PHASE SPACE SHIFTS IN COMMAND STRUCTURES IN NETWORKED SYSTEMS

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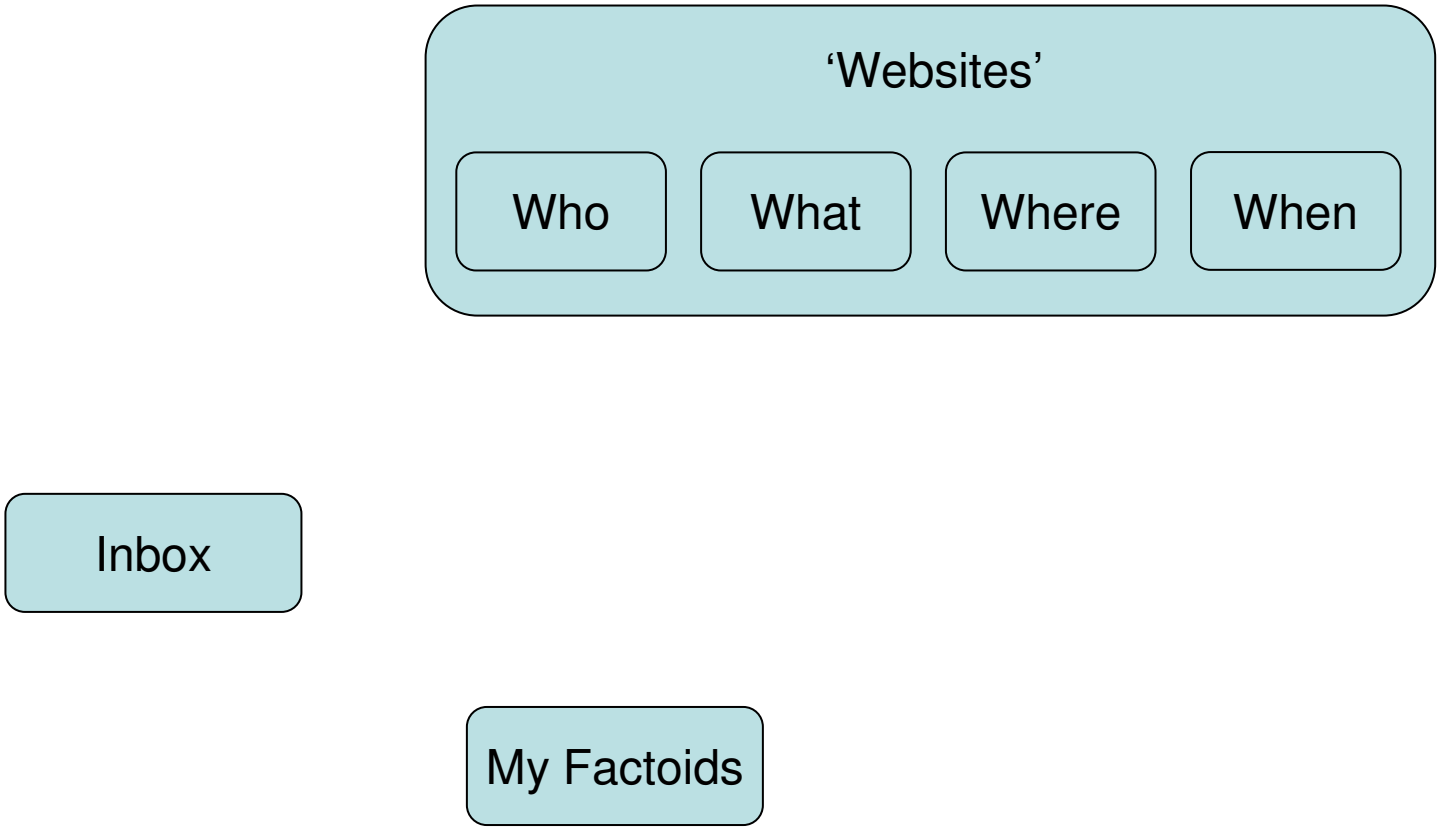
Human Factors Integration Defence Technology Centre

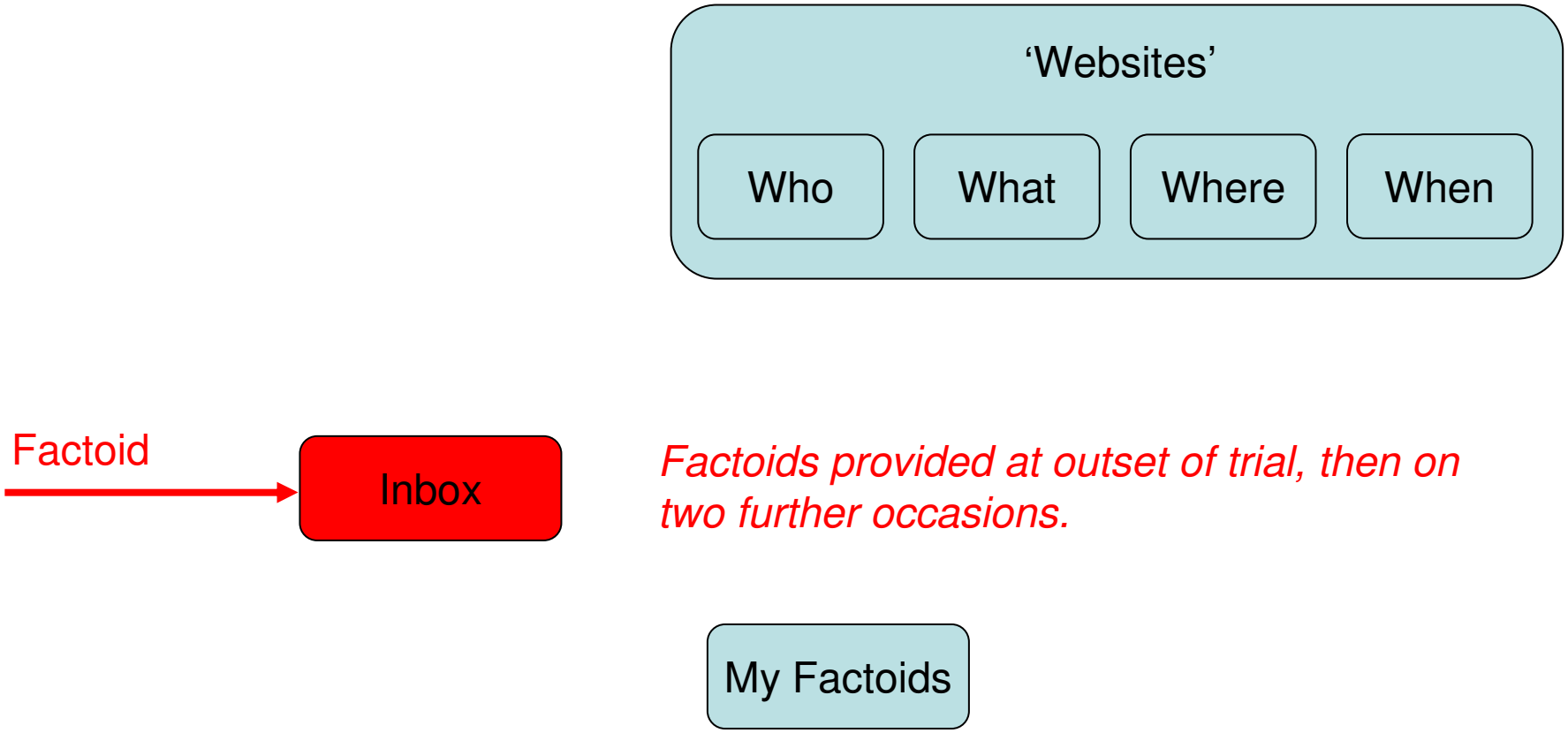
Overview

- ELICIT paradigm
- Modelling in C2
- NATO SAS-050 Phase Space Cube
- From Approach Space to Phase Space
- From Typology to Taxonomy
- Multi-National Experiment
- Conclusions

Components of ELICIT interface

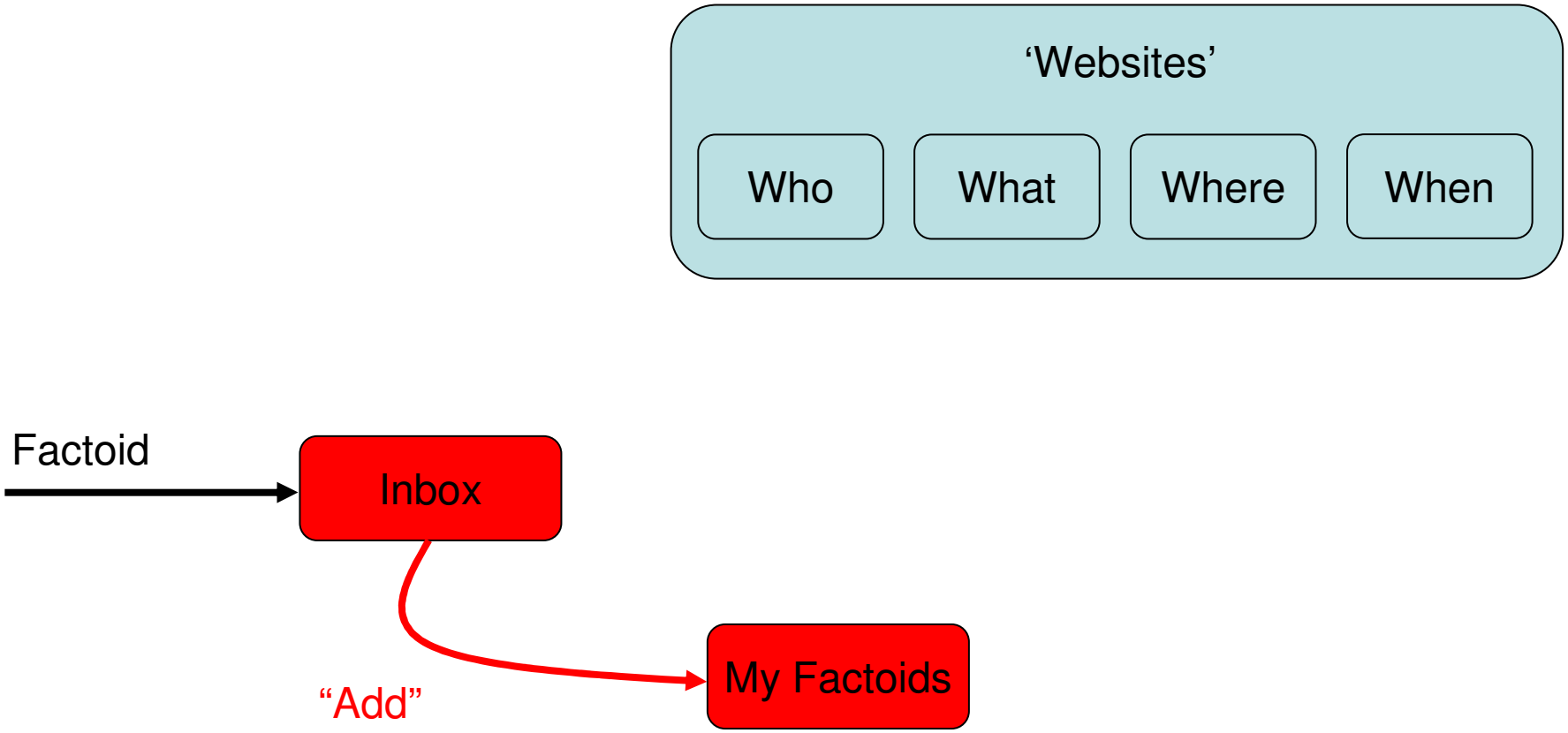


Architecture



Factoids provided at outset of trial, then on two further occasions.

Architecture



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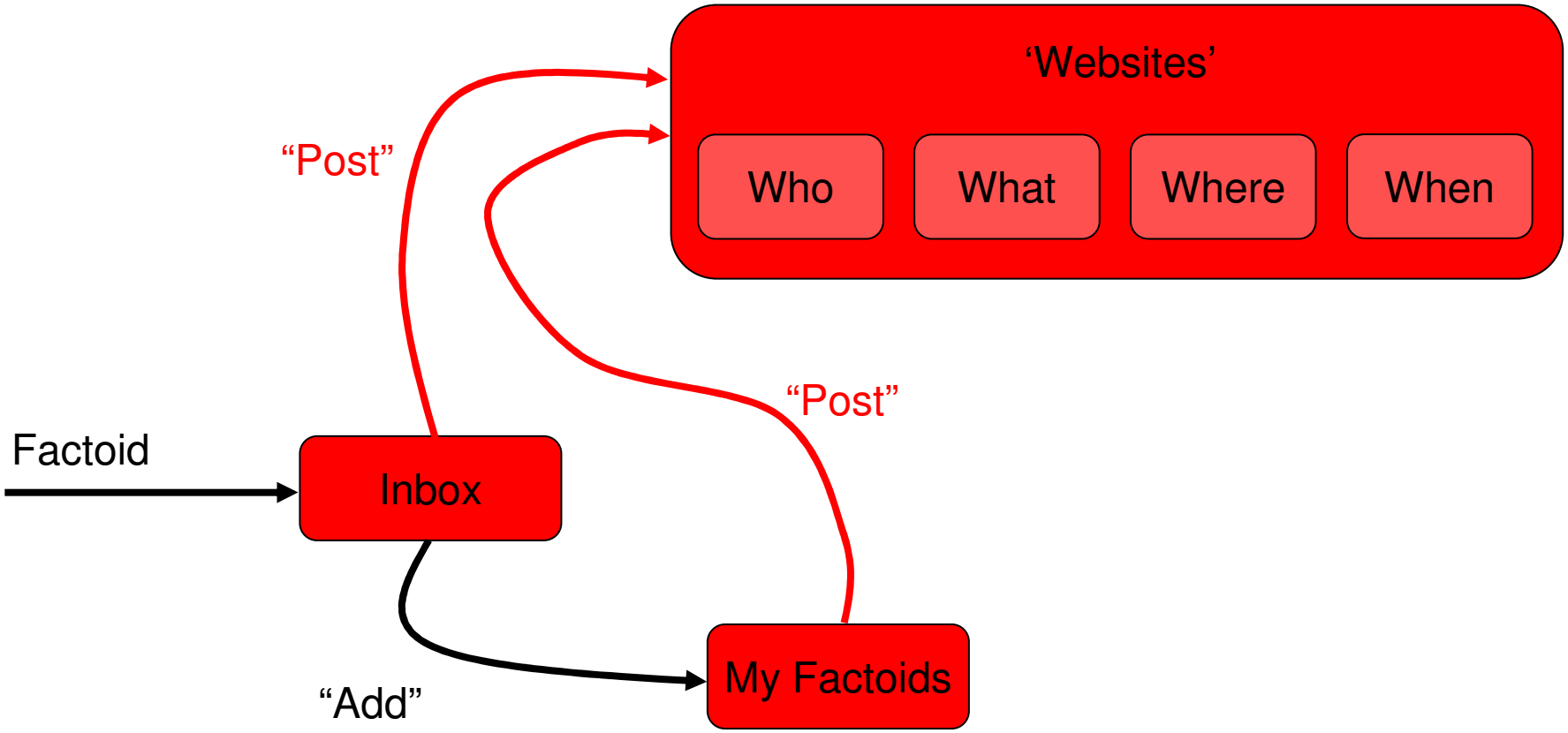

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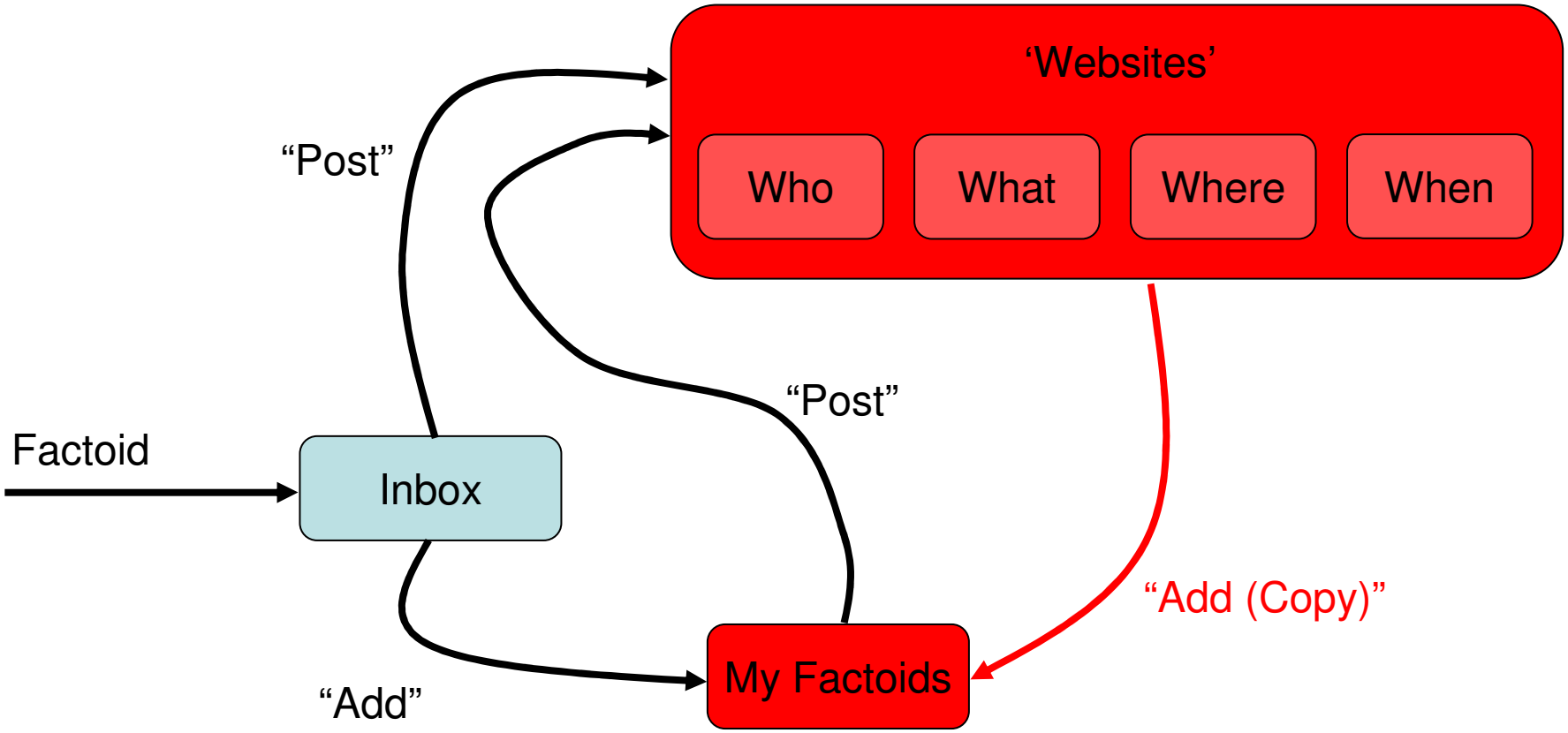

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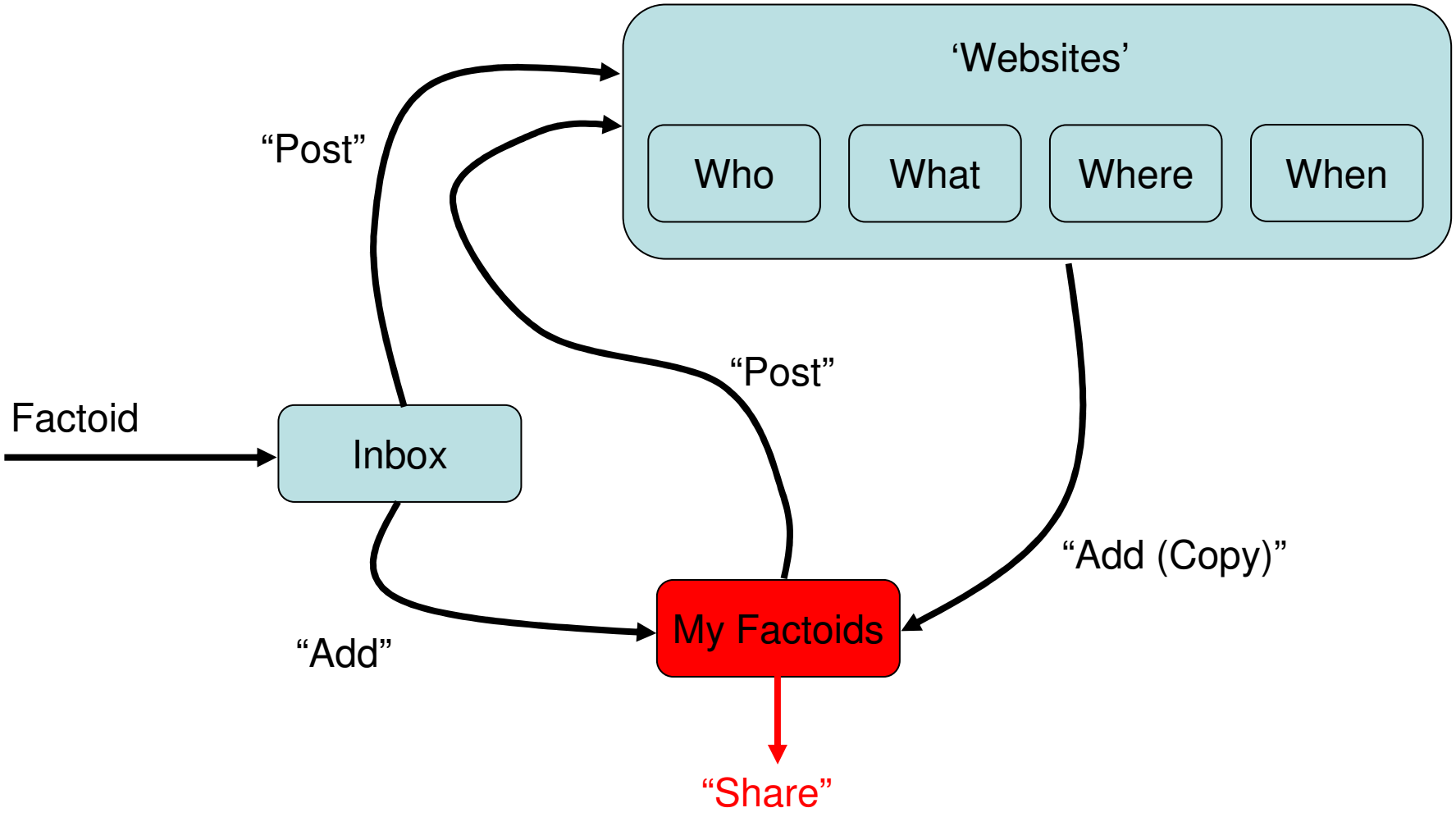
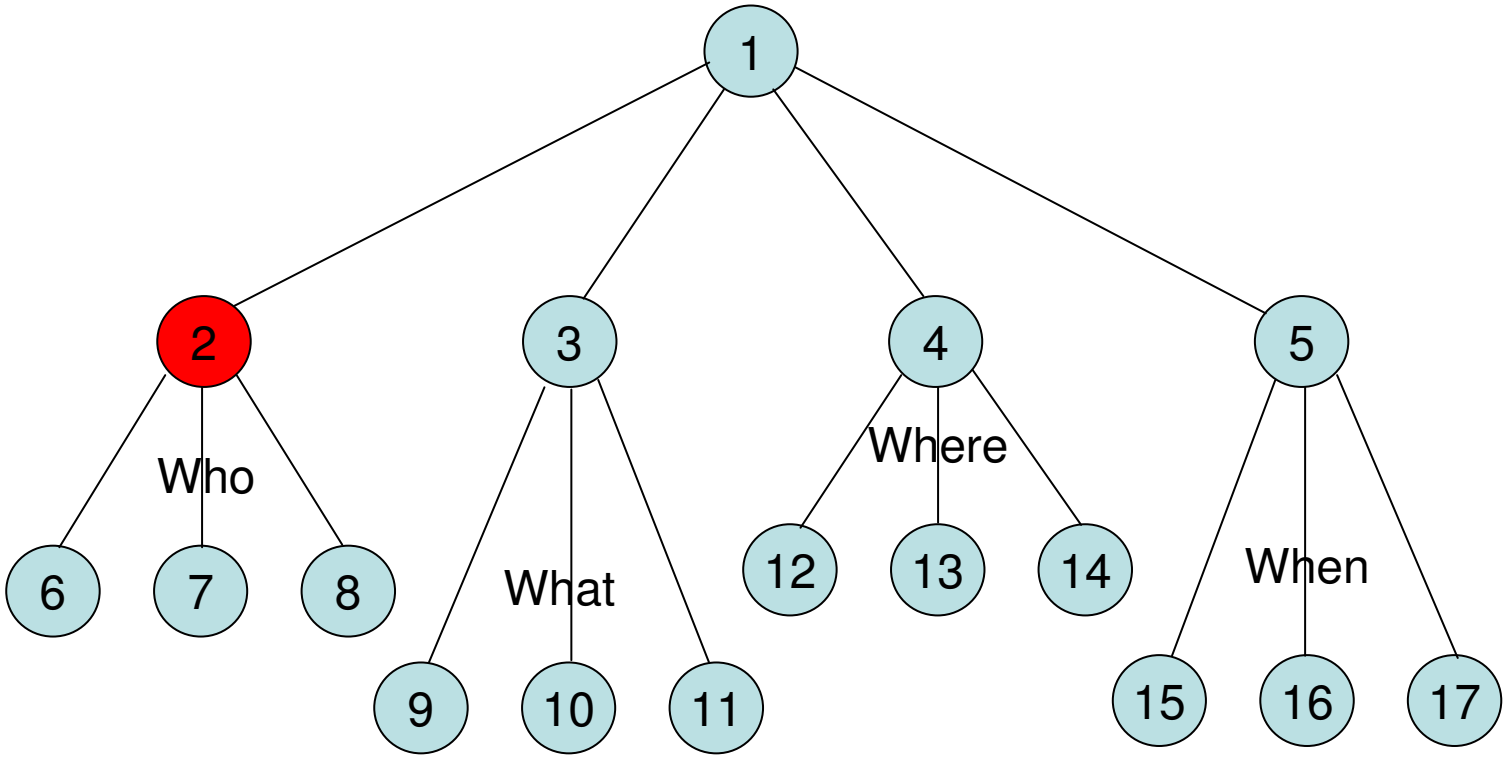
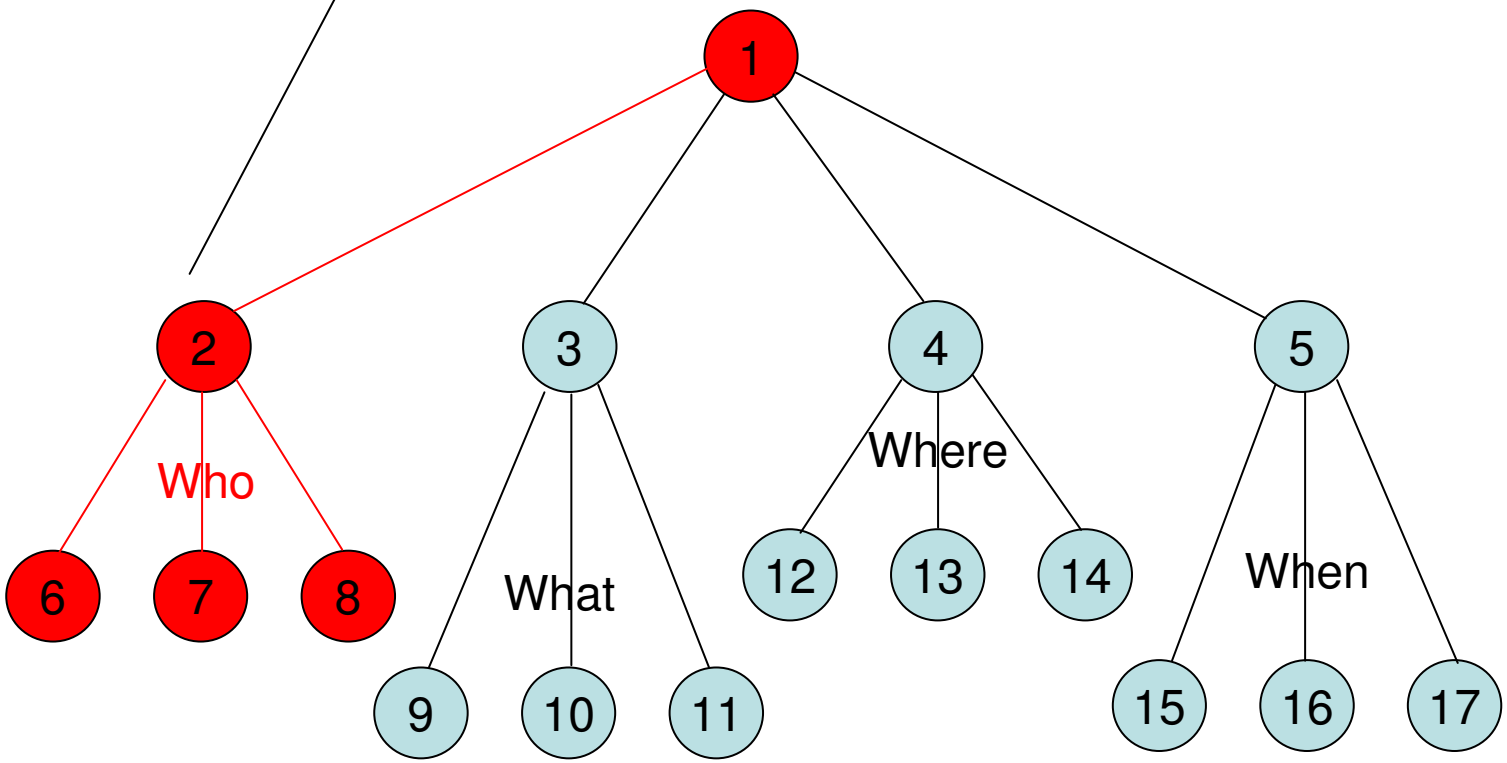


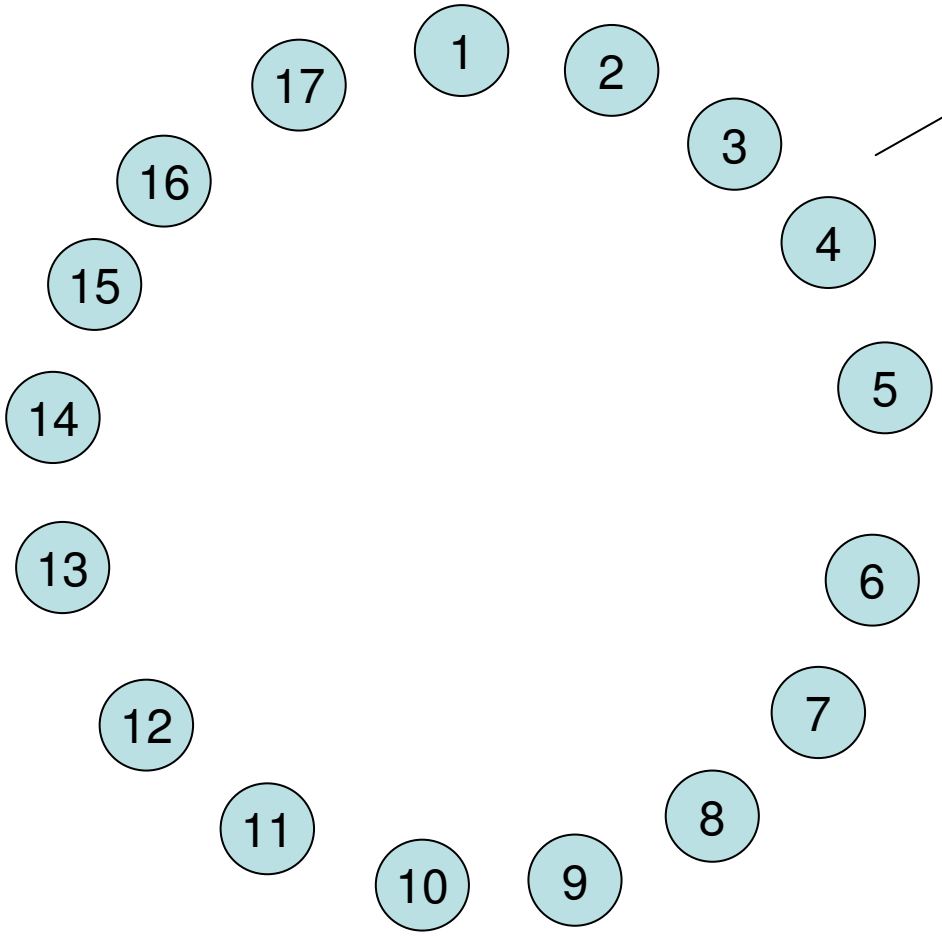
Sharing



Sharing

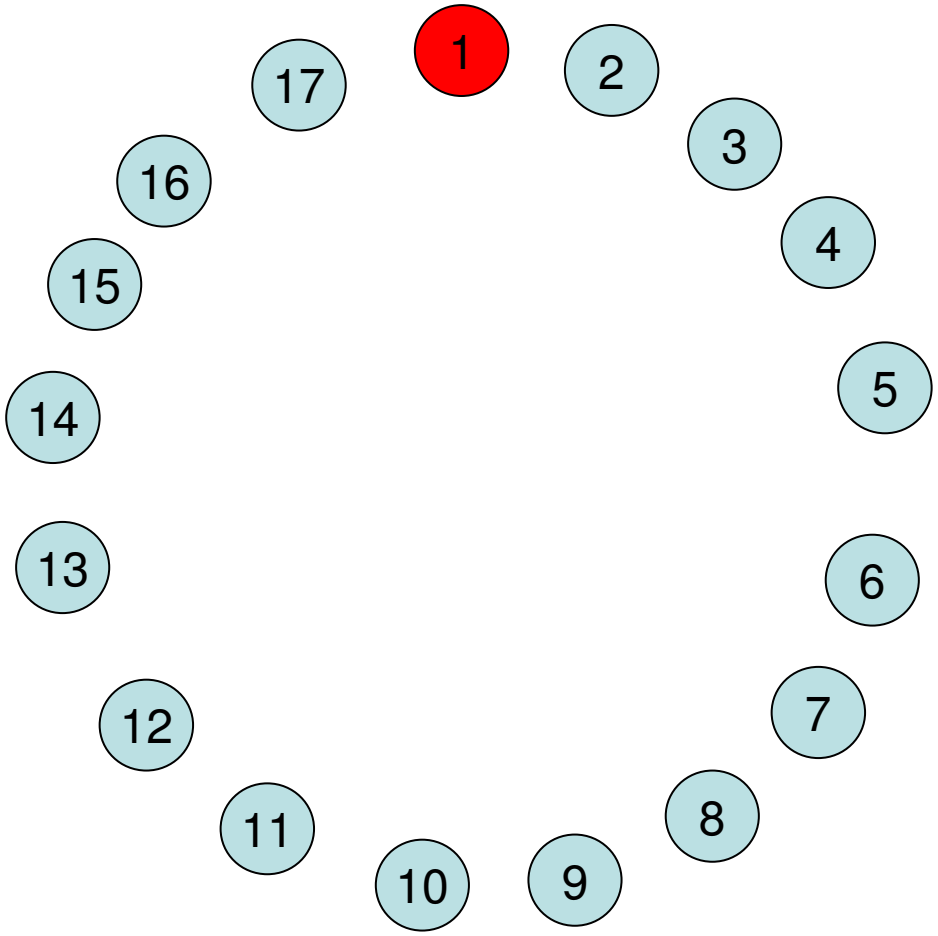
Only have access to respective who/what/where/when 'websites'



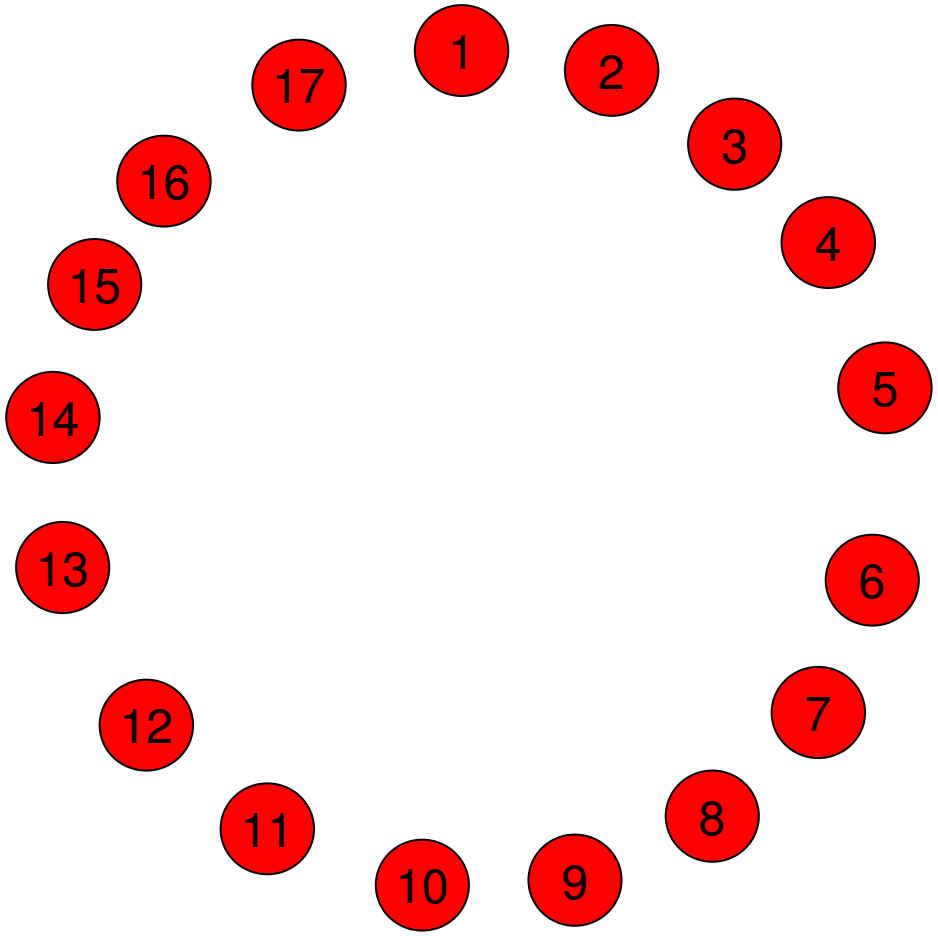


Have access to all who/what/where/when 'websites'

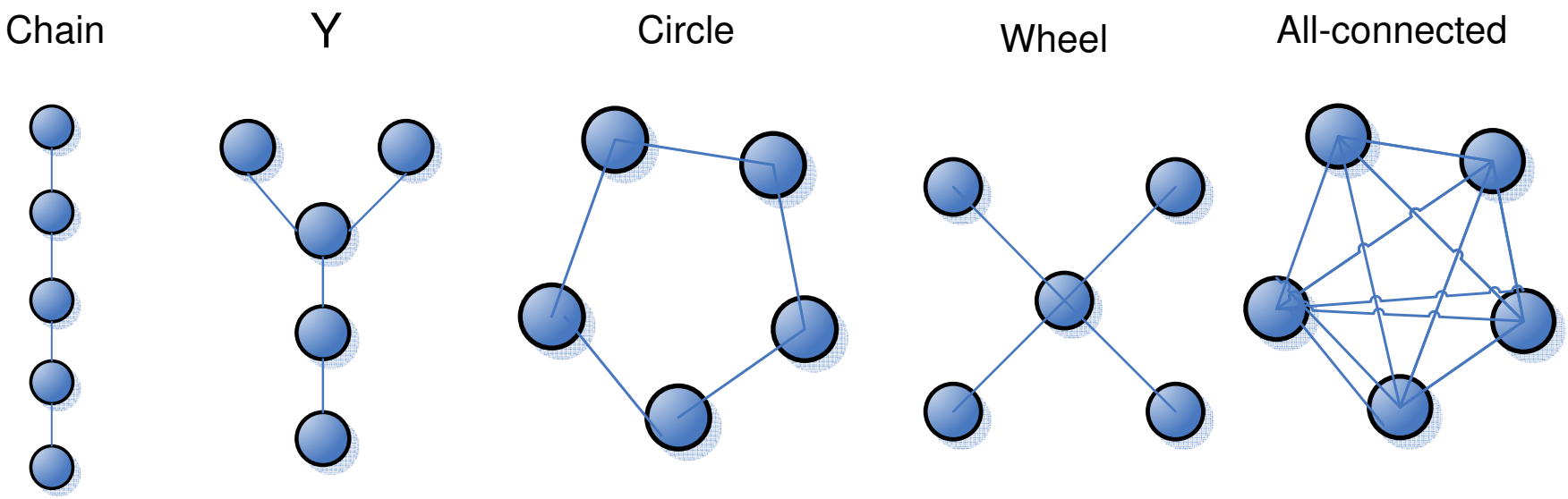
Sharing



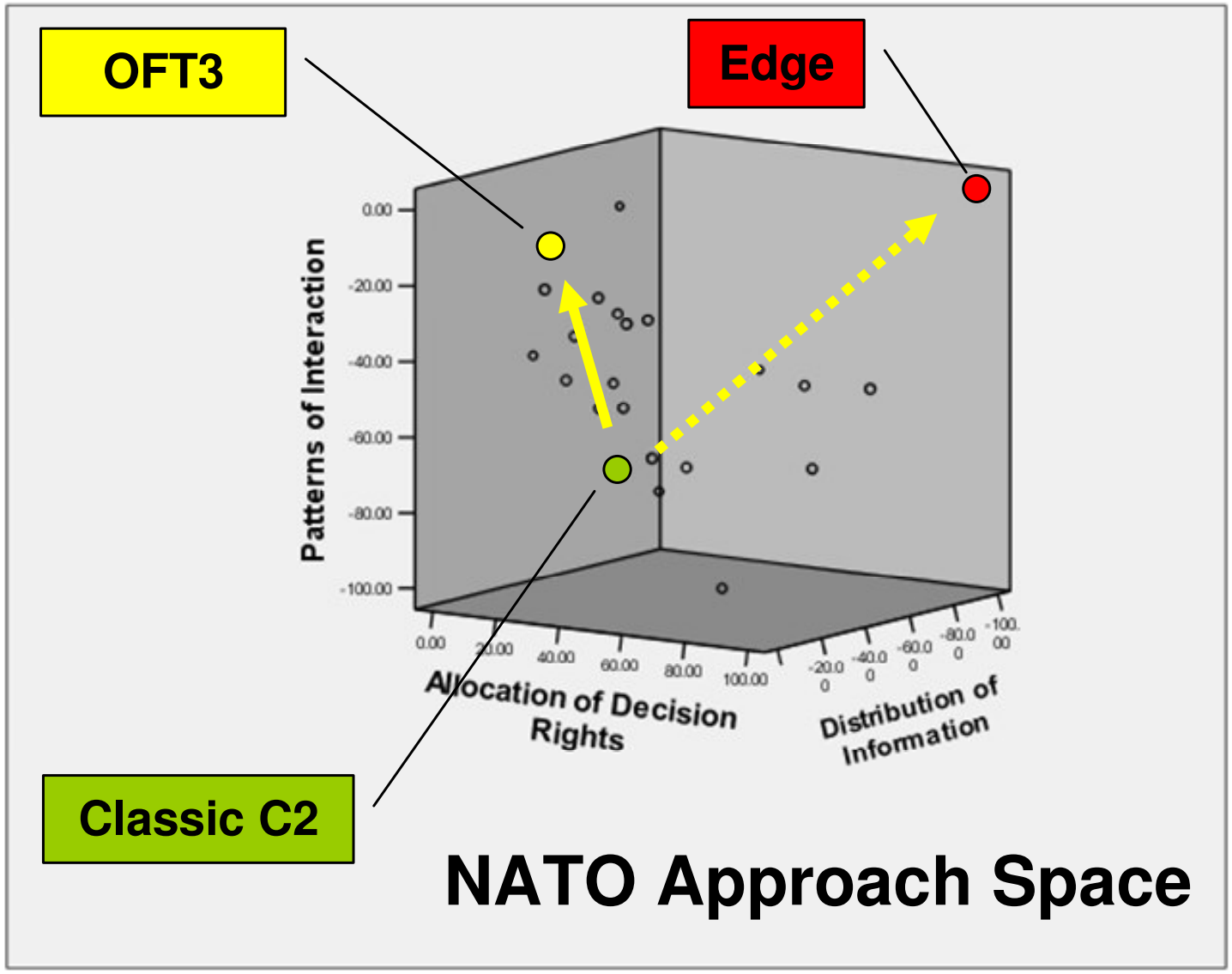
Sharing



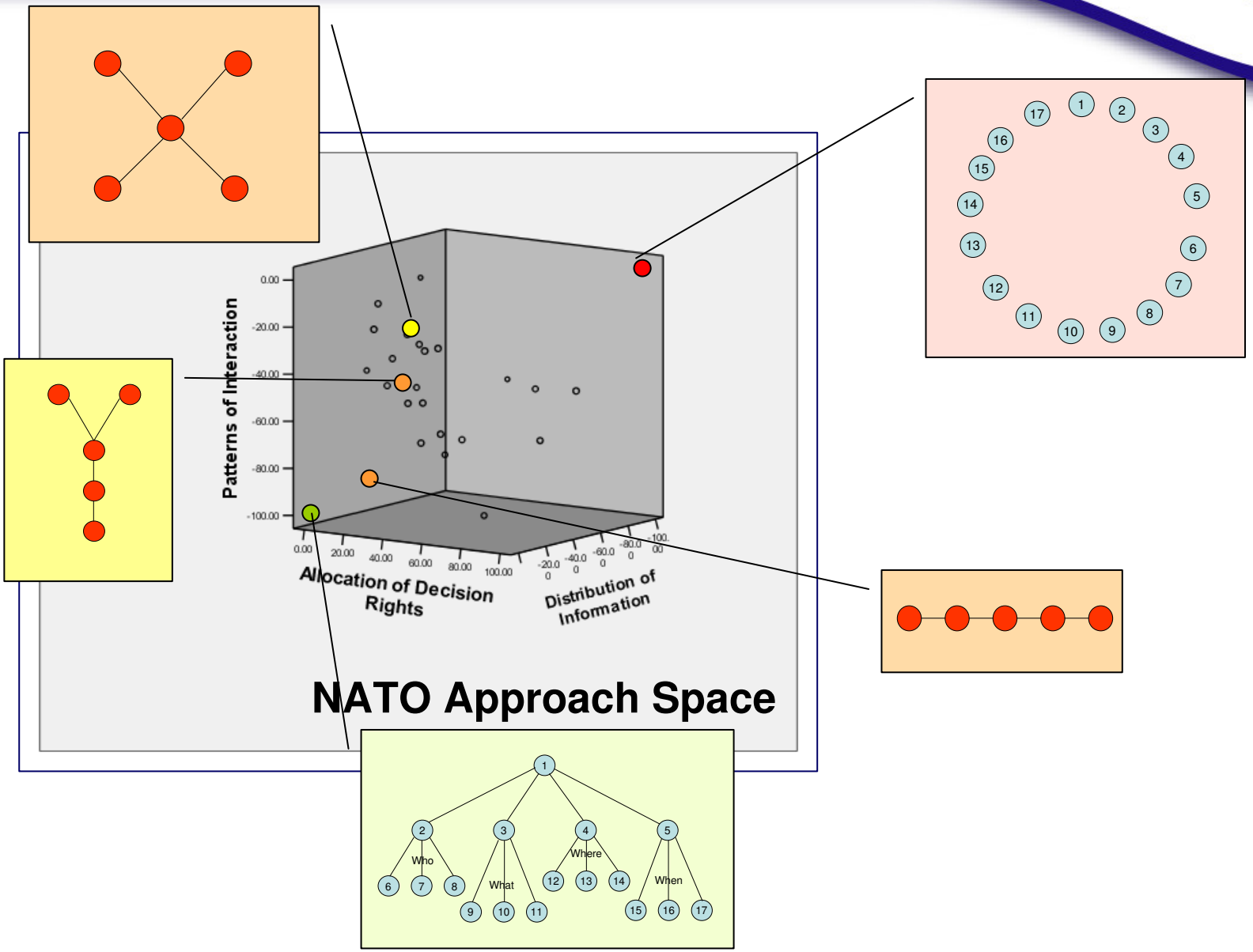
Modelling command structures



NATO SAS-050 Phase Space cube

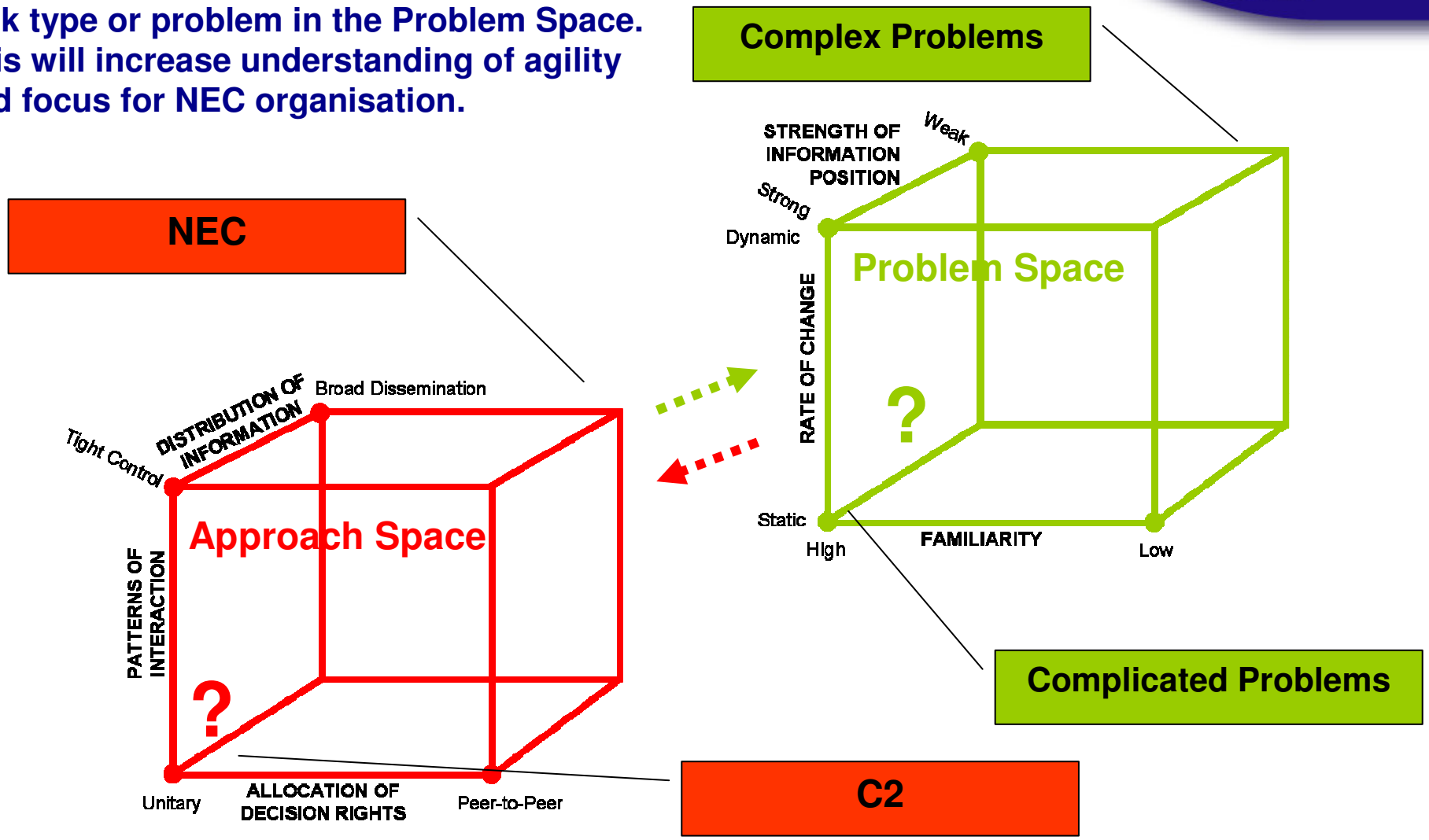


Octant Archetypes



Approach Space to XXXX

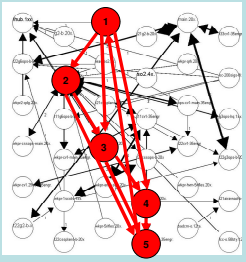
Match the position of a network structure in the Approach Space with the corresponding task type or problem in the Problem Space. This will increase understanding of agility and focus for NEC organisation.

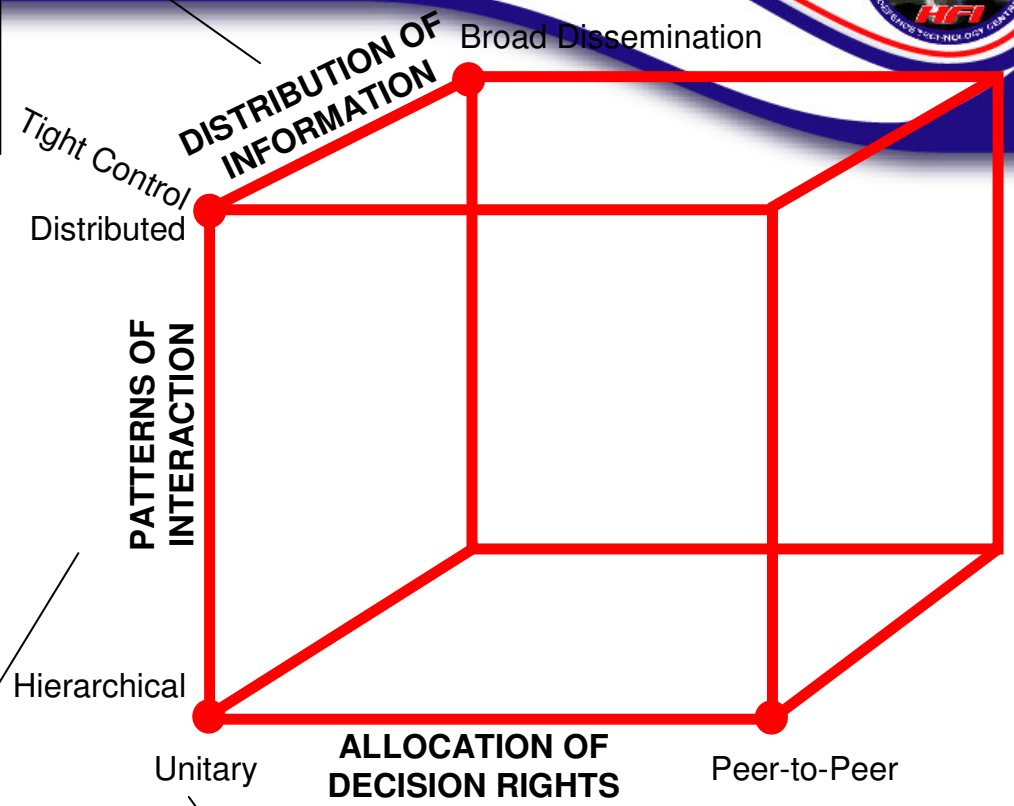


Distribution of Information:

Broad dissemination = more dense.

Tight control = less dense.

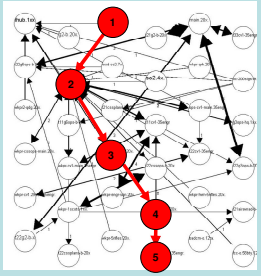




Patterns of Interaction:

Hierarchical interaction = bigger diameter.

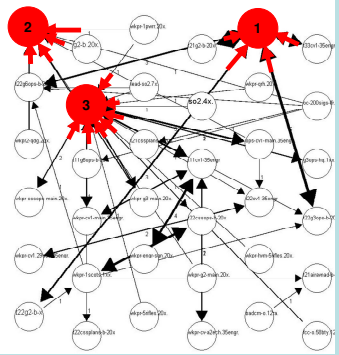
Distributed interaction = smaller diameter.



Centrality:

Unitary decision rights = a few highly central agents.

Peer-to-peer decision rights = greater number of central agents.



Measures of Agility

Challenge:

- Lack of appropriate Agility metrics to describe the changing shape of the organisational structure.

We proposed 2 metrics to analyse Agility:

1) Volume
2) Deviation

Volume

- The larger the volume the greater the space covered by a given network structure

- The hypothesis is therefore that the volume delineates agility in that the greater volume covered the greater flexibility of the network

(AoDR Max - AoDR Min) x (PoI Max - PoI Min) x (DoI Max – DoI Min)

- Where AoDR is 'Allocation of Decision Rights', PoI is 'Patterns of Interaction' and DoI is 'Distribution of Information'.

- The point is to subtract the minimum and maximum values for each of the dimensions (to give length, width and height) and then multiply the resulting numbers together (to give the volume of the cube).

In-house Baseline Study

Background

- This study compares two network structures; traditional C2 and Edge (peer-to-peer).
- Sample of 34 postgraduate students; 17 in C2 and Edge

Aim

- To populate the NATO Approach space with empirical data to represent the movement of the networks over time.
- Explore which theory of SA; Shared SA or Distributed SA which provide the most insight into the actual functioning of the networks in terms of Situation Awareness.

Development of the Log Analyzer

- Data analysed using the Log Analyzer
  - Developed the Log Analyzer with the DoD software provider to allow sharing behaviour to be analysed at specific time intervals
- Development allows us to extract the data needed to calculate SNA metrics which in turn allows us to place the network structures in the NATO cube.
  - The time interval also shows a measure of agility in the networks behaviour across task involvement

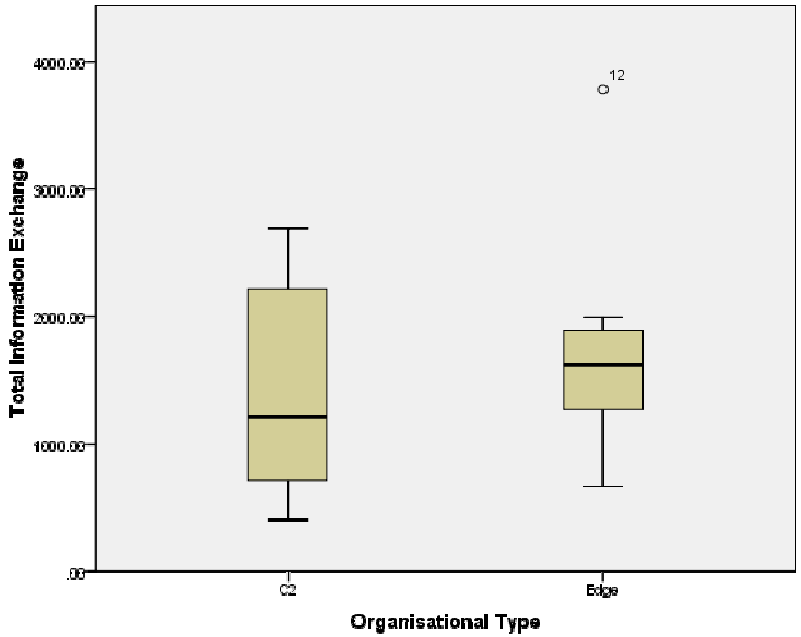
Analysis

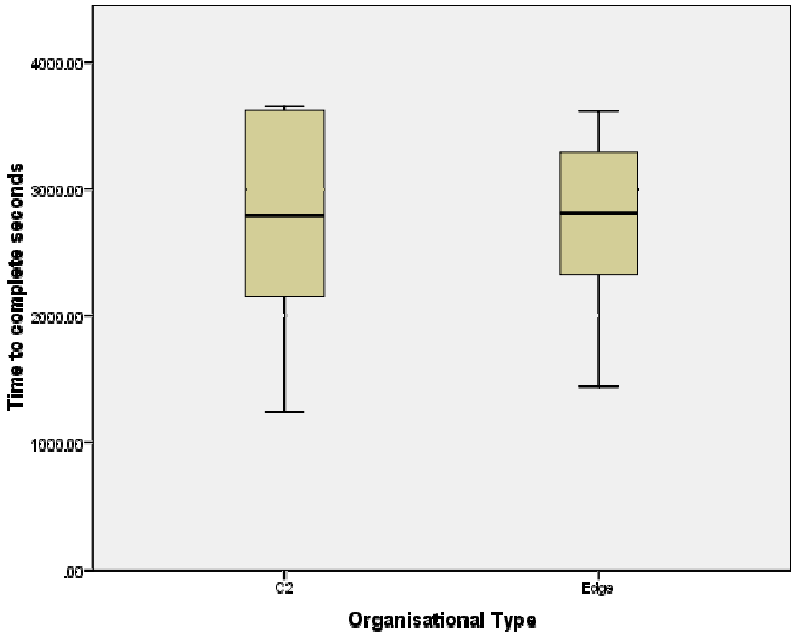
- EAST; ELICIT measures such as situation awareness, time to complete, correct identify and sharing behaviours; NATO Approach Space coordinate calculation and representation.
- Most of the analysis is complete; remaining analysis to focus on Distributed Situation Awareness.

Meta-analysis

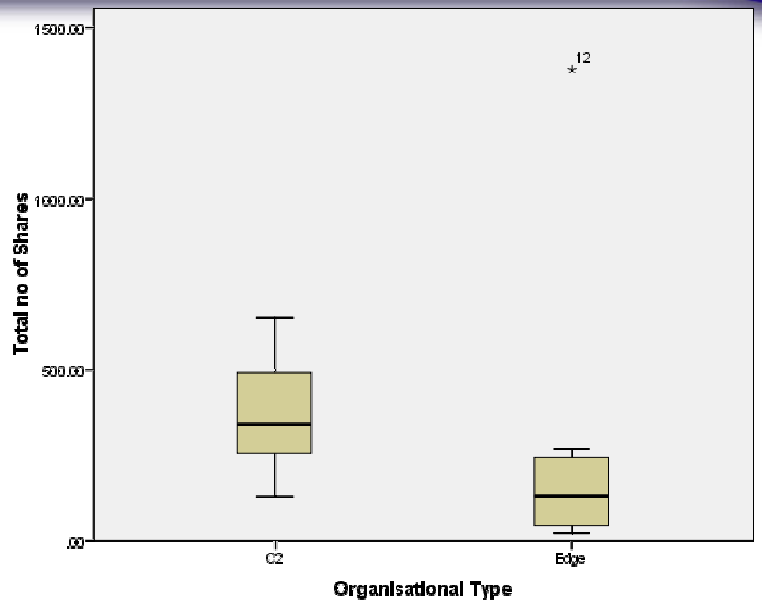
- Meta-analysis of international ELICIT baseline data conducted.
- Data acquired through the ELICIT user community
- Meta-data sample contains 16 data sets: 8 C2 and 8 Edge.
  - Inclusion of Naval Postgraduate School, United States
- 5 countries of origin: Portugal, Singapore, Canada, United States (West Point Military Academy and Boston University, Naval Postgraduate School) and the United Kingdom (Cranfield Defence Academy UK and Southampton University).

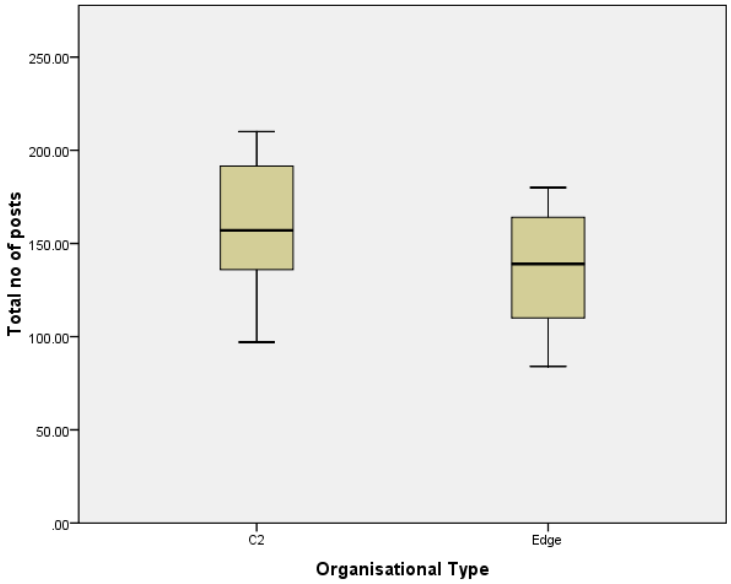
Performance of the networks

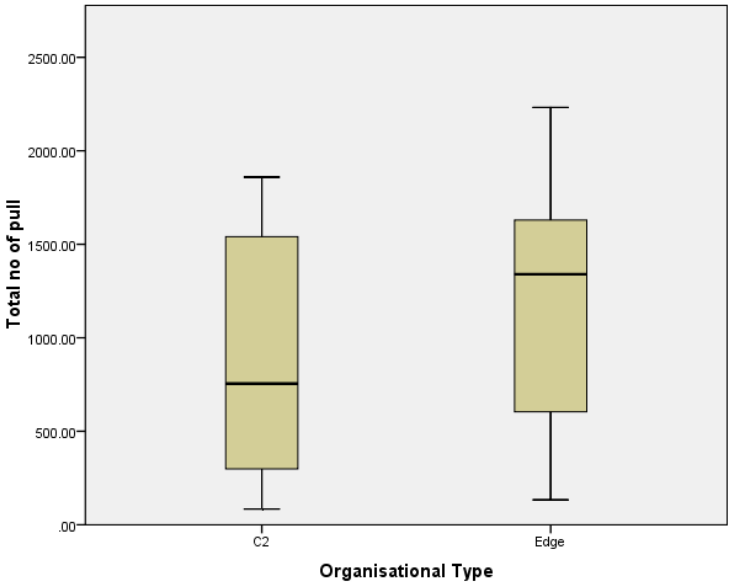




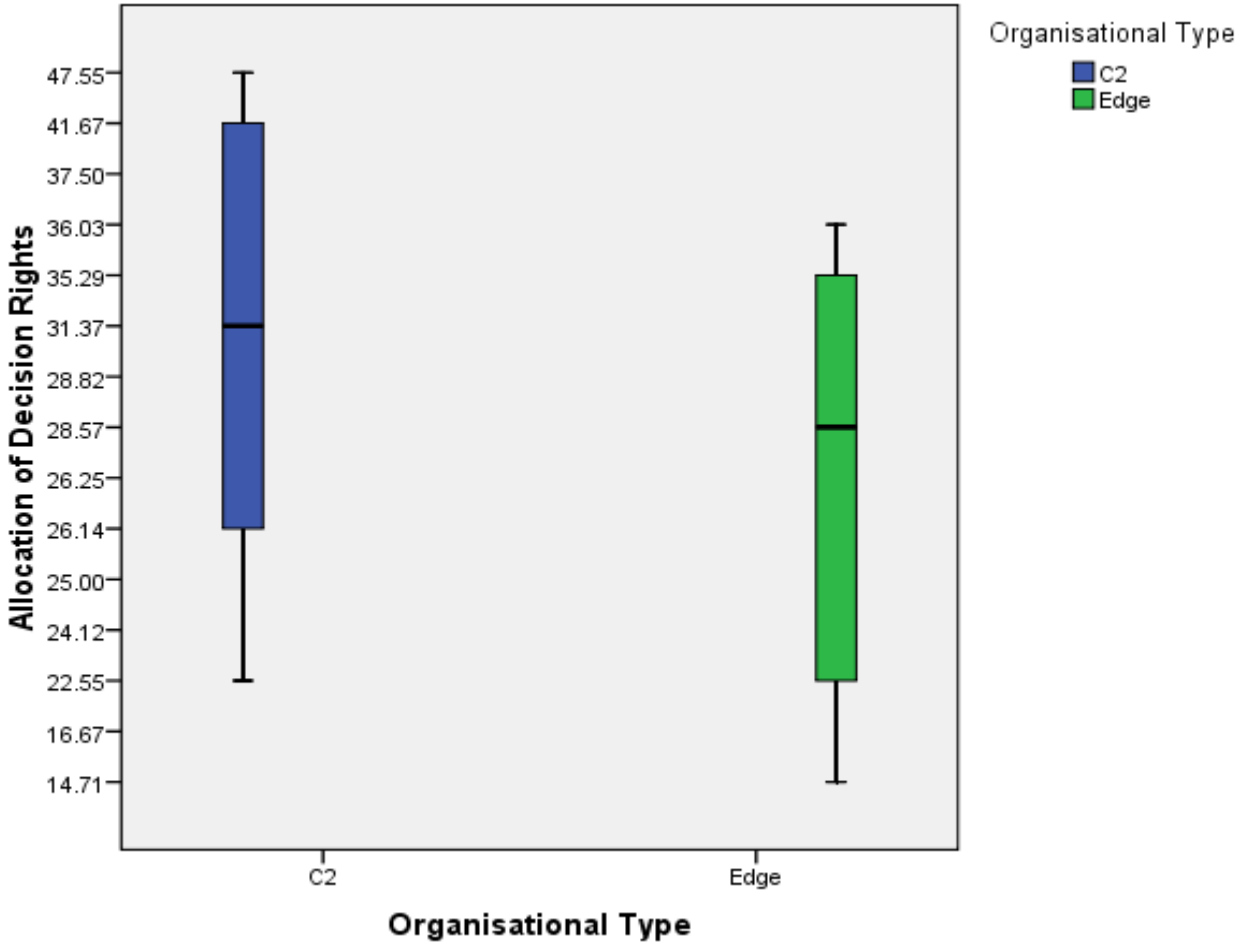
Sharing, posting and pulling



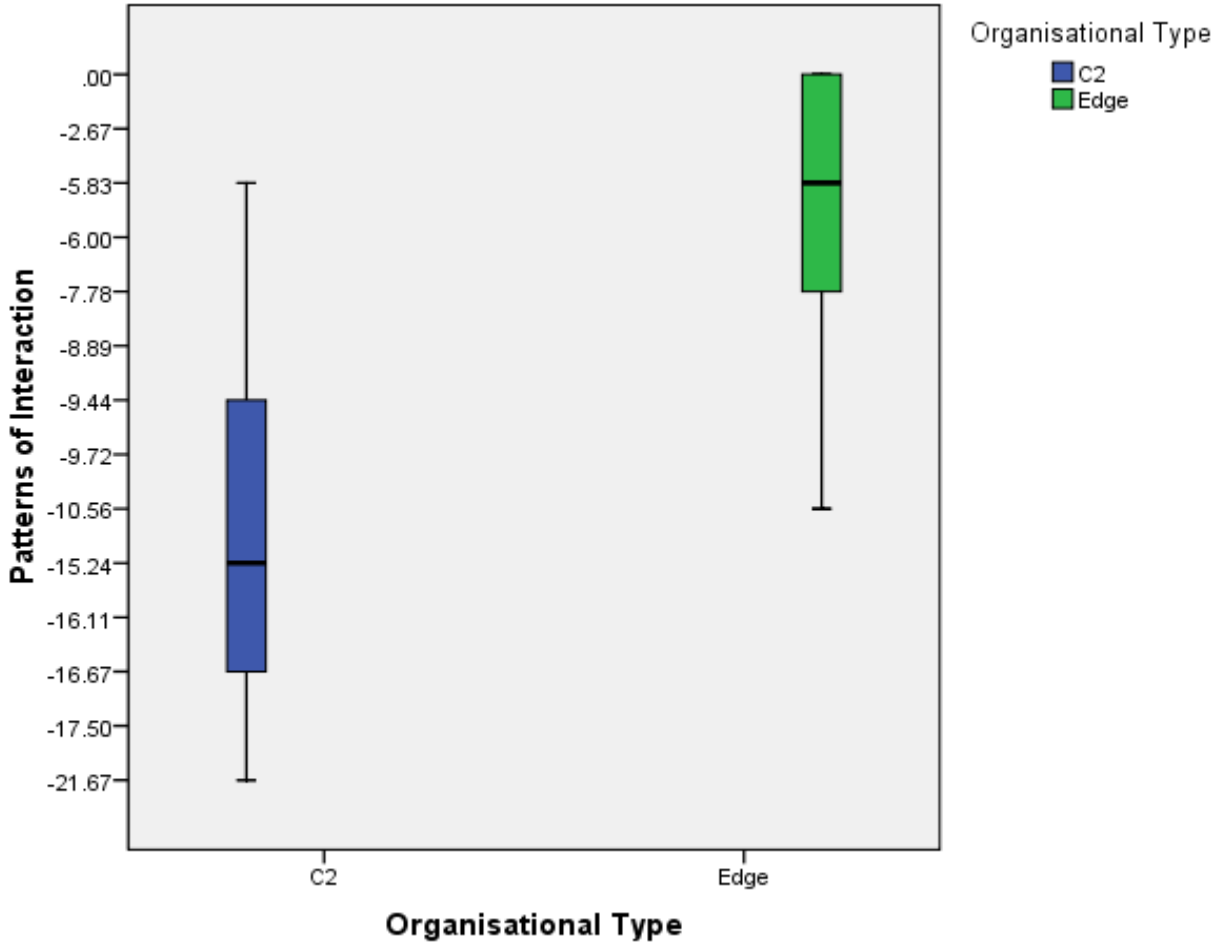




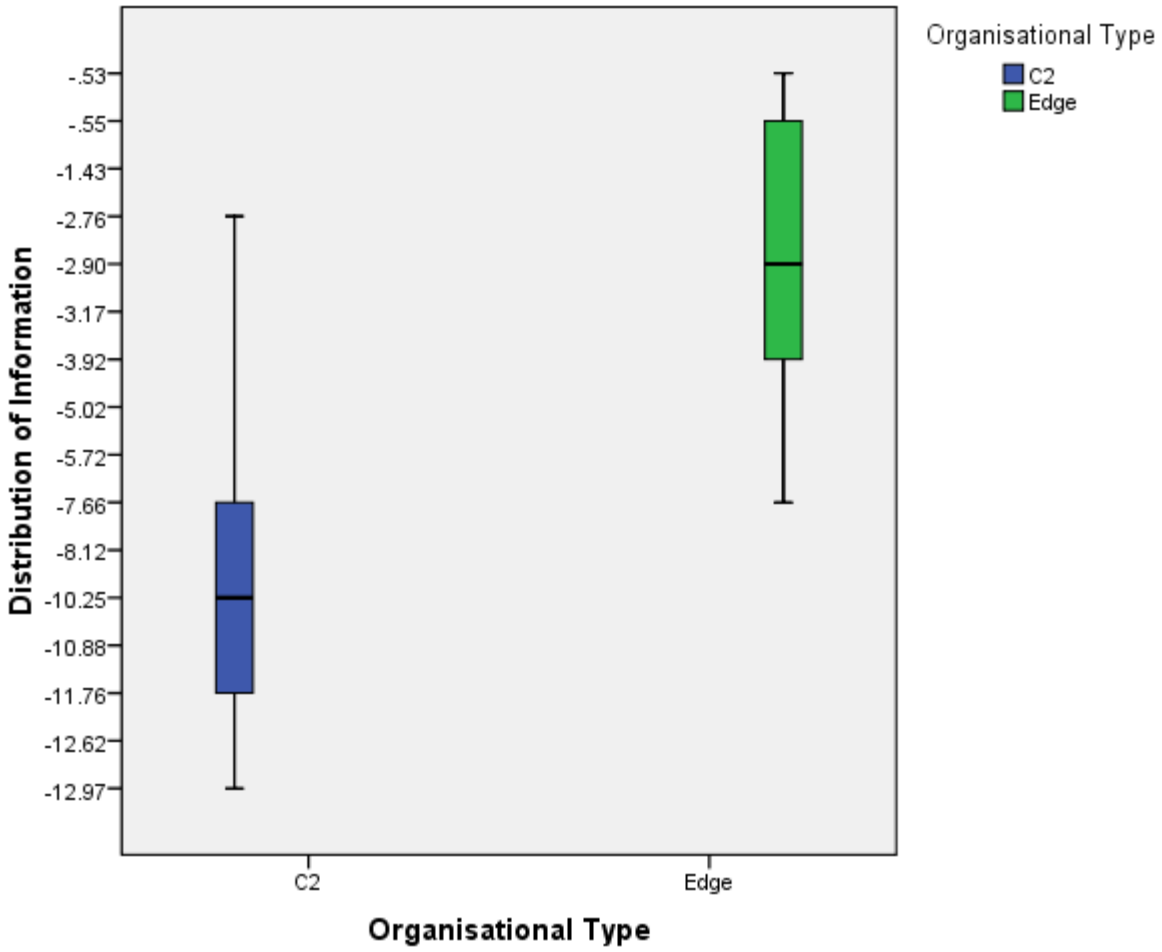
Allocation of Decision Rights



Patterns of Interaction



Distribution of Information

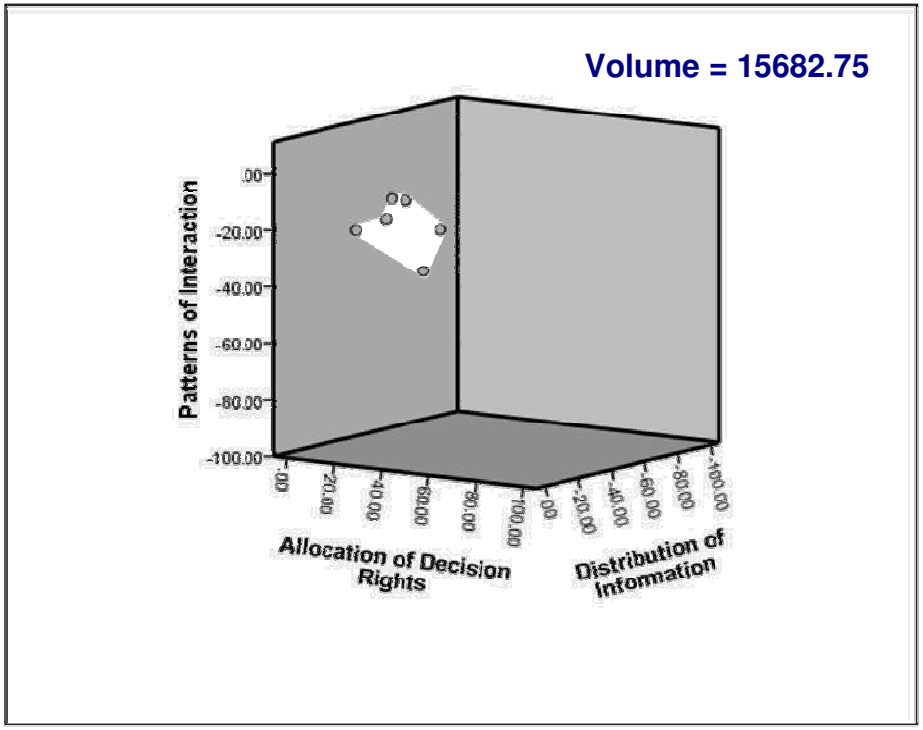


Analysis of Agility

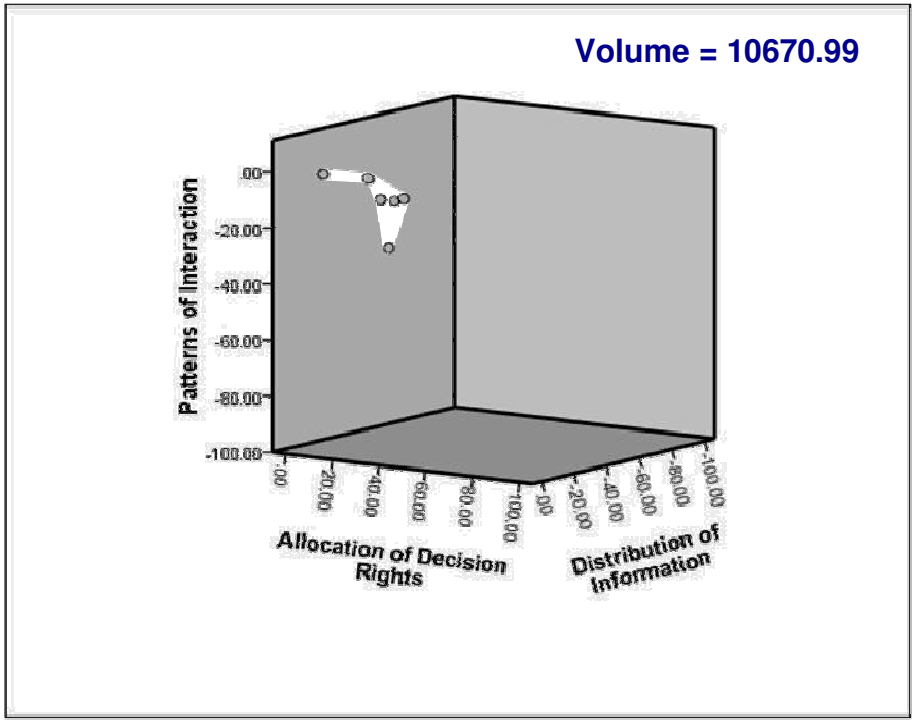
- The data from the In-house Baseline ELICIT Study and Meta-analysis date was further analysed in terms of the agility metrics identified:
  - Calculation of Volume for the movement of an N's sample data within the NATO Approach Space
  - Volume compared across N's for C2 and Edge conditions.

Portugal

Portugal, C2

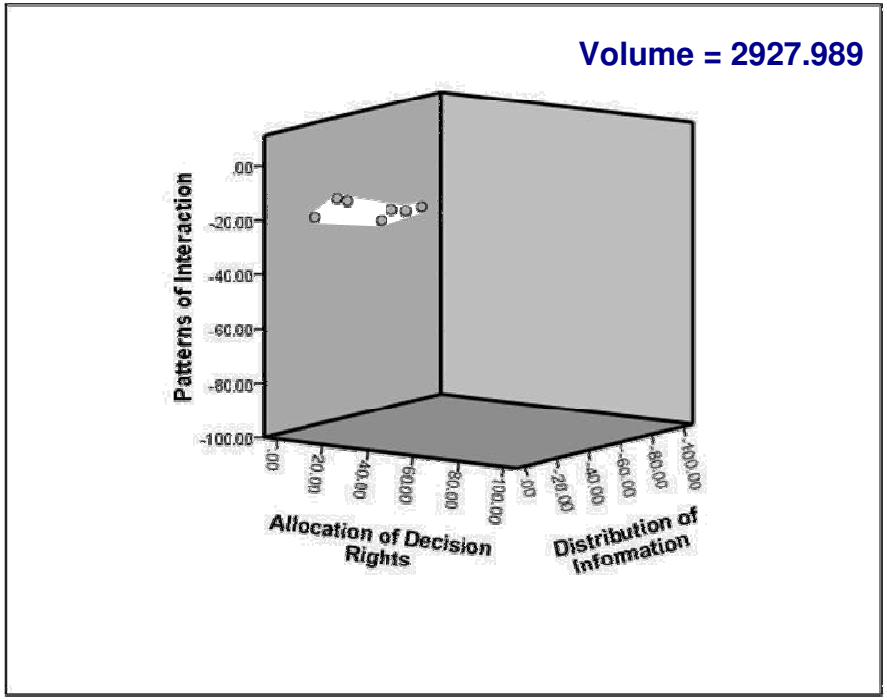


Portugal, Edge

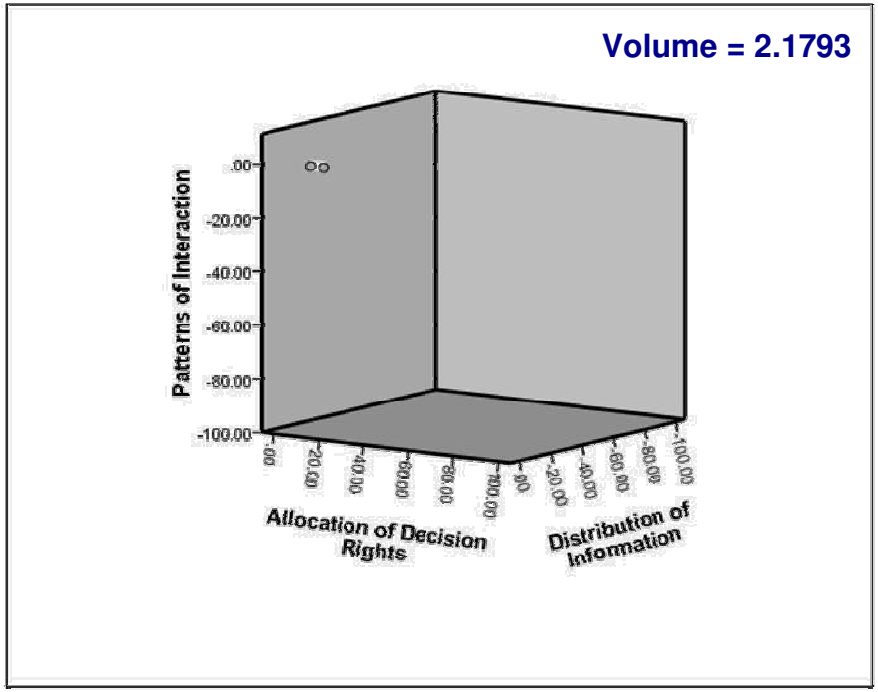


Singapore

Singapore, C2

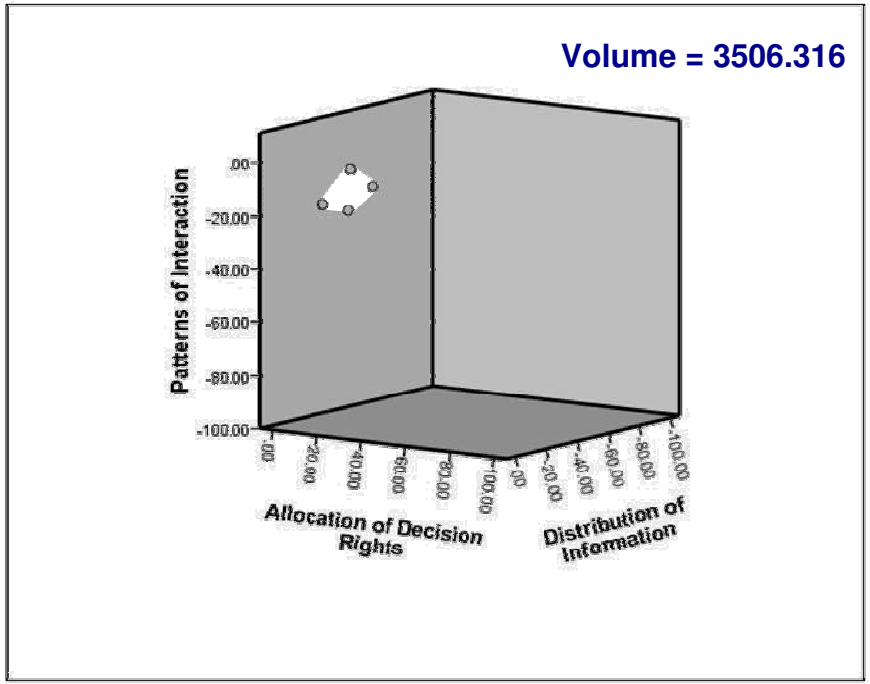


Singapore, Edge

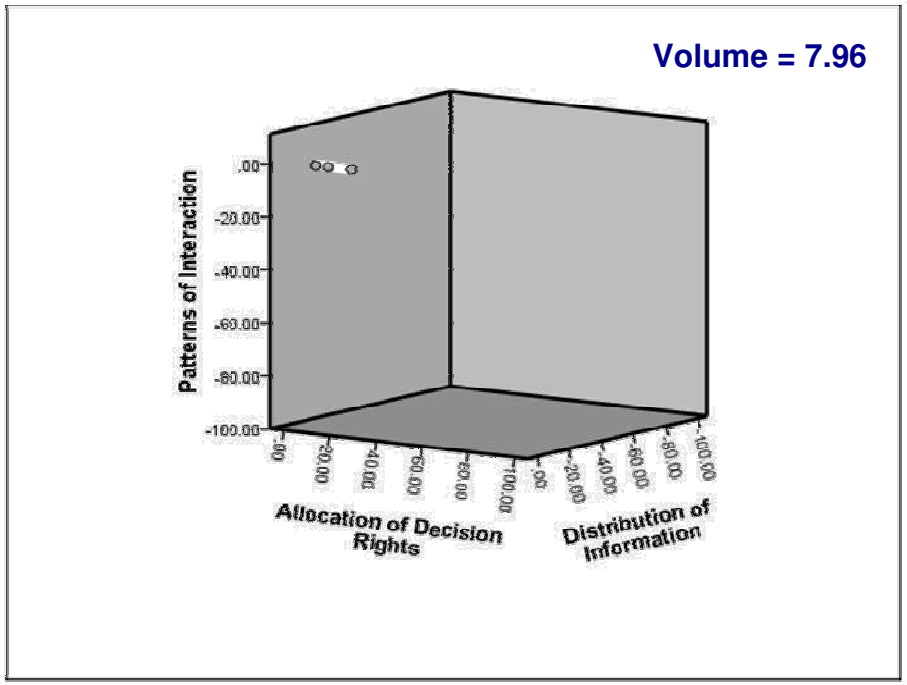


United Kingdom

Cranfield, UK, C2

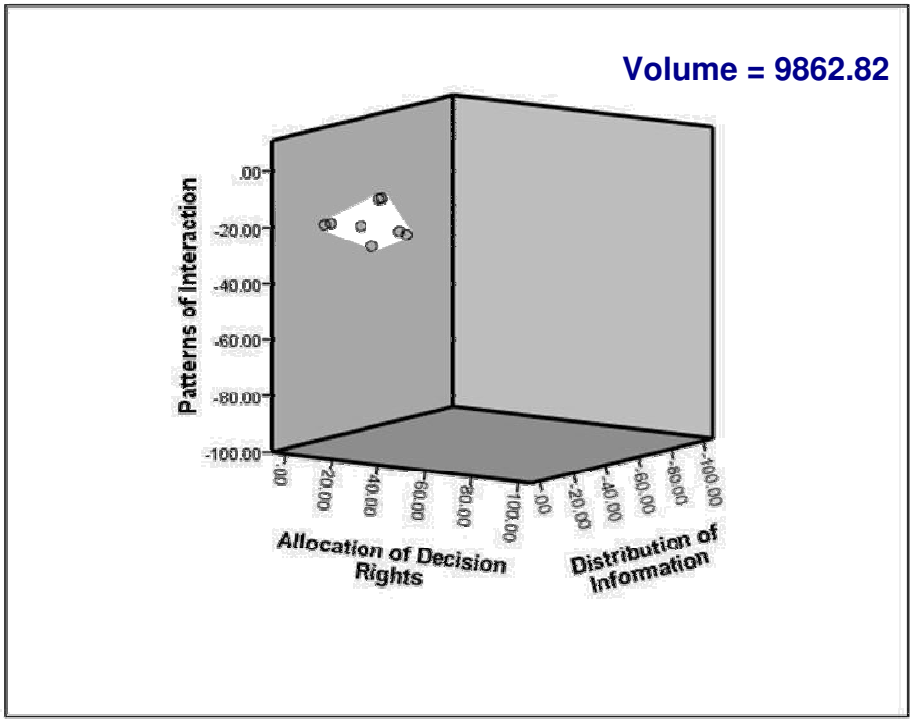


Cranfield, UK, Edge

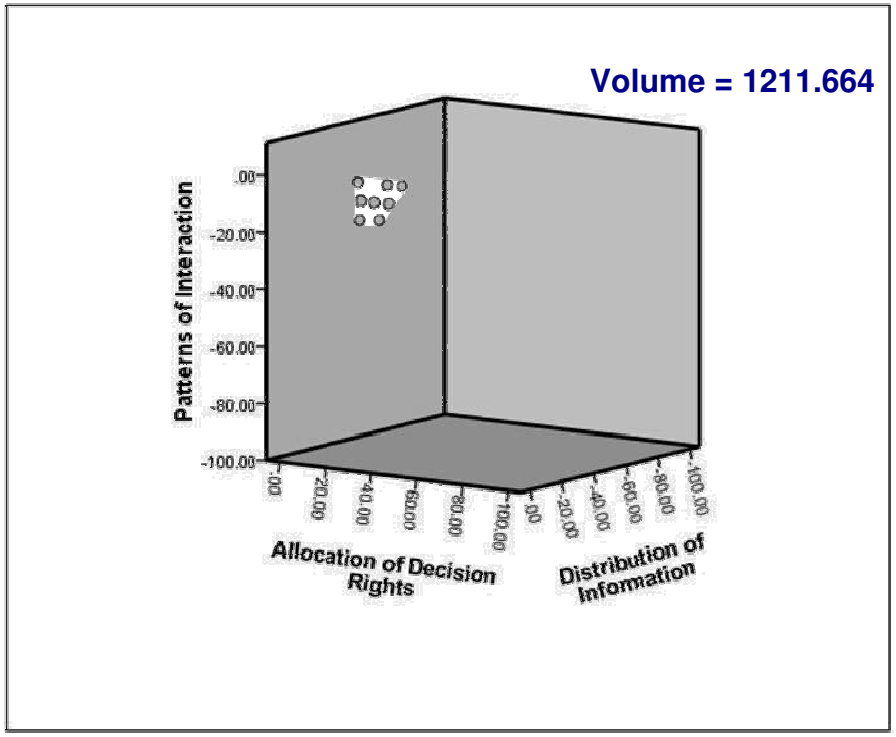


United Kingdom

Southampton, UK, C2

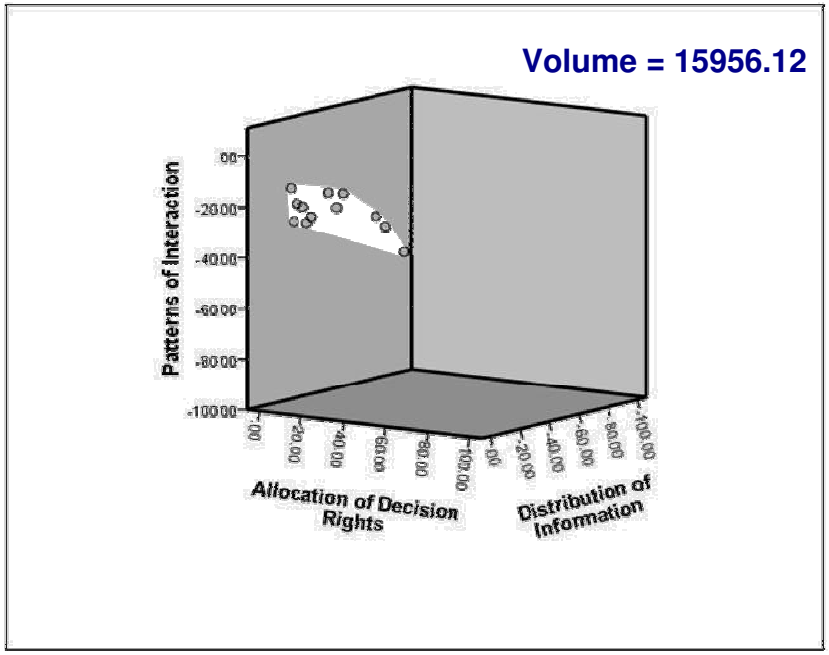


Southampton, UK, Edge

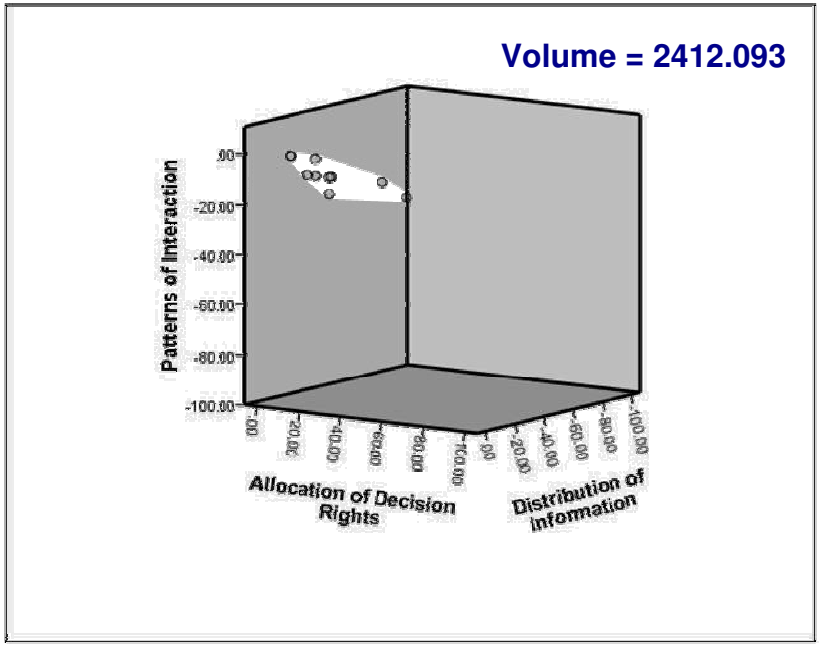


Canada

Canada, C2

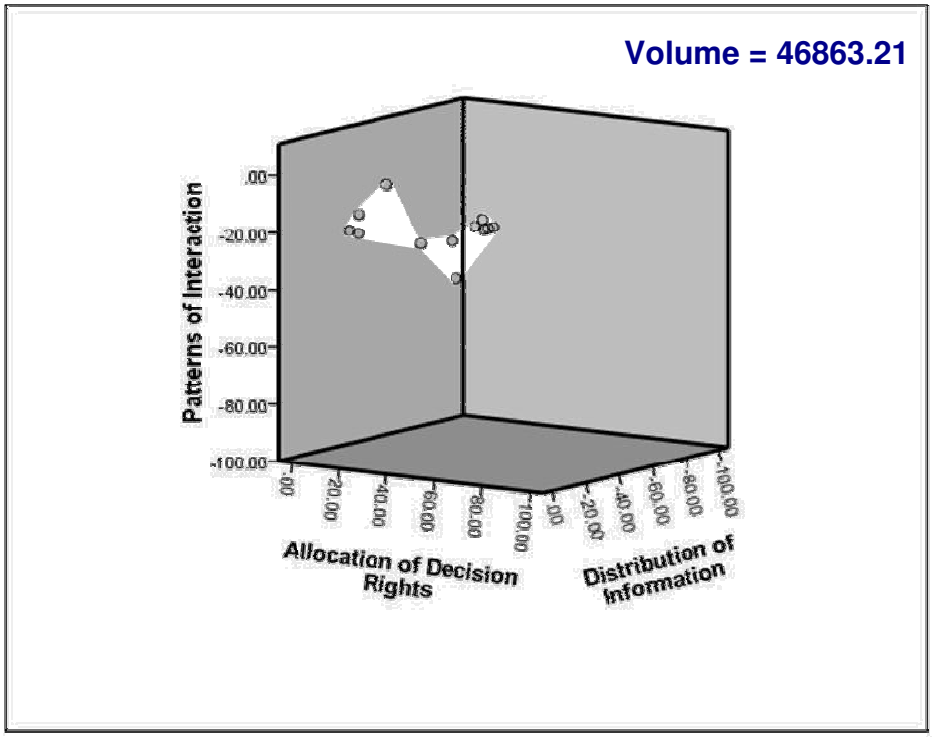


Canada, Edge

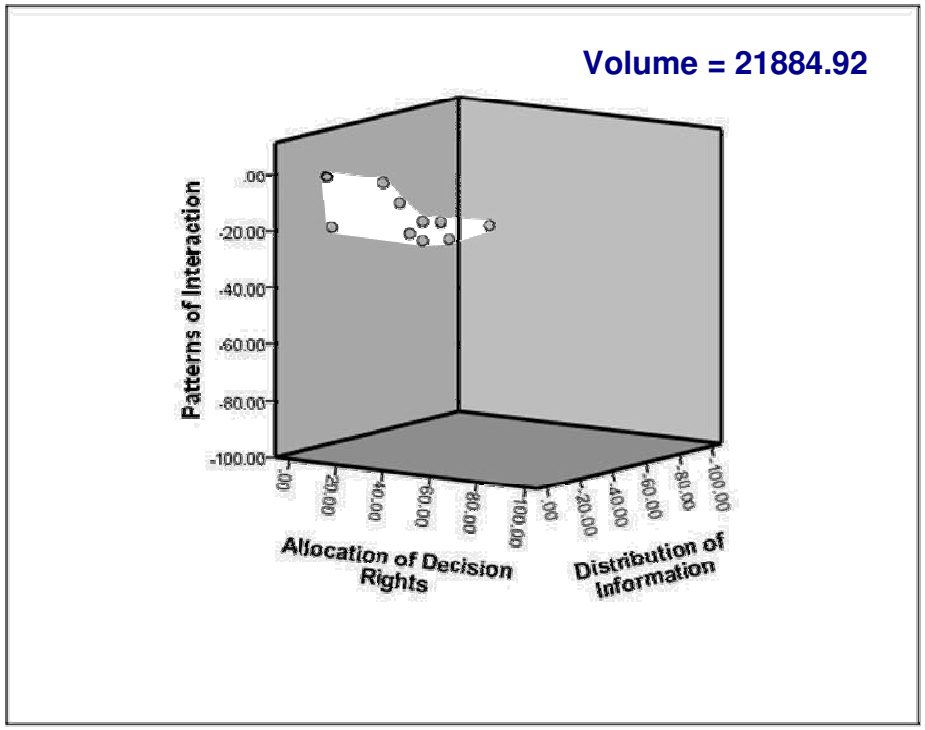


United States

West Point, US, C2

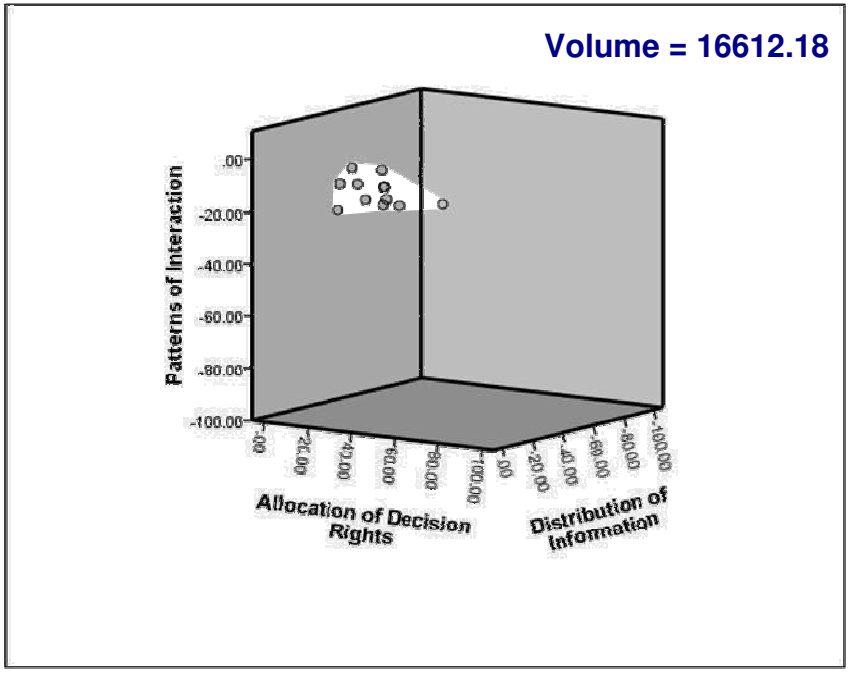


West Point, US, Edge

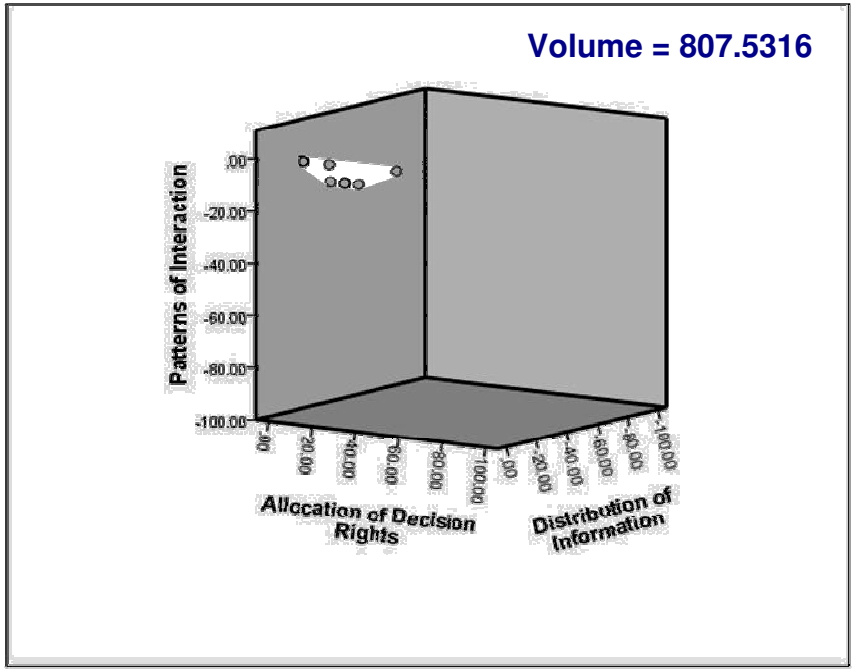


United States

Boston Uni, US, C2

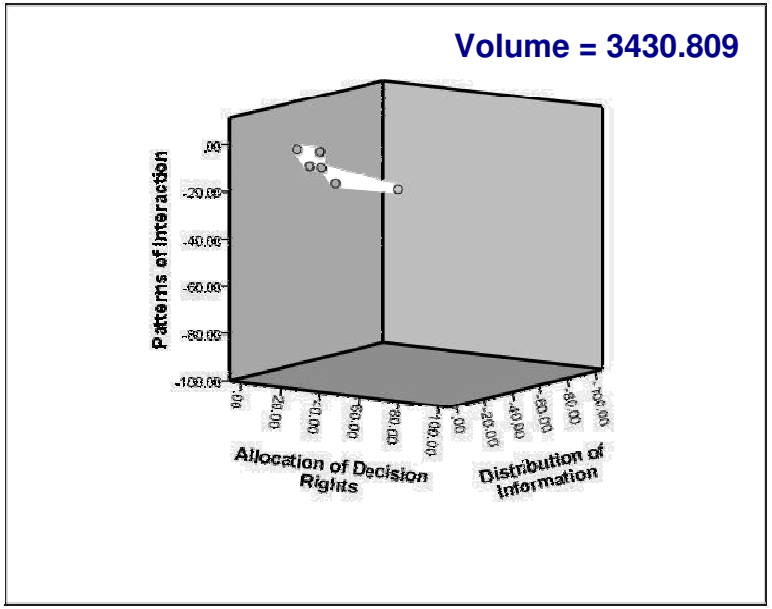


Boston Uni, US, Edge

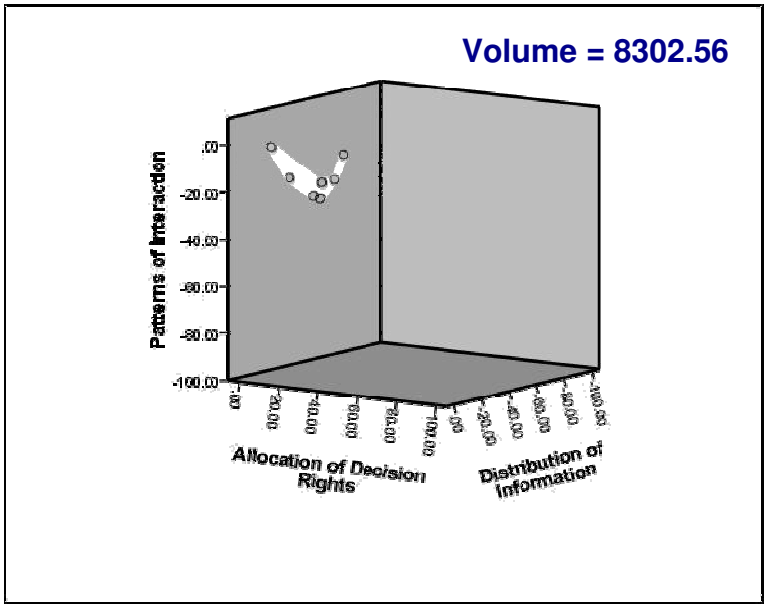


United States

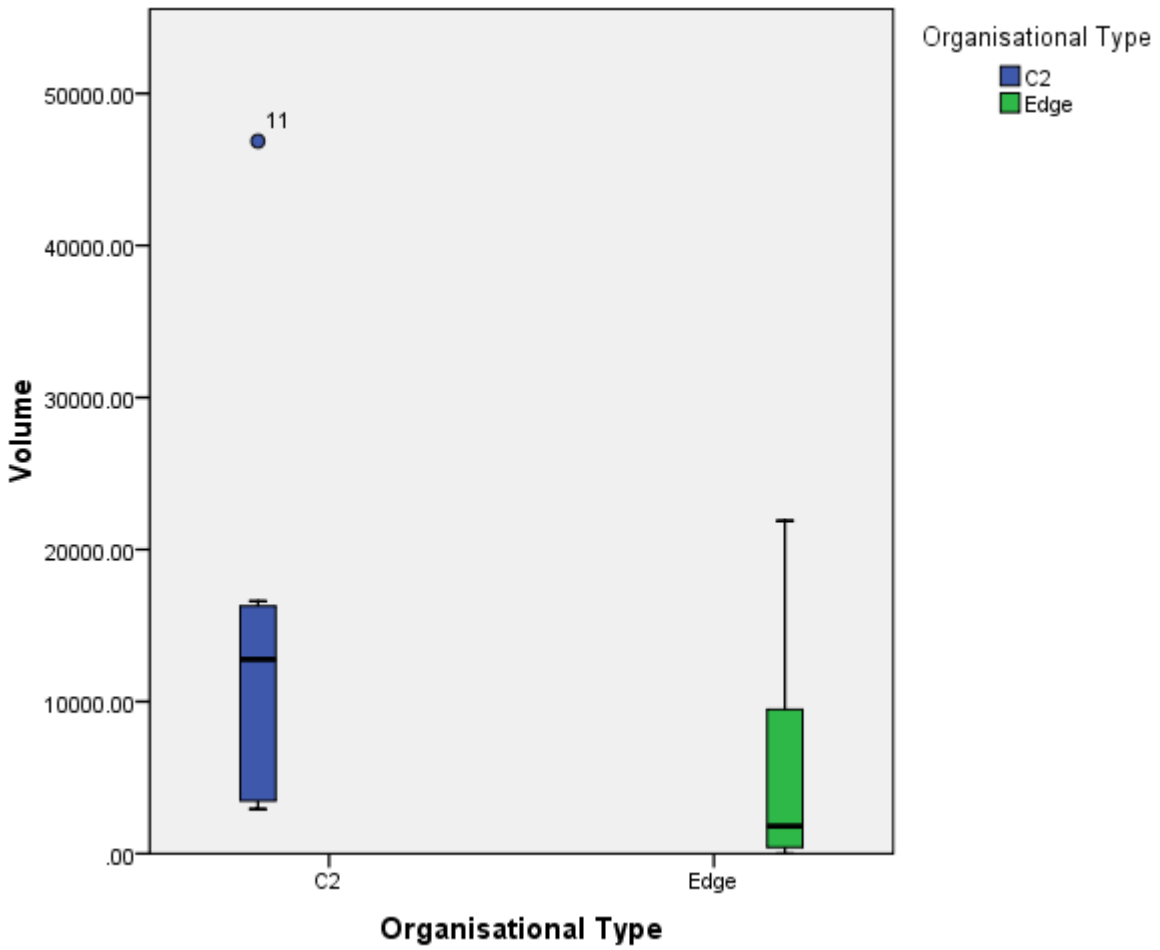
Naval Postgradute School, C2



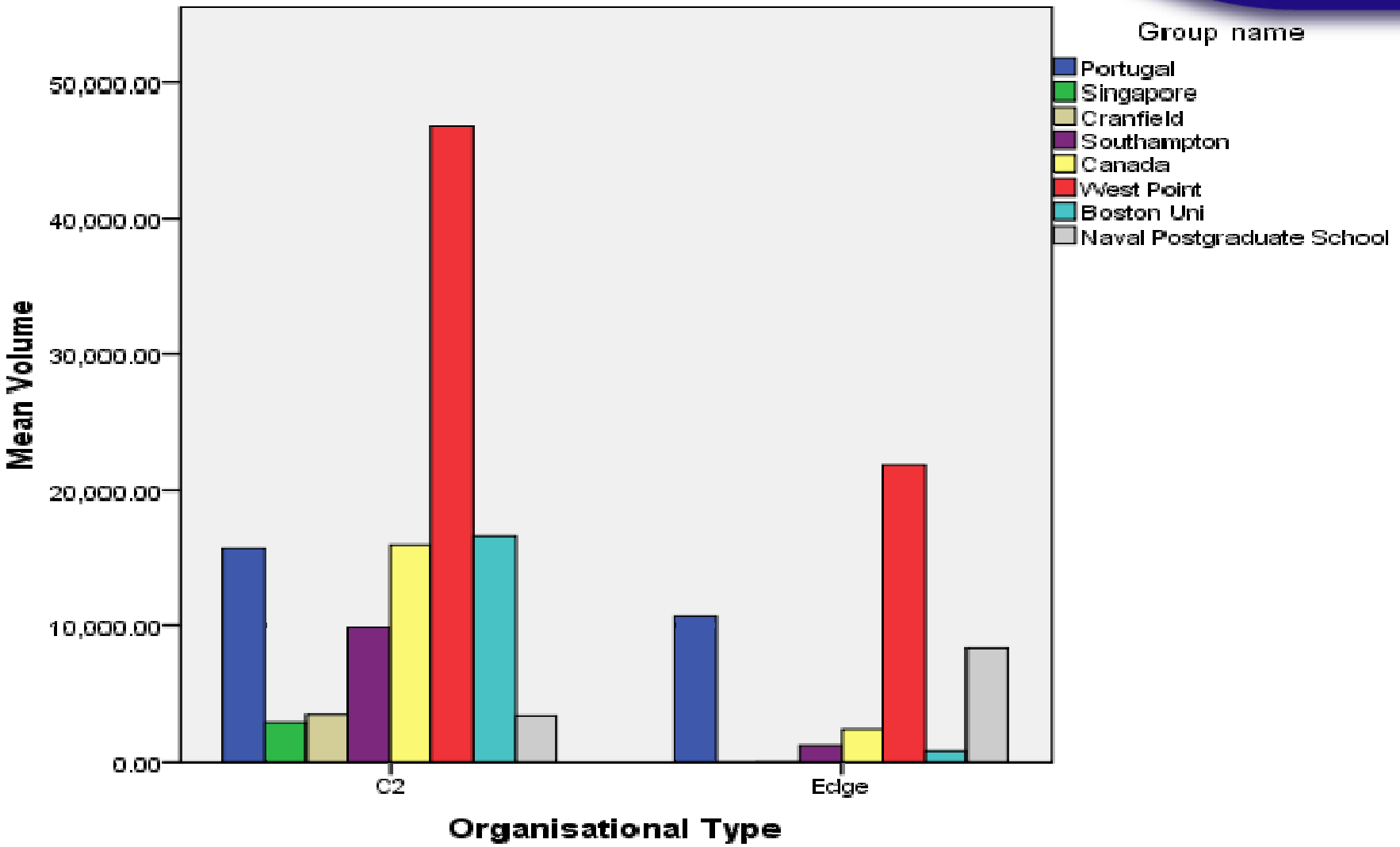
Naval Postgraduate School, Edge



Volume by type



Volume by organisation

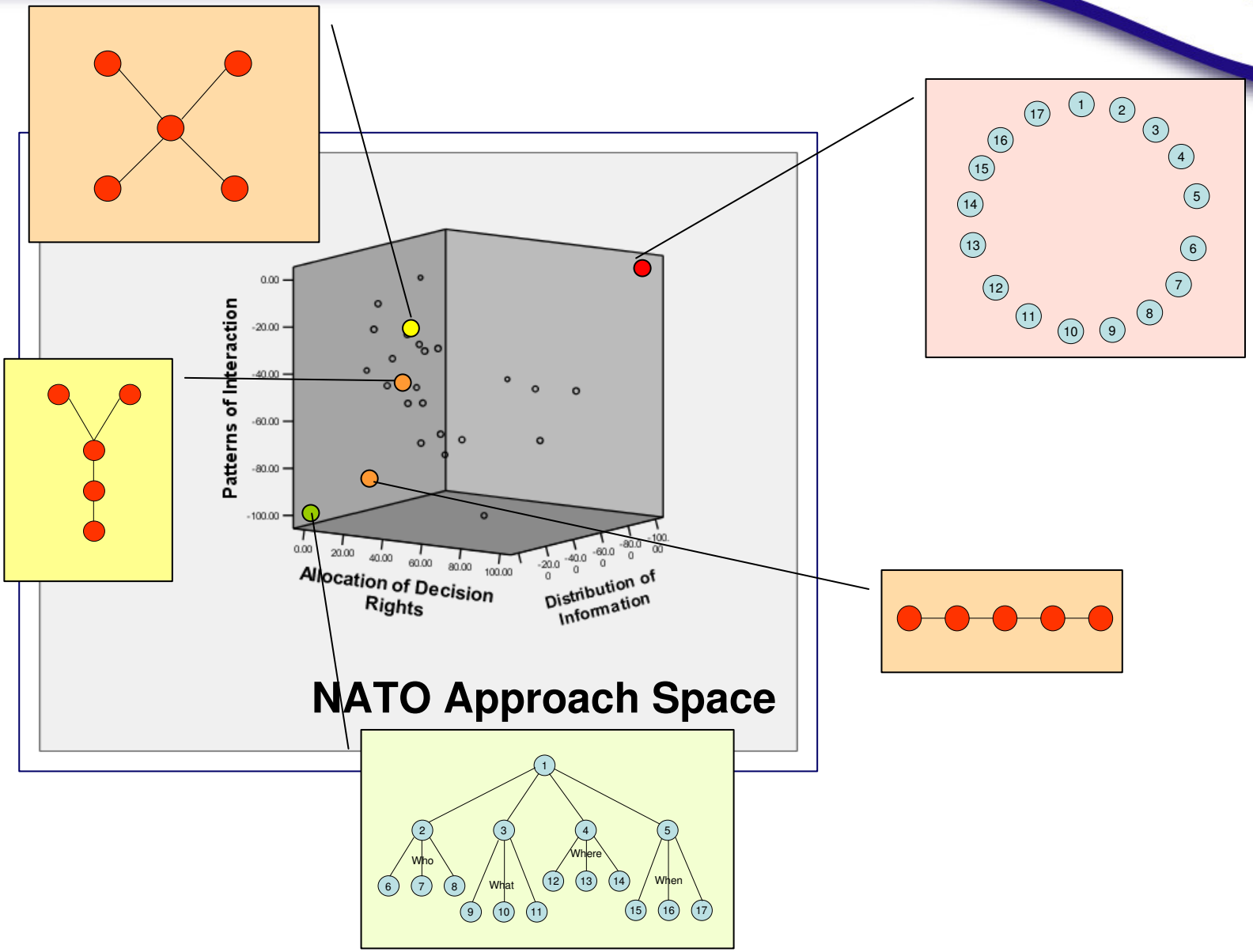


Summary Table

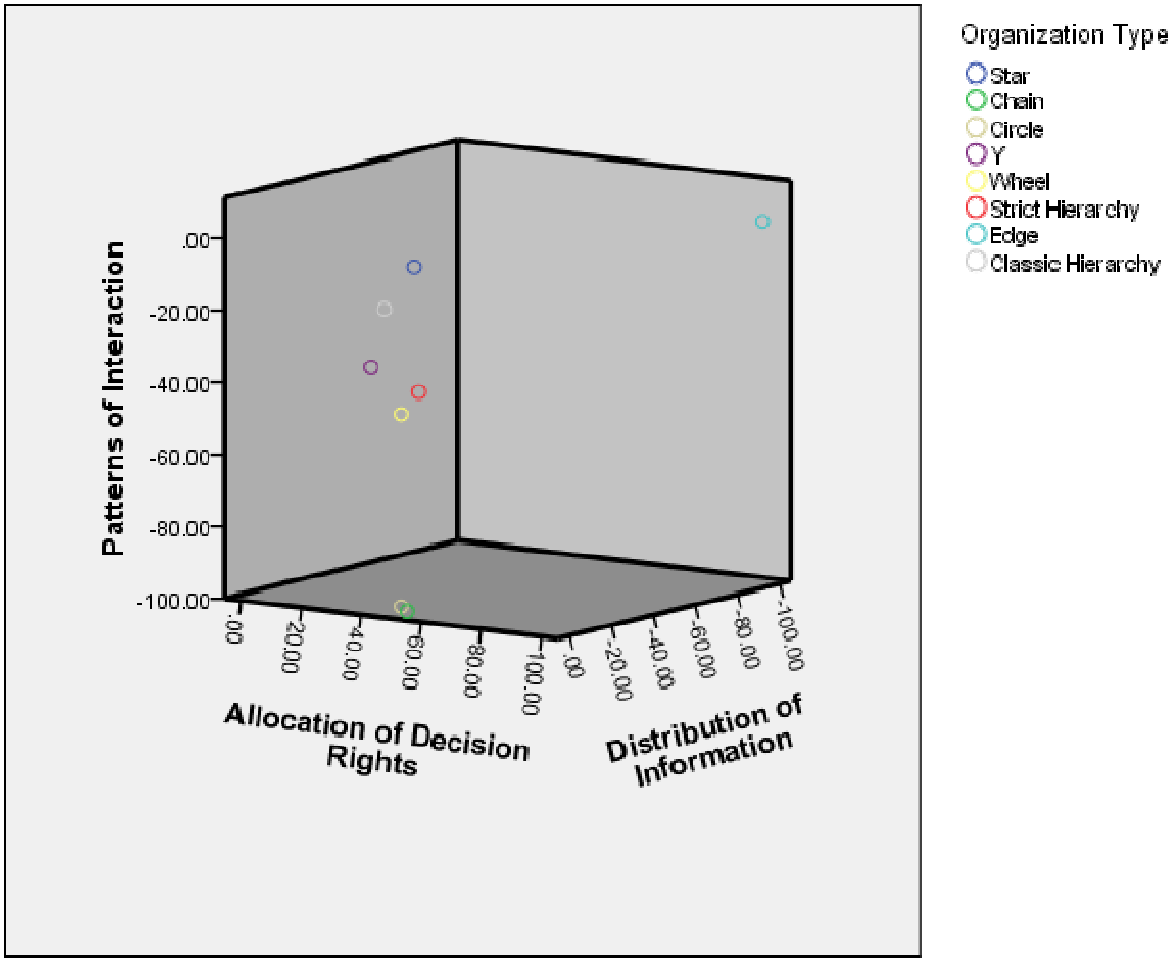
Volume

N	Network structure	AoDR	PoI	DoI	Volume
Portugal	C2	23.53	26.66	25	**15682.75**
Portugal	Edge	29.42	26.67	13.6	**10670.99**
Singapore	C2	41.18	6.67	10.66	**2927.989**
Singapore	Edge	5.89	0	0.37	**2.1793**
Cranfield	C2	30	11.11	10.52	**3506.316**
Cranfield	Edge	15	0	0.53	**7.96**
Southampton	C2	35.3	20	13.97	**9862.82**
Southampton	Edge	17.65	13.33	5.15	**1211.664**
Canada	C2	52.94	20	15.07	**15956.12**
Canada	Edge	14.06	13.33	12.87	**2412.093**
US West Point	C2	58.83	33.33	23.9	**46863.21**
US West Point	Edge	64.71	20	16.91	**21884.92**
US Boston Uni	C2	47.06	20	17.65	**16612.18**
US Boston Uni	Edge	41.18	6.67	2.94	**807.5316**
US NPS	C2	41.18	13.33	6.25	**3430.809**
US NPS	Edge	35.3	20	11.76	**8302.56**

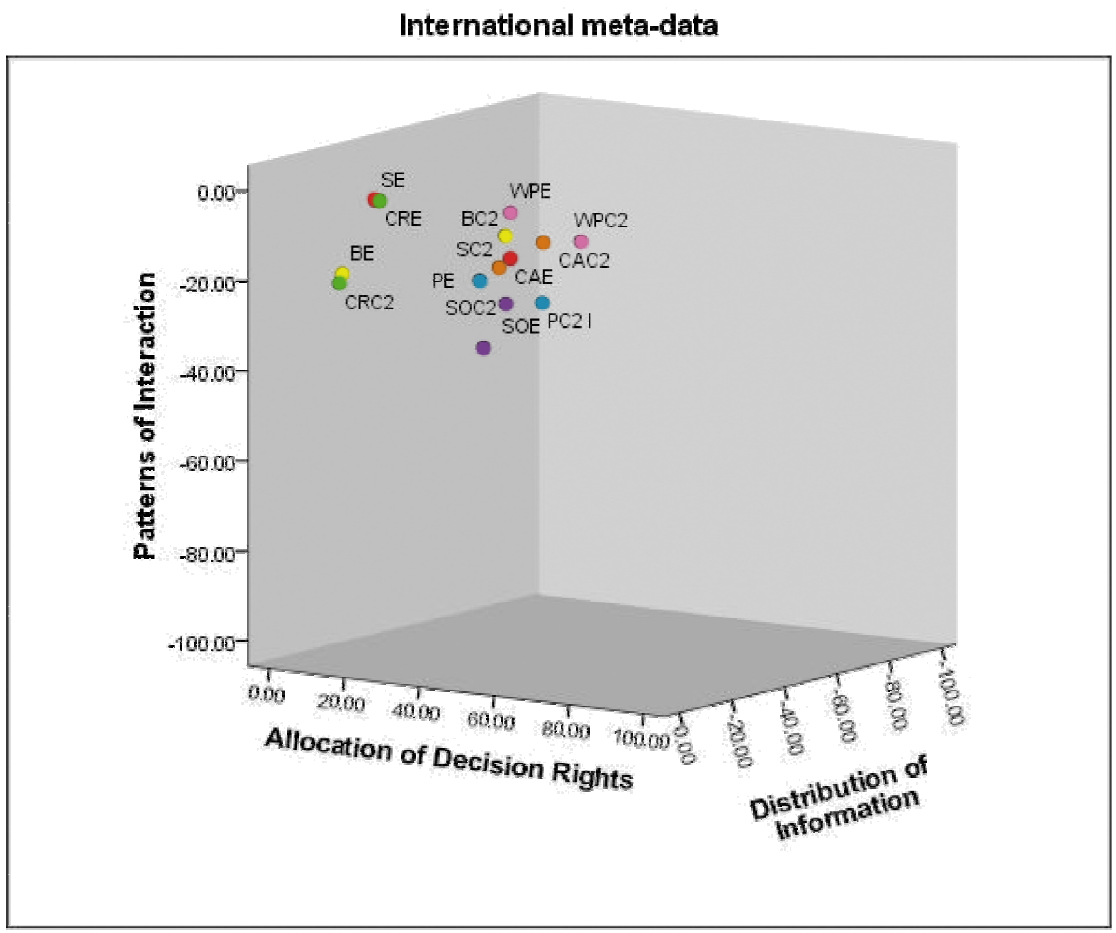
Octant Archetypes



Archetype Network Structures



Meta-data overview



Signapore Edge
Signapore C2

Canada Edge
Canada C2

Boston Edge
Bosten C2

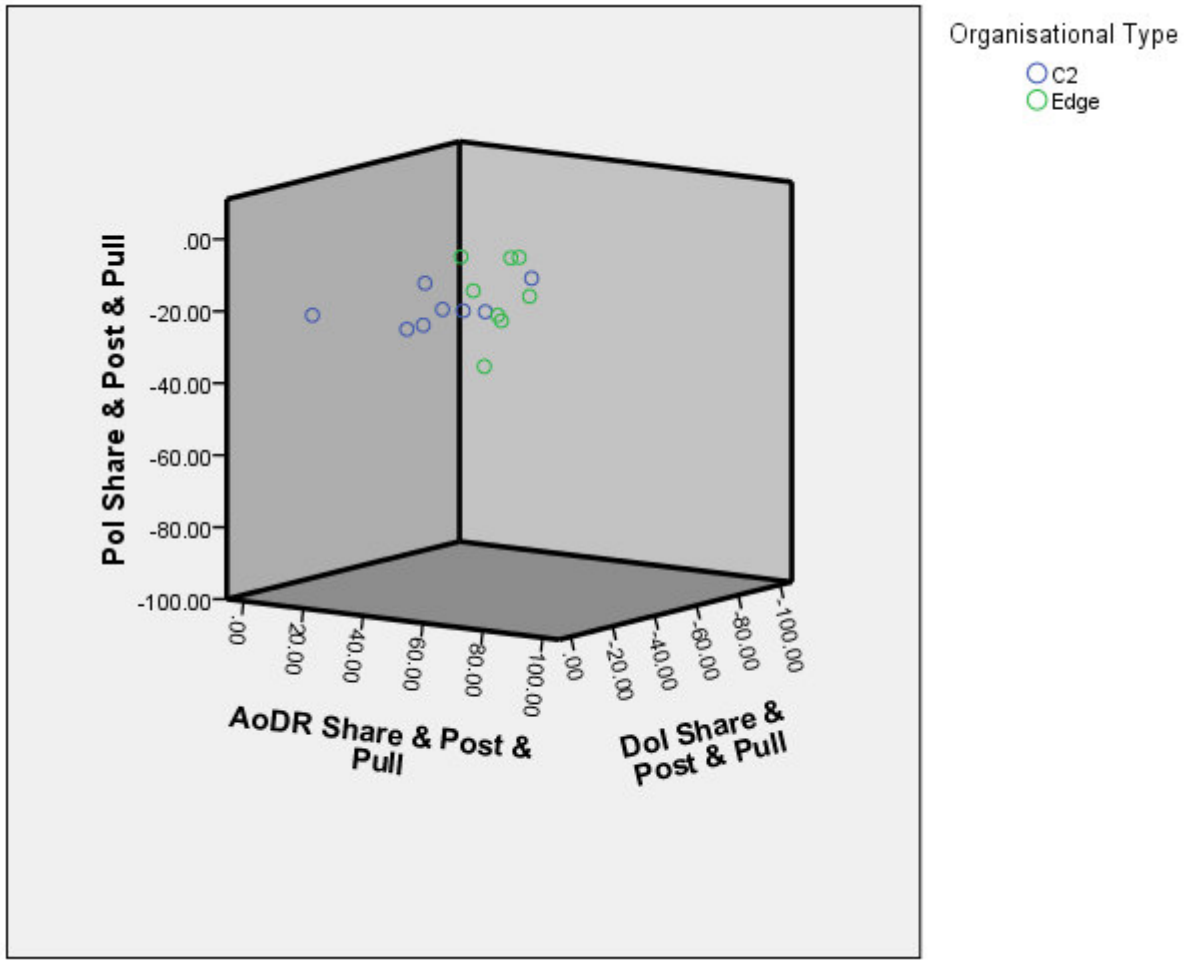
Cranfield Edge
Cranfield C2

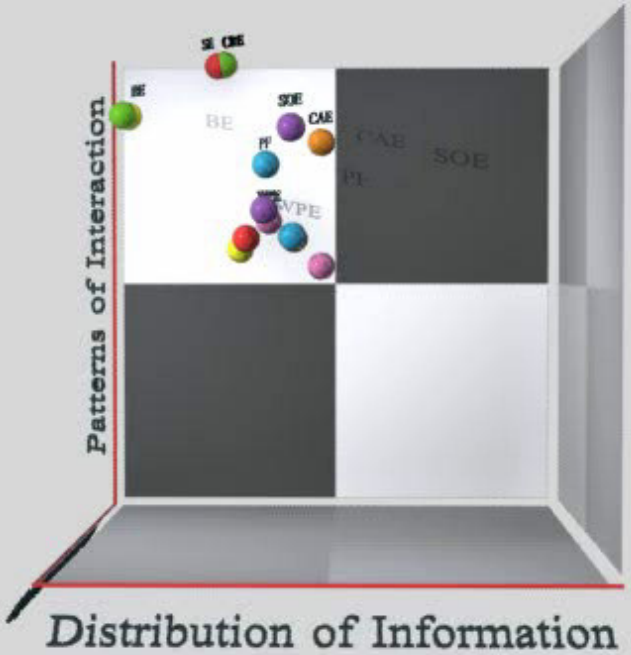
Portugal Edge
Portugal C2

Southampton Edge
Southampton C2

West Point Edge
West Point C2

All information exchange types




Patterns of Interaction
Distribution of Information
BE
SOE
CAE
VPE

Conclusions

- The data to fall into just one of the octants (the star octant).
- Two types of organisations (C2 and Edge) drift toward the same point in the NATO phase space.
- The phase space distinguishes between different organizational structures.
- A problem with the entire ELICIT paradigm is raised.
- What structures might have emerged in the Edge condition if there was an evolving task with no fixed end-state, a task which required teams to continually adapt and evolve with their environment?