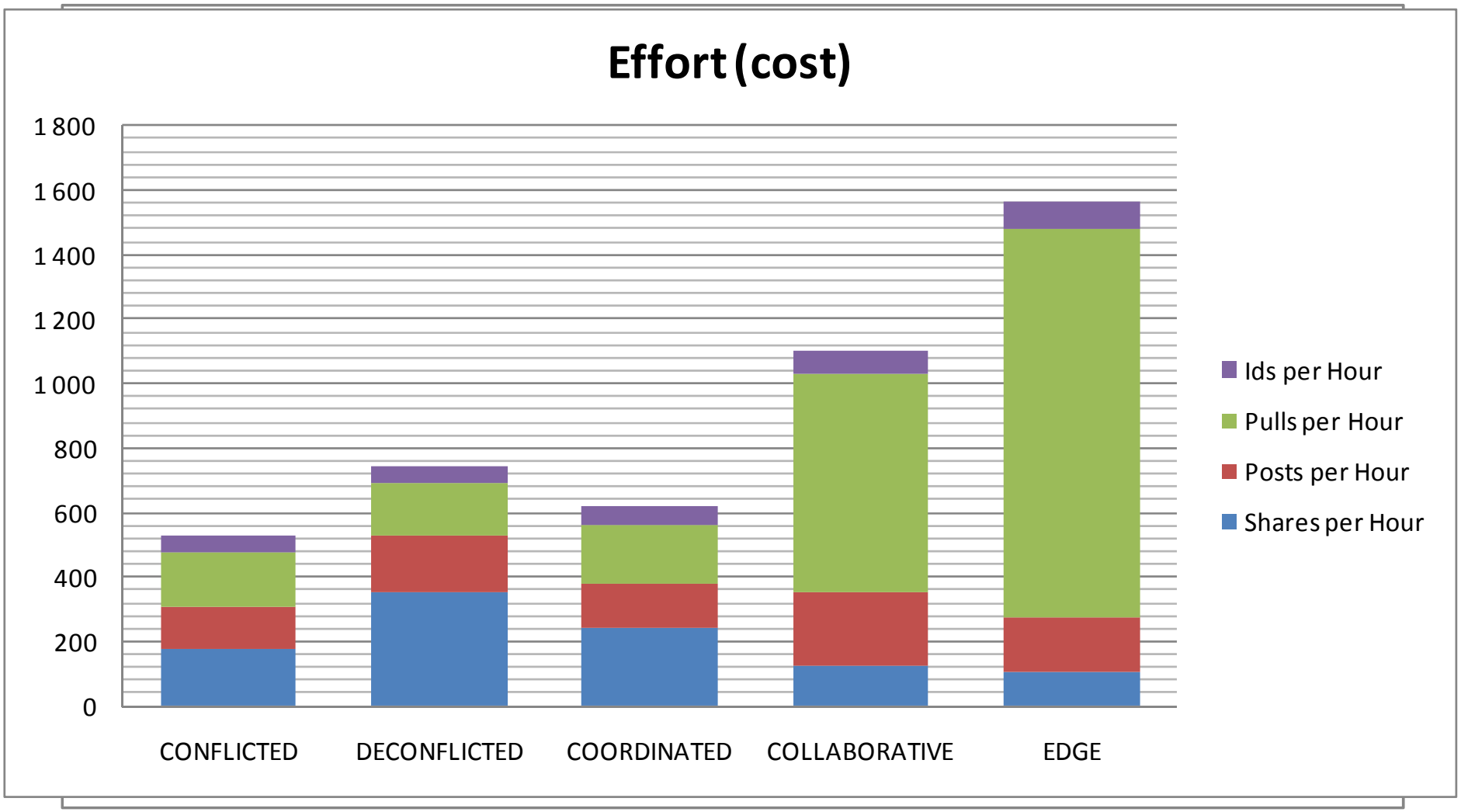
$Correct_ans_i$ is 1.0 if correct answer is provided and 0.0 otherwise

Analysis: MoM



$$Efficiency_{time} = Effectiveness_score^2 * \log_{10}(1 + {}^{1}\!/_{time_last_ID})$$

Analysis: MoM



$$Efficiency_{effort} = Effectiveness_score^2 * \log_{10}(1 + {}^{1}\!/_{effort_spent})$$

Conclusions

Domain / Variable Assessed \ C2 Approach		CONFLICTED	DECONFLICTED	COORDINATED	COLLABORATIVE	EDGE
Information Domain	Shared Information Reach	5	4	3	2	1
	Critical Information Accessible	5	4	3	2	1
Interactions	Quality of Interactions	5	4	3	1	2
Cognitive Domain	Extent of Correct Understanding	5	3	4	2	1
	Cognitive Self-Synchronization	5	4	3	2	1
MoM	Organization Effectiveness	5	3	4	1	2
	Time-Efficiency	5	4	3	1	2
	Effort-Efficiency	5	3	2	1	3

Conclusions

Results are consistent with model expectations (in overall):

[4] *Higher collective C2 maturity approaches exhibit increased/better levels of* ***Quality of Individual and Shared Information*** *than lower collective C2 maturity approaches.*

- **OK**

[5] *Higher collective C2 maturity approaches exhibit increased/better levels of* ***Quality of Individual and Shared Awareness and Understanding*** *than lower collective C2 maturity approaches.*

- **OK – except for Coordinated**

[6] *Higher collective C2 maturity approaches exhibit increased/better levels of* ***Self-Synchronization (at cognitive level)*** *than lower collective C2 maturity approaches.*

- **OK**

Conclusions

Results are consistent with model expectations (in overall):

[1] *For a complex endeavor, higher collective C2 maturity approaches are <u>more effective</u>.*

- **OK – except for EDGE**

[2] *For a given level of effectiveness, higher collective C2 maturity approaches are <u>more efficient</u>.*

- **OK – except for EDGE (with a high-deviation)**

[3] *Higher collective C2 maturity approaches are <u>more agile</u>.*

NOT Covered

Agile C2 is a novel concept under the analysis of SAS-085. This hypothesis will be considered in future research work.

Conclusions

Results are consistent with model expectations (in overall):

[7] *Organizations require a minimum level of maturity to be effective in ELICIT.*

Considering current dataset, requisite maturity in ELICIT is COLLABORATIVE or COORDINATED (having a proper CTC).

[8] *Increasing the degree of difficulty in ELICIT require organizations to increase their level of maturity to maintain effectiveness in ELICIT.*

NOT Covered

There is no sufficient data (factoid set 2 trials) to test this hypothesis.

The Way Ahead

Way Ahead

- Consolidate Findings, i.e., more runs:
  - abELICIT
  - Human runs
- Validate all hypotheses:
  - Agility
  - Requisite Maturity
  - Difficulty Level
- Further explore ‘Agility’ and ‘CCSync’

Way Ahead: the ELICIT CoI

Next Meeting is TODAY June 24, 2010

Starts at 14h00 (see Track 8)

Sign up at the ICCRTS registration desk !

Join the Community !

Online resources and membership form: www.dodccrp.org/html4/elicit.html

Image: www.worldtimezones.com/content/worldmap

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