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Social network analysis in joint experimentation:

Analysing organizational robustness in JFCOM Multinational Experiment 4

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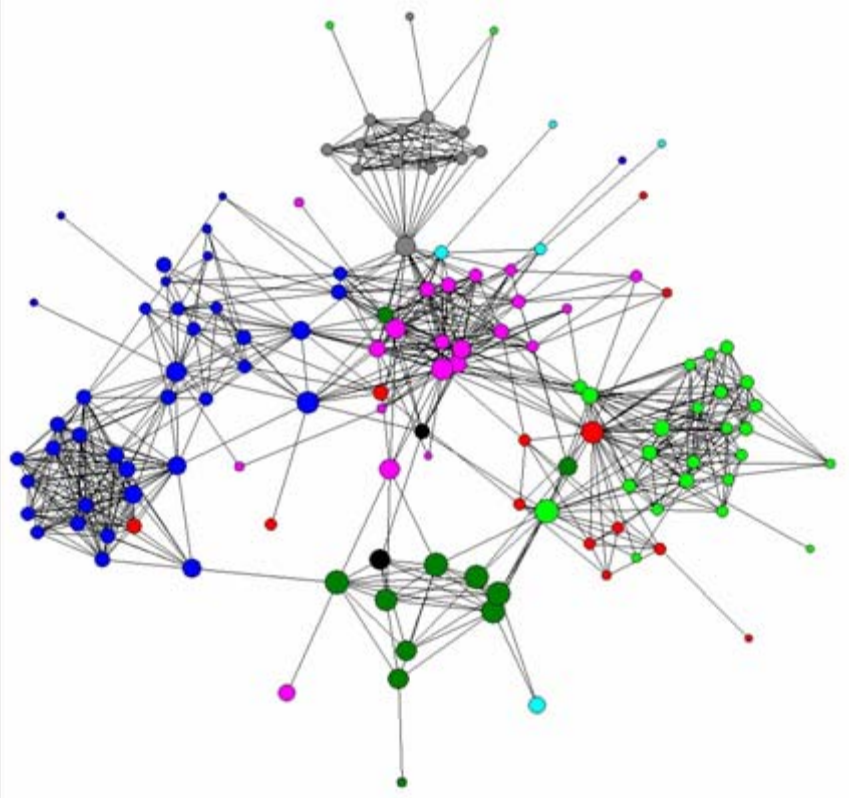
To: ICCRTS 06

Contract: UK MOD Contract AES/N05501 *Report on the Analysis of Organisation at MNE4.*

28 Sep 2006



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- Exploratory analysis – IWS
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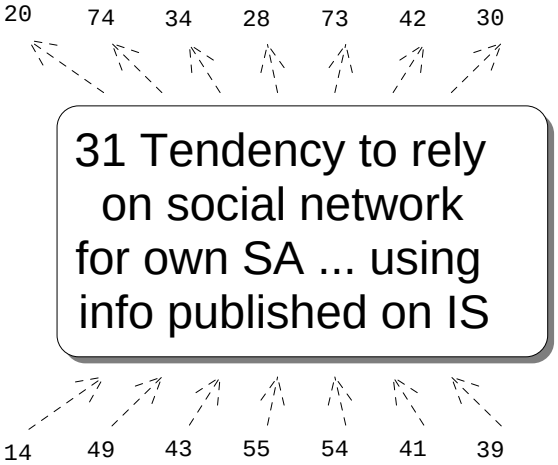


MNE4 Organisational Analysis Questions

- 1. How **robust** is the organizational structure (formal and informal) employed for conducting EBO for MNE4?
- 2. What organizational structure (formal and informal) will **best** facilitate the effective conduct of EBO?
- 3. Does the org structure used to conduct EBO in MNE4 support the **efficient** flow of communication & information?
- 4. Were **expected** levels of interaction observed?
- 5. What constraints are imposed on individuals in terms of their access and use of the **tools** in MNE4?

- UK. What value might there be in employing SNA techniques in experimentation?

Robustness – a measurable definition

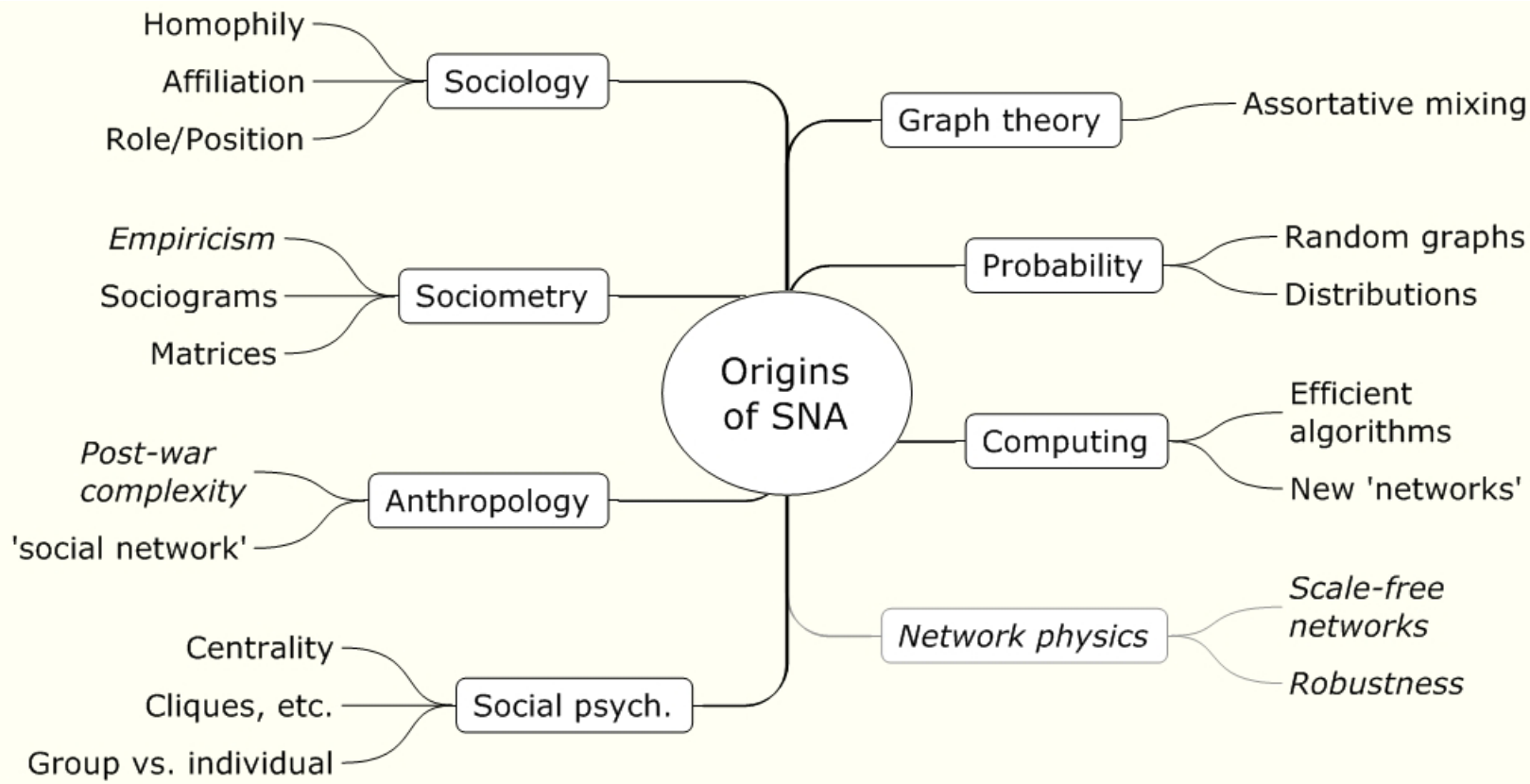
- … *the persistence of specified system features in the face of a specified assembly of insults.* [e.g. Allen]
- **Structural** organizational robustness
  - the persistence of organizational structures in the face of the OP/injects
- **Functional** organizational robustness
  - the ability of a system (the HQ) to maintain function even with changes in internal structure or external environment. [e.g. Fontana and Wagner]
  - e.g. by *adapting*, esp. by changing roles & groups

- Extensive research exists into robustness of certain types of network, esp. random & *scale-free* networks

Why Social/Org Network Analysis?

- Individual-level measures cannot capture the strengths and vulnerabilities of an *organization*.
- SNA can bridge the gap by addressing *interactions*
  - between staff and groups,
  - between measures of both (e.g. command intent vs. commander's network)
- SNA is unique in addressing *self*-organization – seeing how interactions & flows (info, knowledge, tasks) adapt to meet the functional demands of the situation.
- e.g. http://www.casos.cs.cmu.edu/projects/networks.html

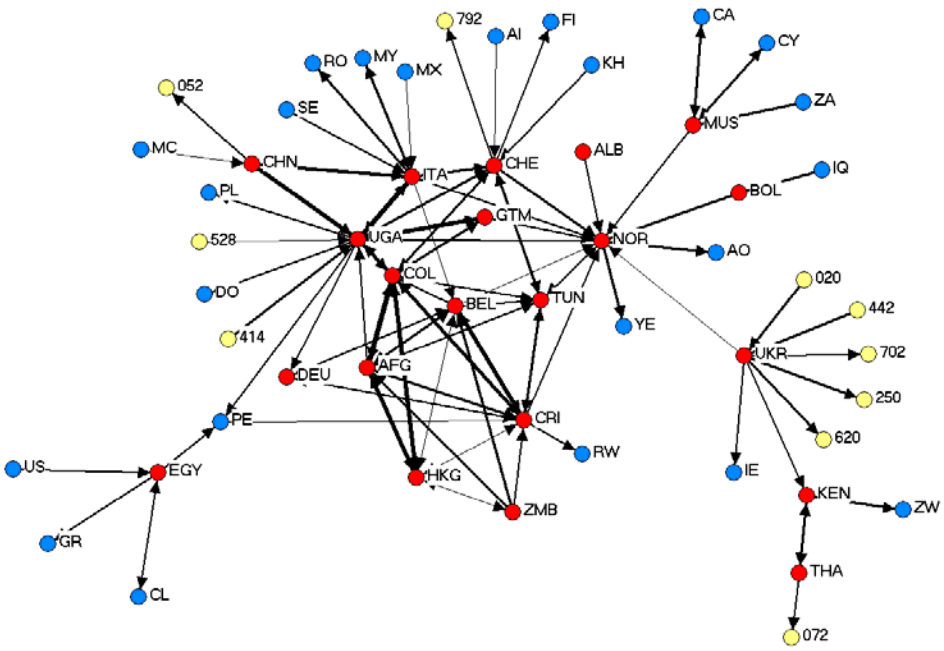
Origins of SNA



Applications of SNA

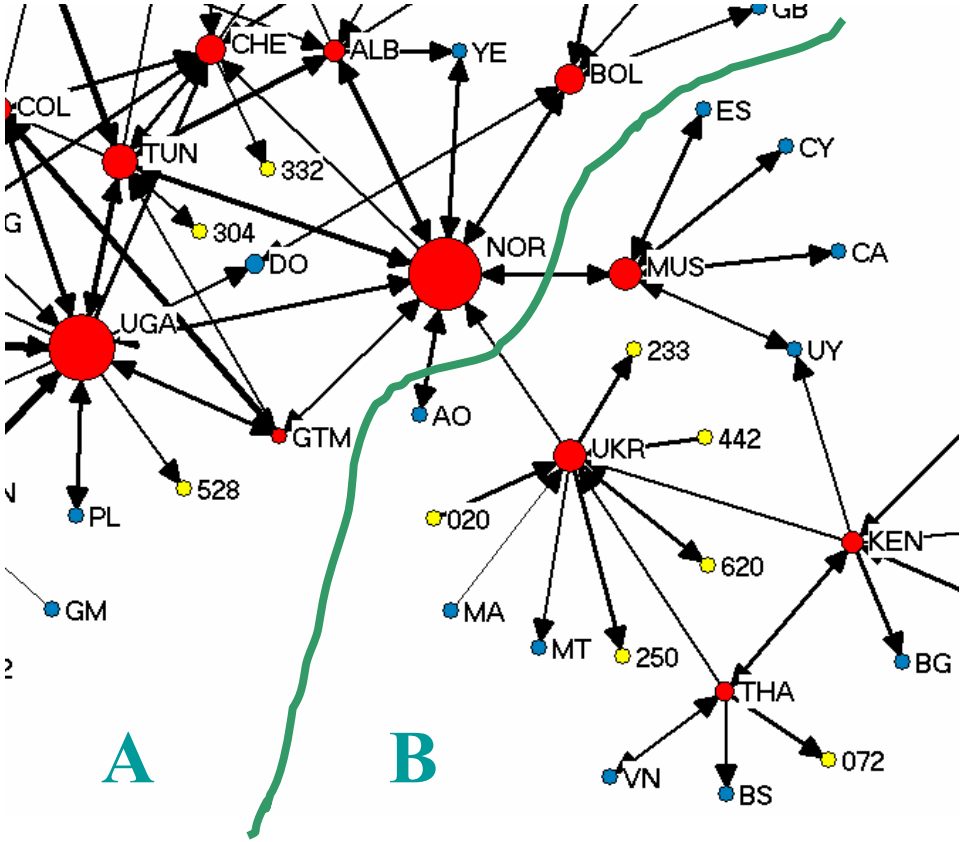
- Academic studies
  - theory-driven – product is theory or policy
  - society, social capital, power, prestige
- Organizational consultancy
  - problem-driven – product is issues + action plan
  - teamwork: knowledge mgt, integration & agility
  - reward & retention
- Command and control research
  - inferences (C2 theory): re. agility, robustness, emergence
  - …?

Techniques: sociograms



- A set of dyadic ties among a set of actors
- Actors can represent people, technology, groups or organisations
- A tie or link between the actors represents one social relation (*knows*, *reports to,…*)
- This network has only one component

Techniques: behaviours, e.g. brokerage



- Ability to exploit ‘structural holes’ in the network through connecting nodes that would otherwise not be connected

Benefits:

- Key areas within the network which would otherwise not be connected
- Build redundancy through increasing connections
- Increase awareness across groups
- Enable assessment of replacing those filling brokerage roles with technology

Data: QinetiQ problem-solving questionnaire

Data sources

- Organizational ‘design’ docs: Battle Rhythm (meetings), manning list
- Daily logs (x15)
  - IWS event logs – public rooms (*following slides…)*
  - IWS chat logs – public & private rooms
  - Email logs
- Weekly surveys (x3)
  - ‘Meeting Attendance’
  - ‘Information Flow’ (info provided, info received)
  - ‘Awareness of Roles & Responsibilities’
  - ‘MNIG Reach-back’
- Observations & results from parallel analyses

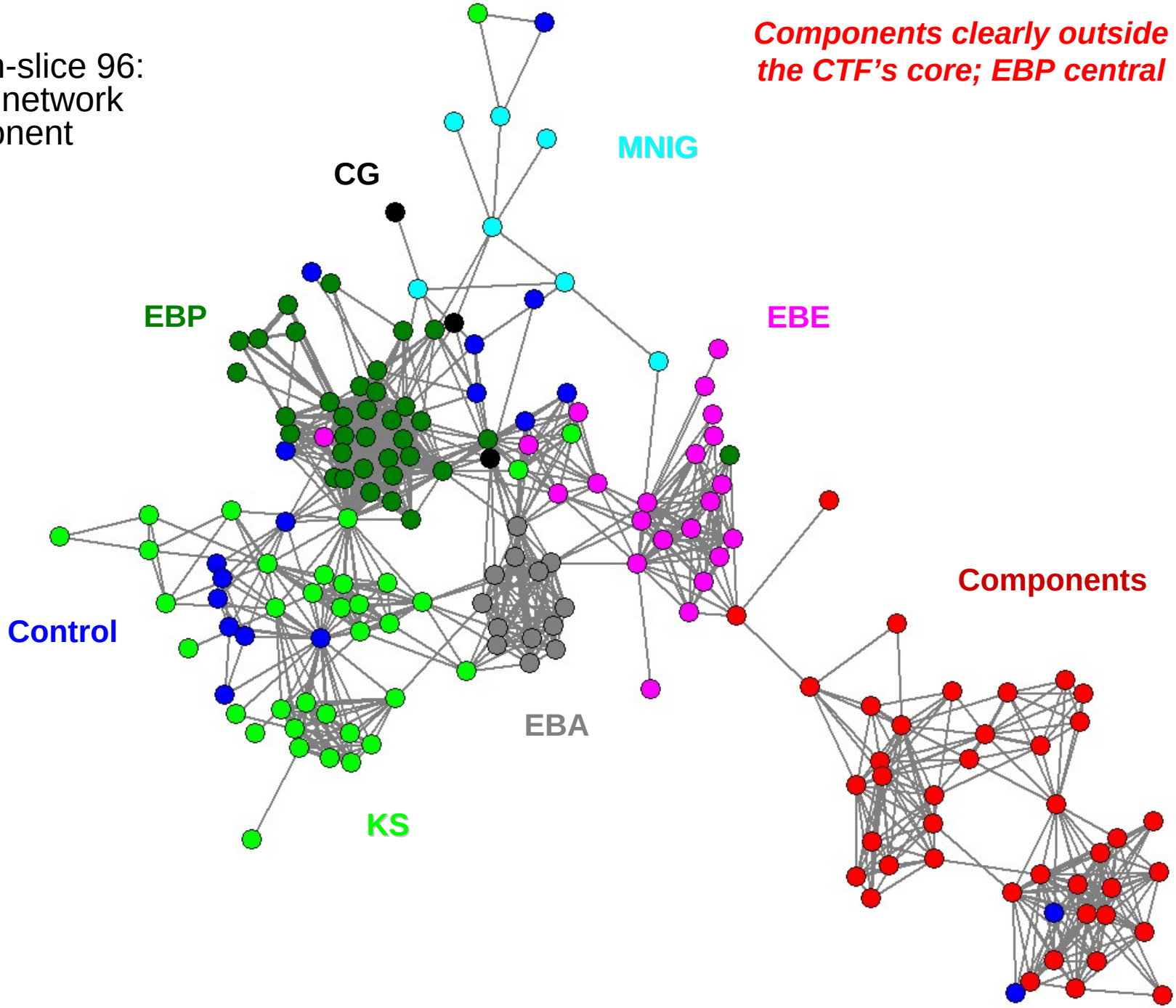
Analysis: IWS event logs

- Staff in the same room have a channel for information exchange
- IWS logs show activity in rooms
- In analysing these logs, we get an indication of how good the channels were between *all* staff
- Measurable features
  - centrality: for key players, **vulnerable** points,
  - ego-centric density: robustness thro **redundancy**
  - clustering measures: natural sub-groups

Week 1

IWS m-slice 96: single network component

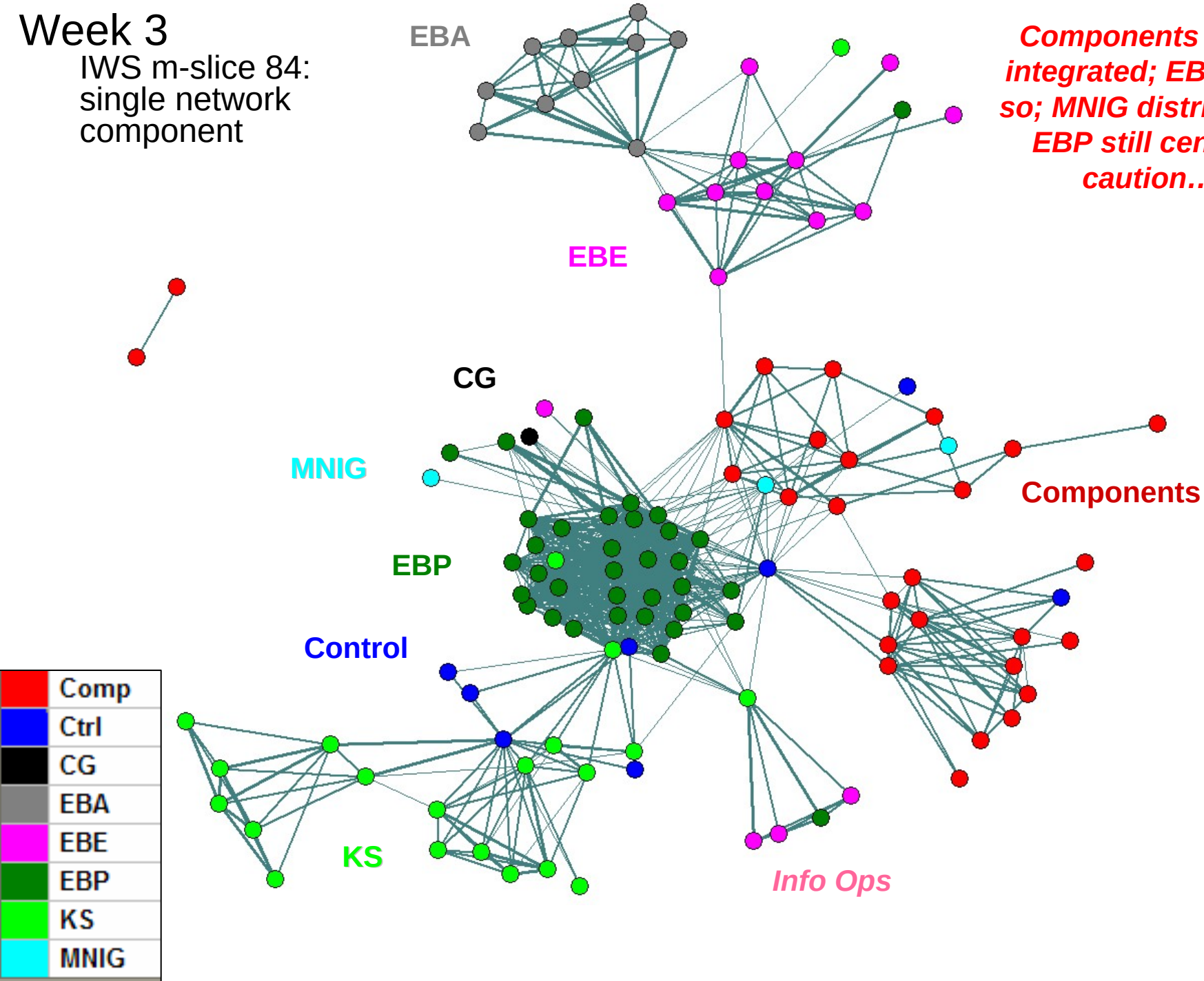
Components clearly outside the CTF's core; EBP central



	Comp
	Ctrl
	CG
	EBA
	EBE
	EBP
	KS
	MNIG

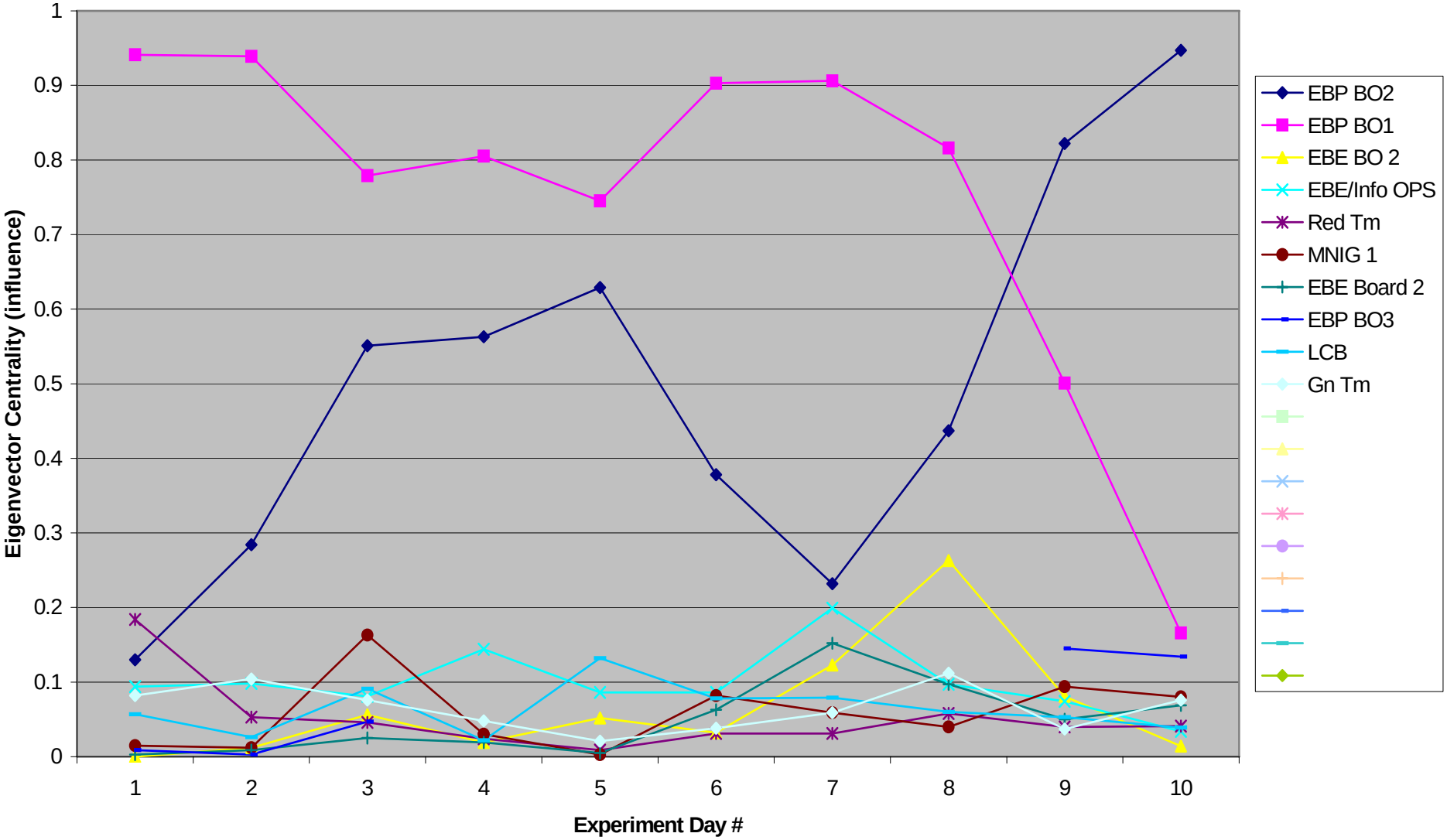
Week 3

IWS m-slice 84: single network component



Components more integrated; EBA less so; MNIG distributed; EBP still central; caution…

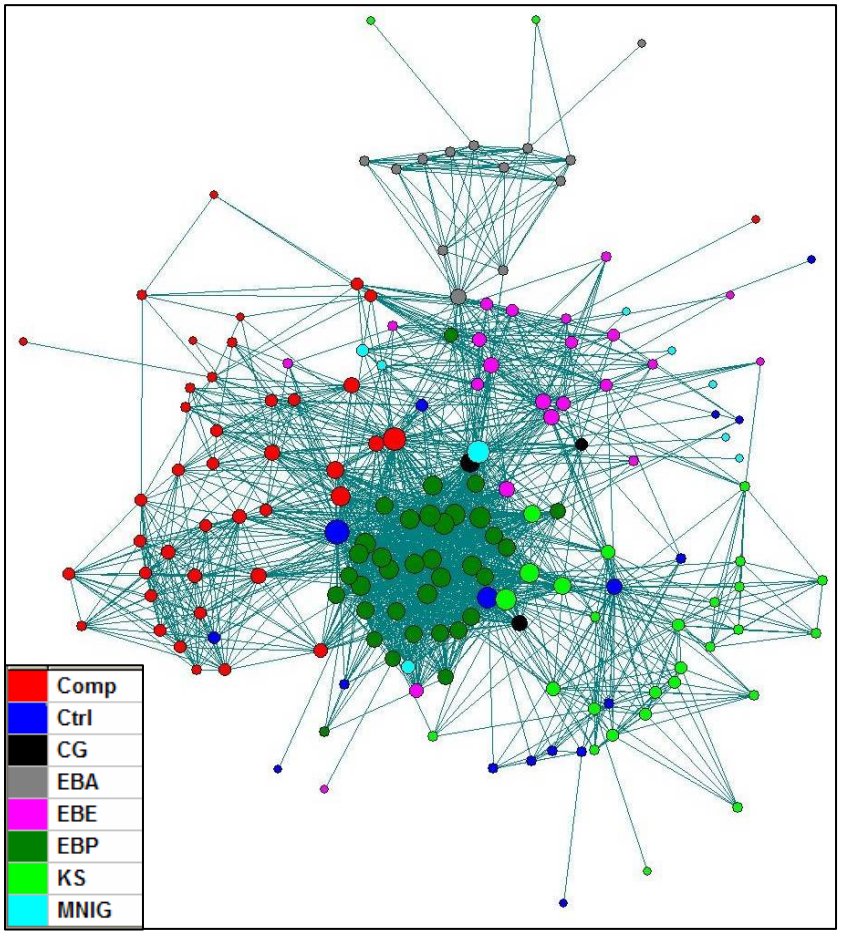
IWS Rooms: Eigenvector Centrality from actor-room logs



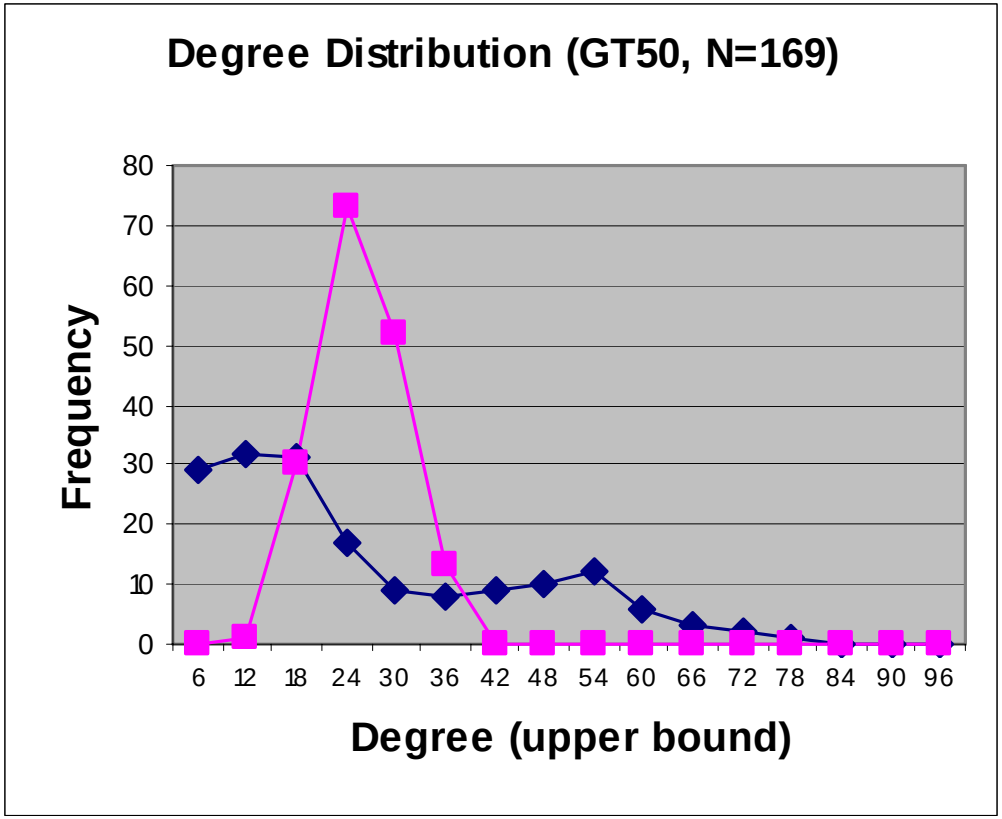
Analysis – Wk3 vs. Wk1- *preliminary*

- Increase in integration of groups
- Increase in evidence of x-func activity (e.g. Info Ops)
- Increase in centrality of components vs. EBE, EBA
- Continuing dominance of EBP staff as integrators
- Conclusions
  - organization was still evolving at endex
  - influence of a group not obviously related to stage of process
  - a flexible, complex system, but not (yet) *adaptive?*

Re. robustness: degree distribution

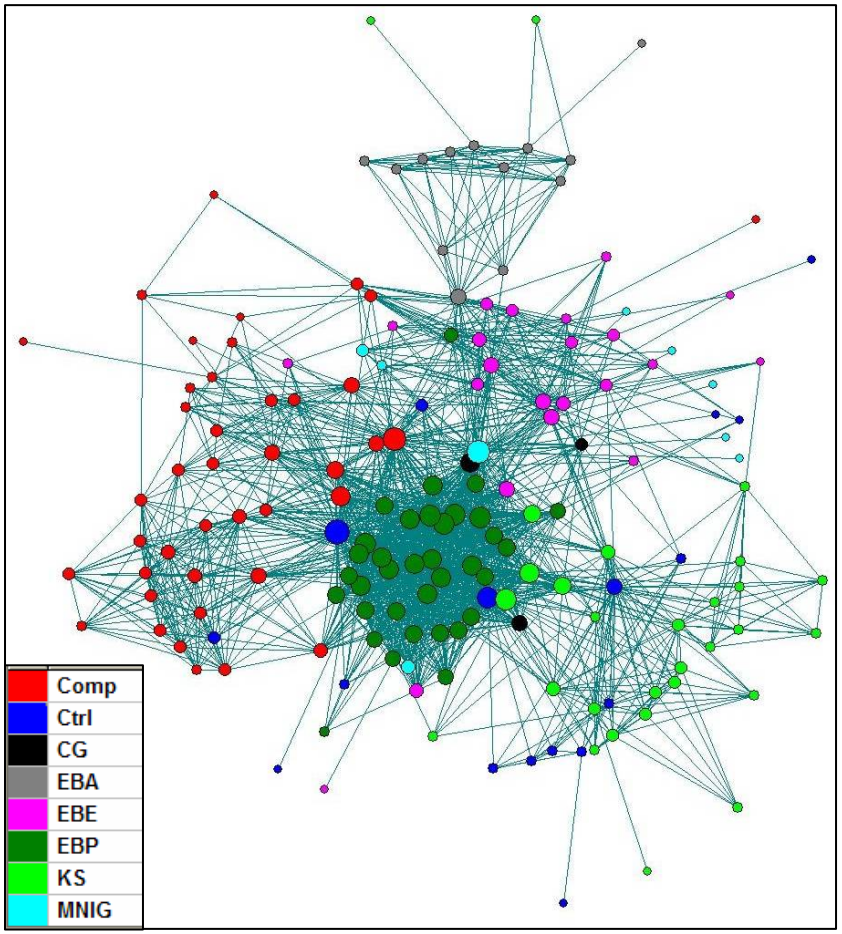


Collaboration tool logs (IWS/Wk3-GT50)



IWS (blue) vs. random network (pink): bimodal, suggests robustness to both targeted attack & random failure

Re. robustness: simulated attack



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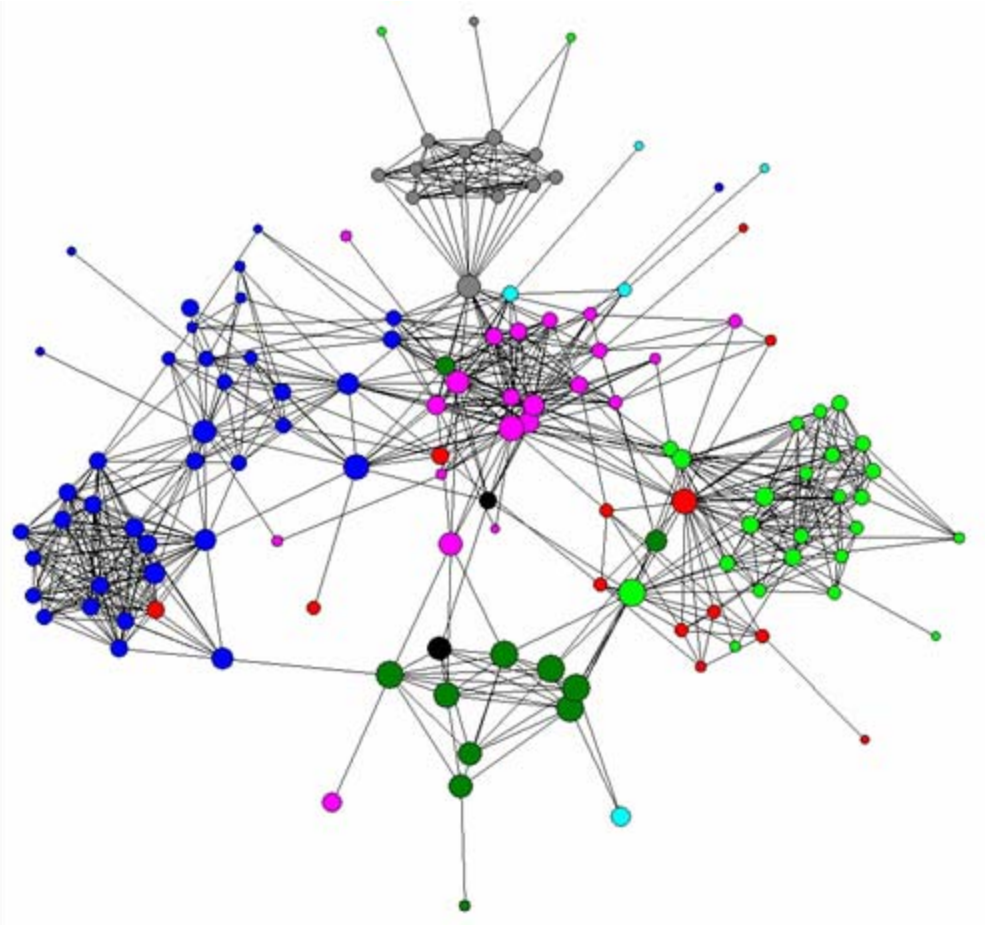


Removal of top 20% (degree) - small increase in diameter

Robustness results table

Components more integrated; EBA less so; MNIG distributed; EBP still central; caution…

	Nodes	**Density**	**Mean Degree**	**Cluster Co-eff.**	**CPL**	**ΔCPL**
	N	**d**	**K**	**C**	**L**	**ΔL**
Random network (matched N, d)	169	.137	23.0	.141	1.90	--
Wk3 IWS (GT50)	169	.137	23.1	.752	2.40	**--**
Wk3 IWS (GT50) **ATTACK**: -20% by degree (1 trial)	135	.083	10.7	.729	3.25	**+35.7%**
Wk3 IWS (GT50) **RANDOM FAILURE**: Means for GT50, 20% random failure, (10 trials)	--	.138	18.5	.750	2.43	+1.5%
Std deviation	--	.007	.94	.009	0.05	

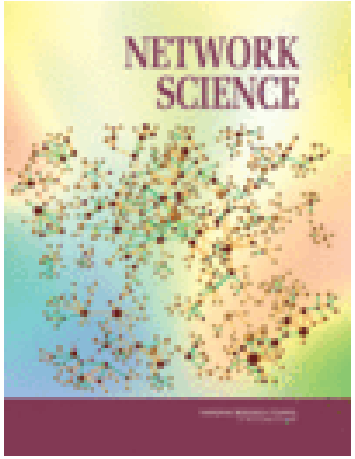
Robustness conclusions

- The CTF role structure at STARTEX did not show strict *structural robustness*
  - Insufficiently specified, tasks over- and under- resourced
- In the absence of a formally designed organisational structure, the structure re-organised to address this dissonance – partial success.
- In the face of EBA, HQ need to be designed for *adaptivity*, not just flexibility.
  - Need to design in the ability to self-organise and adapt to meet the requirements of predictable operations.
  - Need to control tendency for EB-HQs to be plans-heavy (cf. Storr)

Challenges & opportunities (personal view)

- Difficulties in inferring causality – groups/individuals
- Analysis & visualisation accounting for weighted data
- Fragility & over-use of some measures
- Multiplexity for incompleteness (email vs. chat)
- Multi-modal networks (people-groups-organizations)
- Danger of cognitive bias directing analysis mid-stream
- Moving from static to dynamic (predictive) models
- Landscape of network states (network corpus)
- Tools: academic, borderline usable
- *But see (e.g.) Monge & Contractor*

Challenges (US NAS, 2006)



- Dynamics, spatial location, and information propagation in networks.
- Modelling and analysis of very large networks.
- Design and synthesis of networks.
- Increasing the level of rigour and mathematical structure.
- Abstracting common concepts across fields.
- Better experiments and measurements of network structure.
- Robustness and security of networks.

» *Board on Army Science & Technology, US National Academy of Sciences*
http://del.icio.us/chronos/SNA%2Bbook

So what?

- The Components facilitated cross-functional interaction within the IWS network.
- However, as the role of the Components was to stimulate the CTF under experimental conditions, not facilitate information flow, this has implications for the ability to achieve the required level of cross-functional integrations required to support an Effects Based Approach.

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