Dynamic Network Analysis: Management and Intervention

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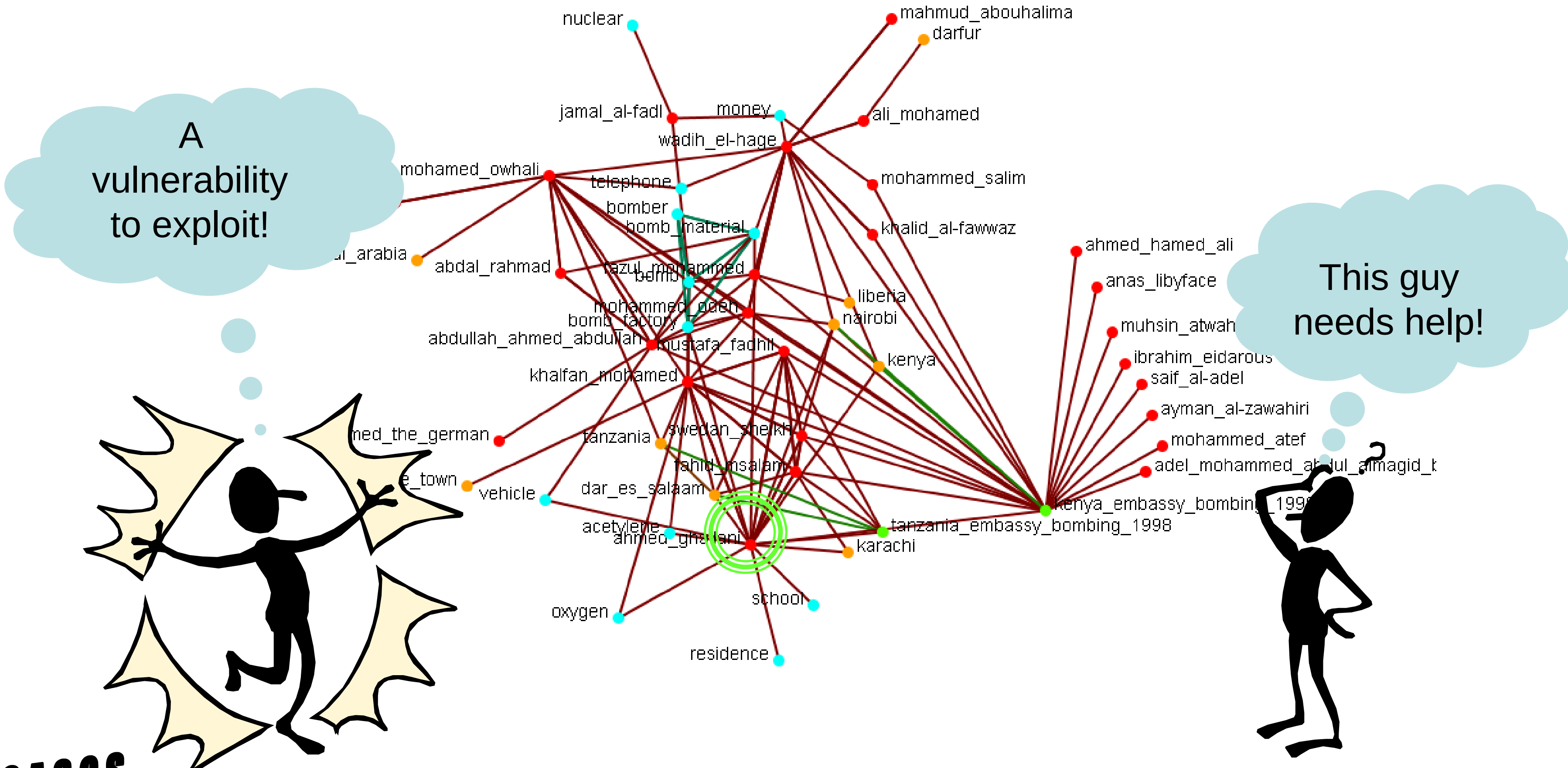
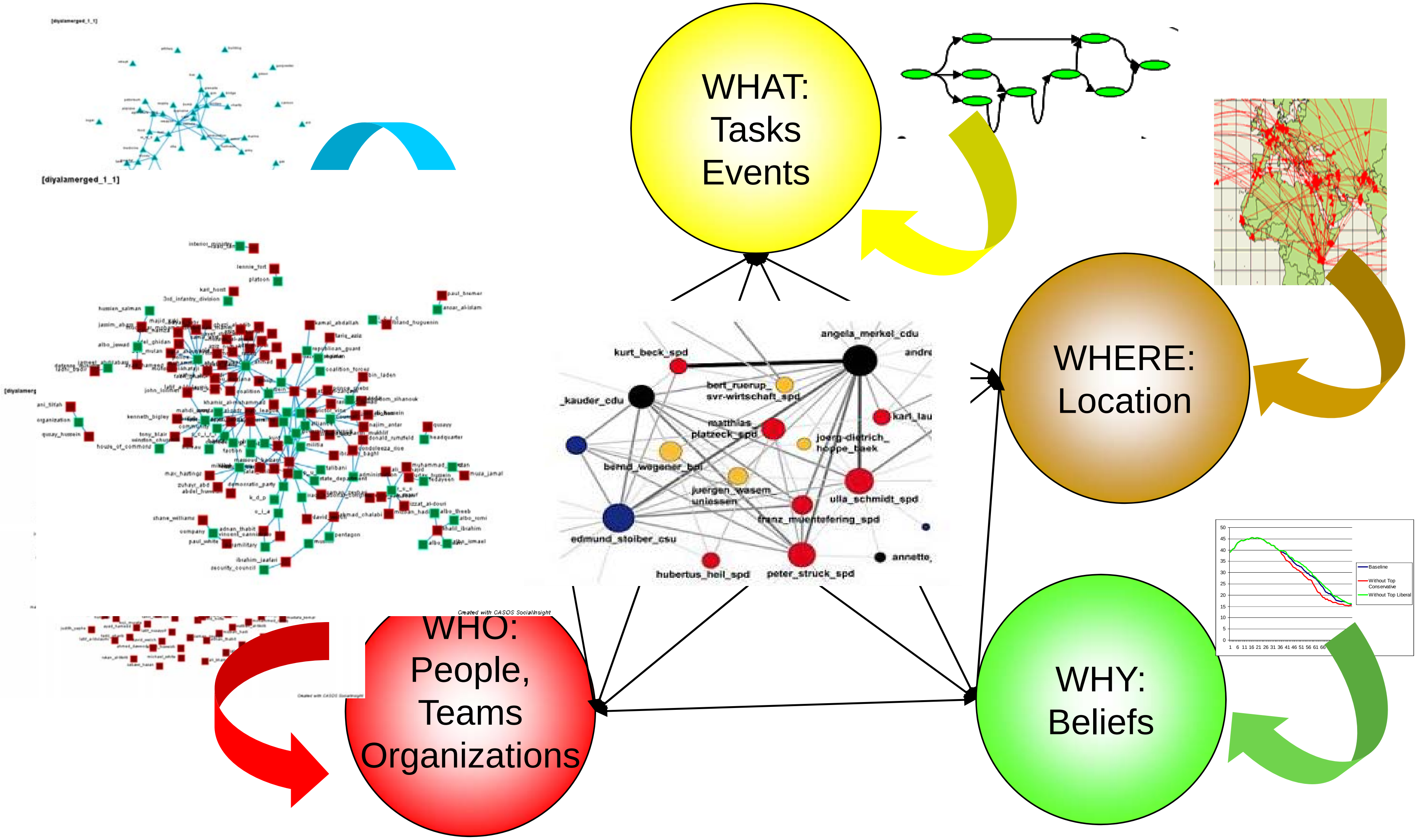
Network Analysis Enables Management and Disruption



PCANS

	People	Resources	Tasks
People Relation	**Social Network** ***Who knows who***	**Skills Network** ***Who knows what***	**Assignment Network** ***Who does what***
Resources Relation			**Commitment Network** ***What resource is needed for what tasks***
Tasks Relation			**Precedence Network** ***Which tasks must be done before which***

Network to Meta-Networks



Interconnection Among Networks

- To understand groups/organization need a meta-network perspective
  - Social network is NOT ENOUGH
  - Need to move beyond single mode networks
- Connections among networks drive/determine
  - Adaptivity / evolution of single mode networks
  - Enable prediction of missing data
  - Provide basis for process analysis

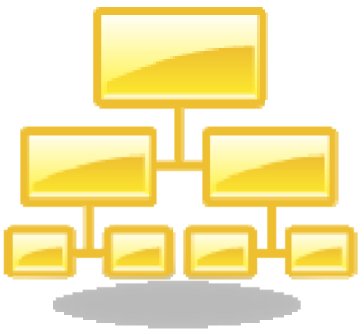
Connectivity Logics and Concerns

- Homophily based interaction
- Expertise based interaction
- Co-work based interaction
- Congruence
  - The need for match
- Task analytics
  - Resource needs
  - Knowledge needs
  - Personnel needs

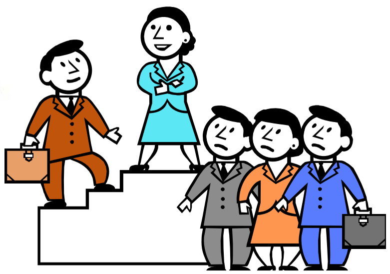
The Power of Meta-Networks Illustrative Examples

1. Organizational Performance
   – Public Health
2. Identification and Disruption of Groups
   – Gangs and border control
3. Identification of Key Actors
   – Missing Information and key terrorists
4. Geo-Spatial Networks
   – Drug interdiction
   – Hidden Ports

1: Organizational Performance

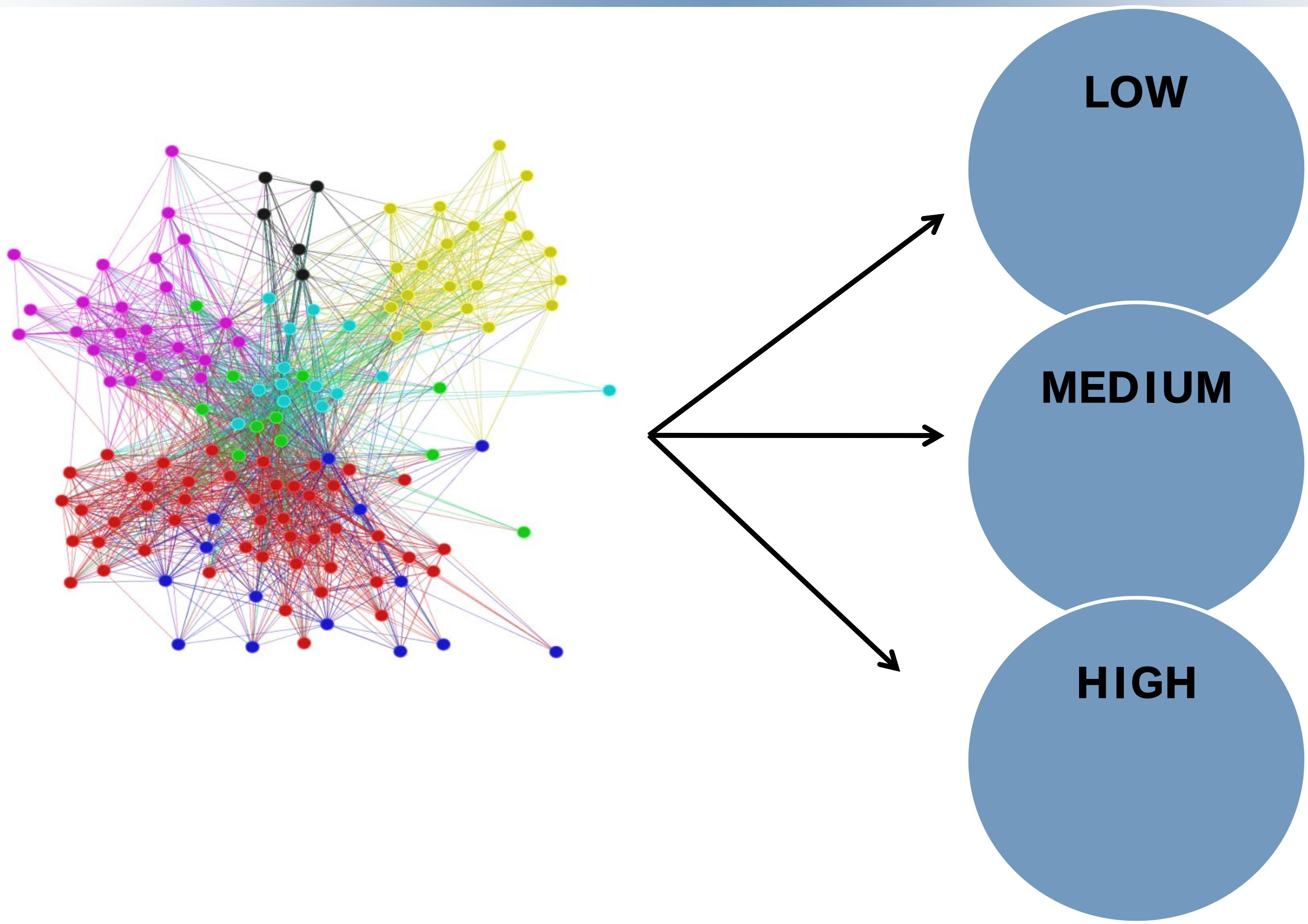


Formal Network

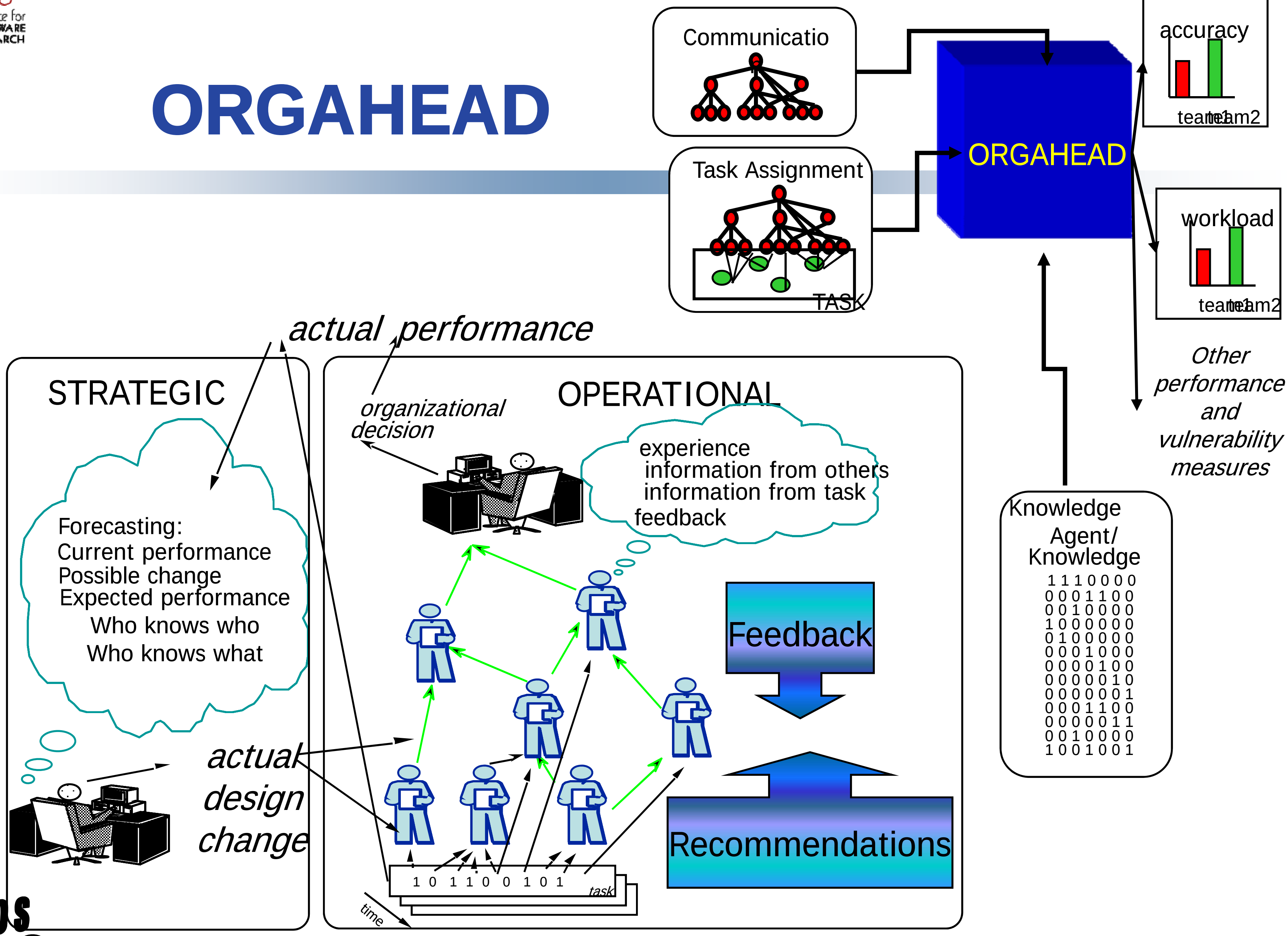


Informal Network

Impact of Social Structure on Performance



ORGAHEAD



Communicatio
Task Assignment
TASK
ORGAHEAD
accuracy
team1 team2
workload
team1 team2
Other performance and vulnerability measures
actual performance
STRATEGIC
Forecasting:
Current performance
Possible change
Expected performance
Who knows who
Who knows what
actual design change
OPERATIONAL
organizational decision
experience
information from others
information from task
feedback
Feedback
Recommendations
1 0 1 1 0 0 1 0 1
task
time
Knowledge Agent/ Knowledge
1 1 1 0 0 0 0
0 0 0 1 1 0 0
0 0 1 0 0 0 0
1 0 0 0 0 0 0
0 1 0 0 0 0 0
0 0 0 1 0 0 0
0 0 0 0 1 0 0
0 0 0 0 0 1 0
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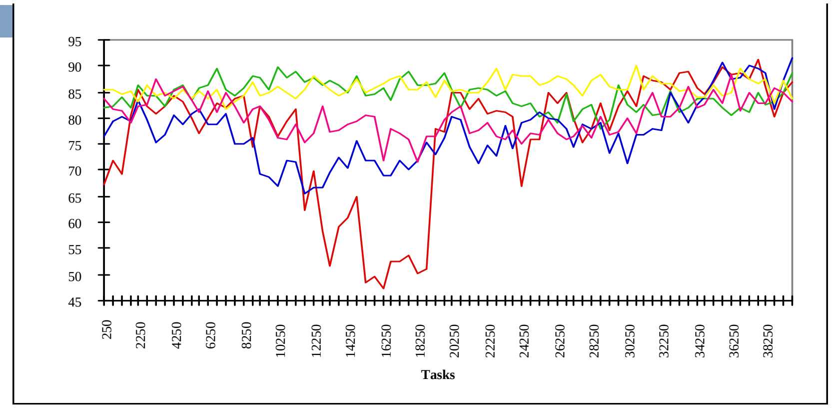
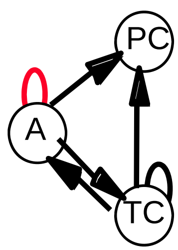
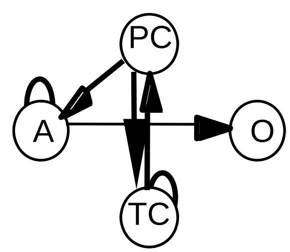
0 0 0 0 0 1 1
0 0 1 0 0 0 0
1 0 0 1 0 0 1

Learning Clashes and Patterns of Change



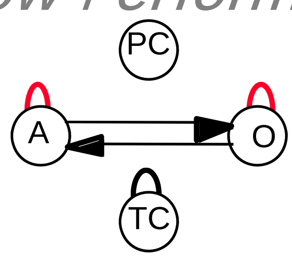
High Performance Organizations



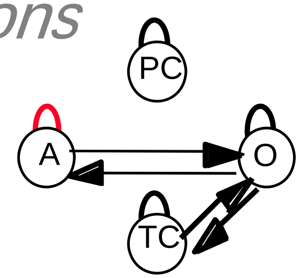


A= augment
O = transfer out
PC = redesign
TC = retask

Low Performance Organizations



CHANGE



With different technologies these patterns and sets of actions change

Time

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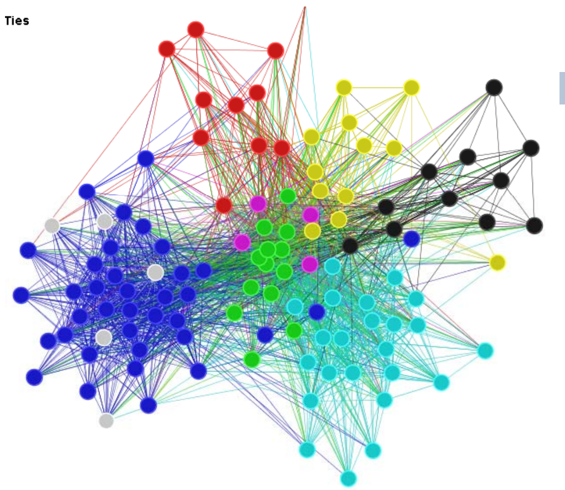
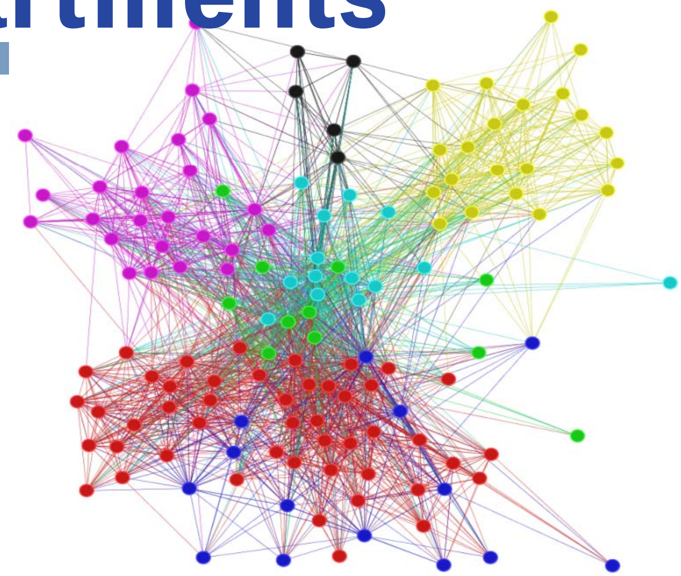
Four Illustrative Health Departments



Champaign

Density .24

115 nodes

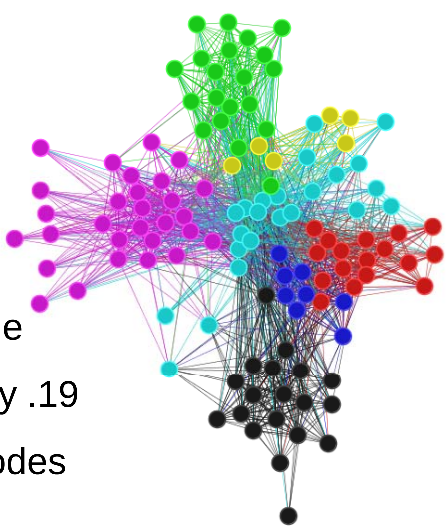


Coconino

Density .16

136 nodes

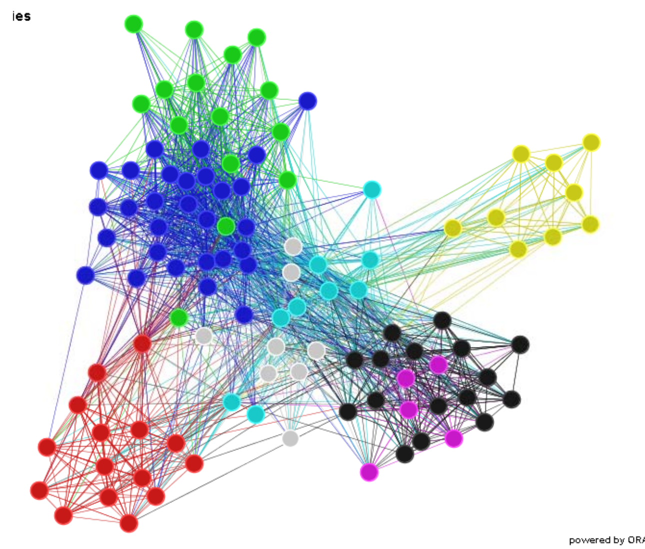
BroomeCountyAllTies



Broome

Density .19

122 nodes



Missoula

Density .21

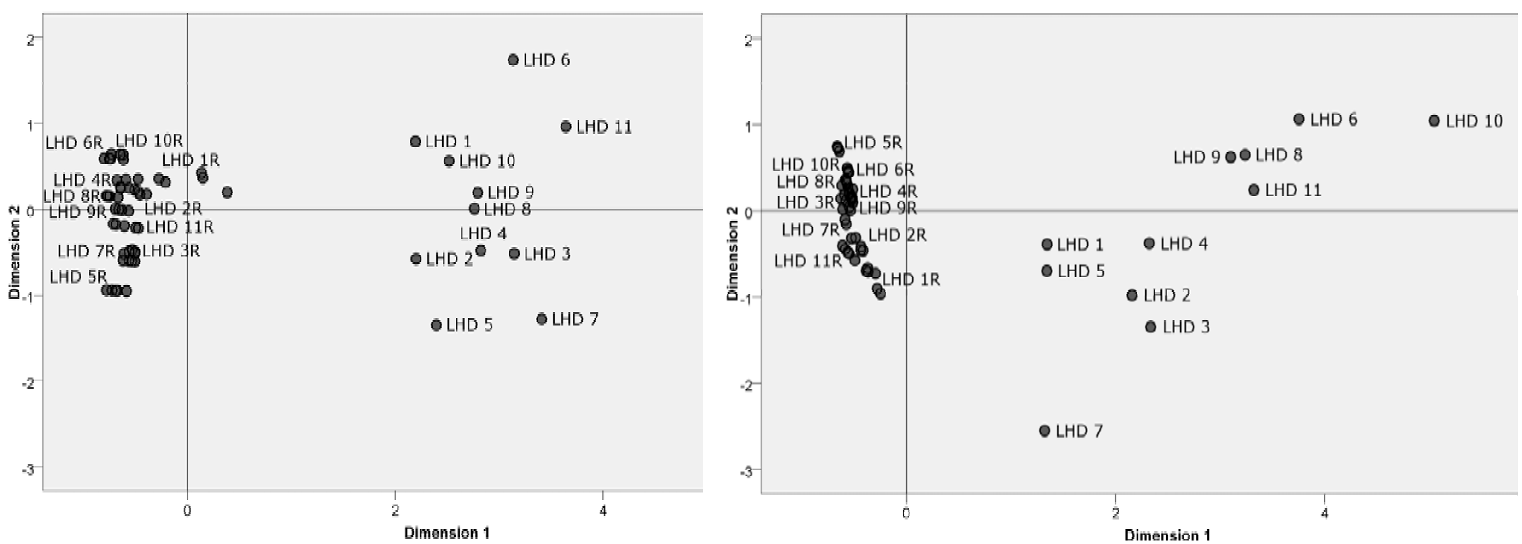
106 nodes

Health Department Structures

Centralization

a. All ties networks

b. Strongest ties networks



† Centralization, complexity, percent silos, plus task, knowledge, and resource redundancy. Density was excluded because it was used to generate random network sets

Redundancy

Public Health: Common Structure is NOT about the Social Network

Diversity in authority and communication

- Centralization
  - CV 50.20
  - Mean .25
- Silos
  - CV 49.00
  - Mean .01
- Average Betweenness
  - CV 41.02
  - Mean .01

Similarity in coordination and grouping

- Clustering Coefficient
  - CV 15.23
  - Mean .53
- Task Assignment Redundancy
  - CV 11.58
  - Mean .30
- Resource Availability Redundancy
  - CV 13.71
  - Mean .42

Impact of Silos

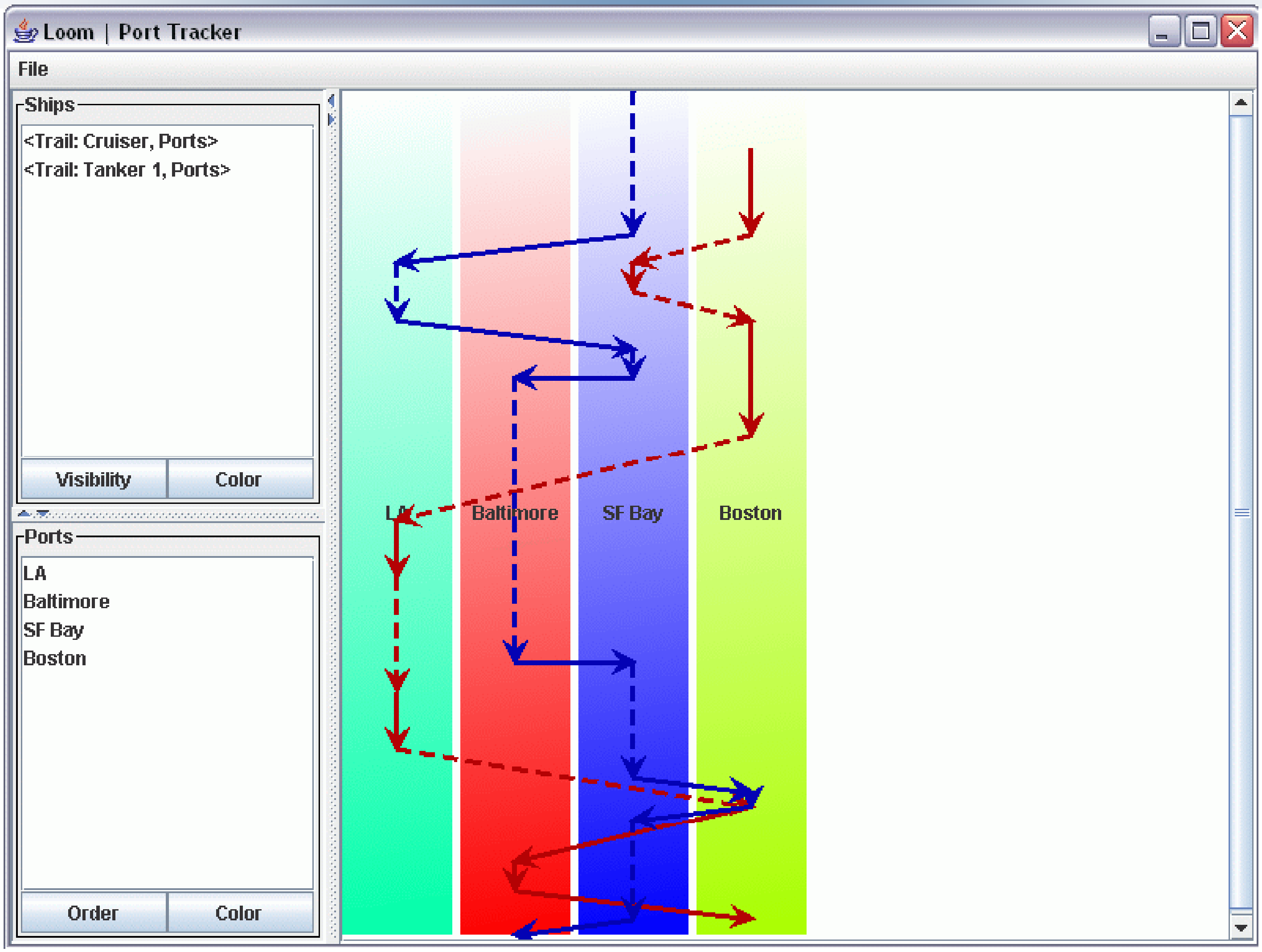
- Local efficiency
- Minimized training
- But ...

- What happens when people retire????
  - Level of silos increases
  - Lack of redundancy means real loss of skills!

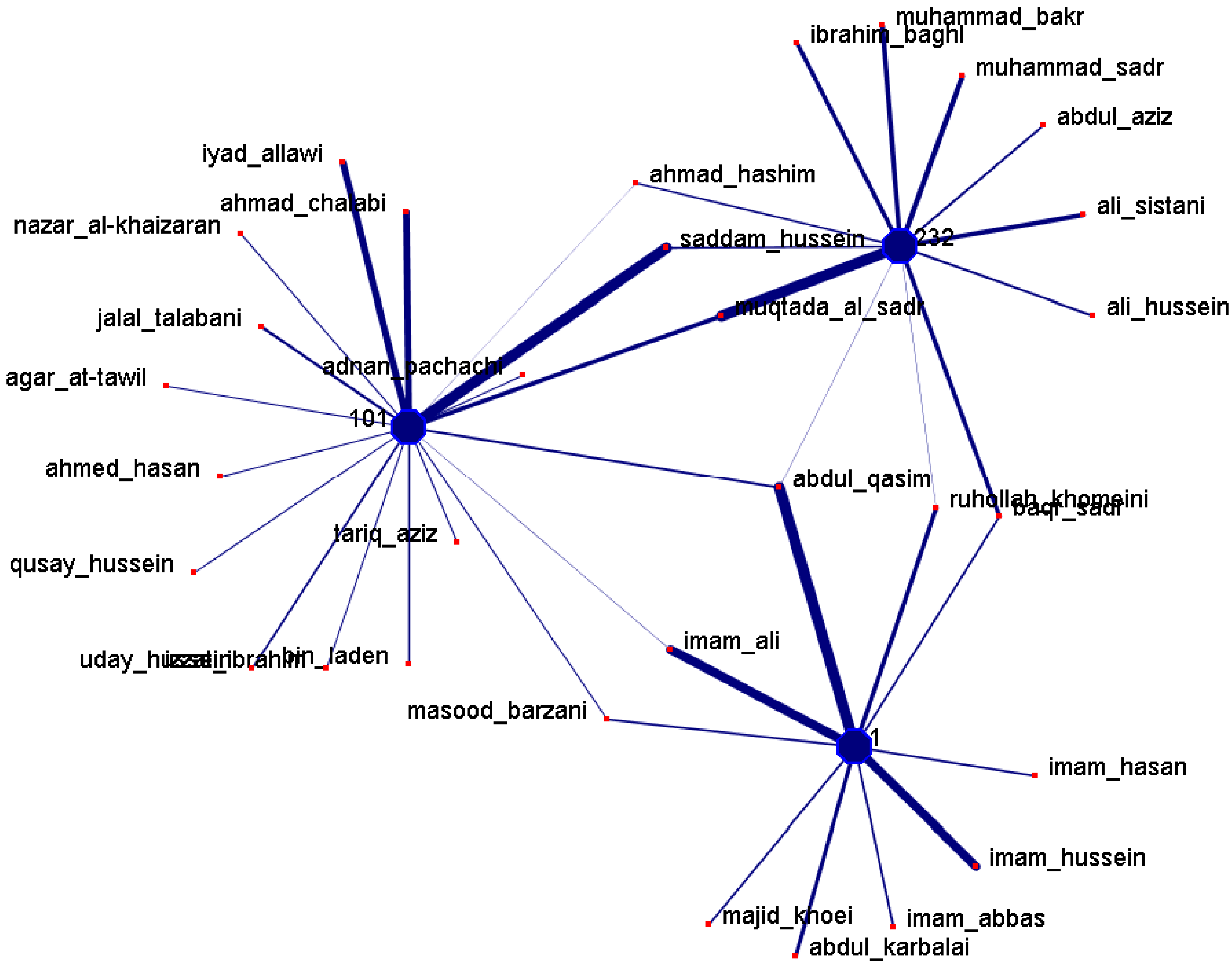
- Informing health departments led to restructuring!

2: Identification and Disruption of Groups

Trails: How are Things Moving?



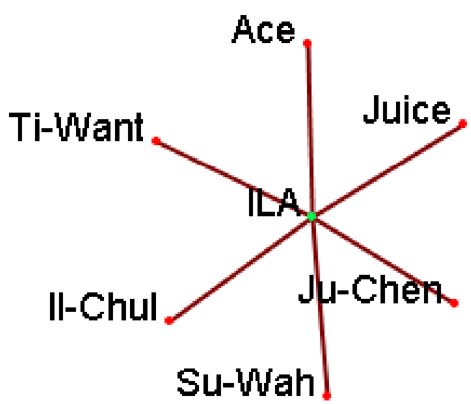
FOG: Fuzzy Groups on Central Core

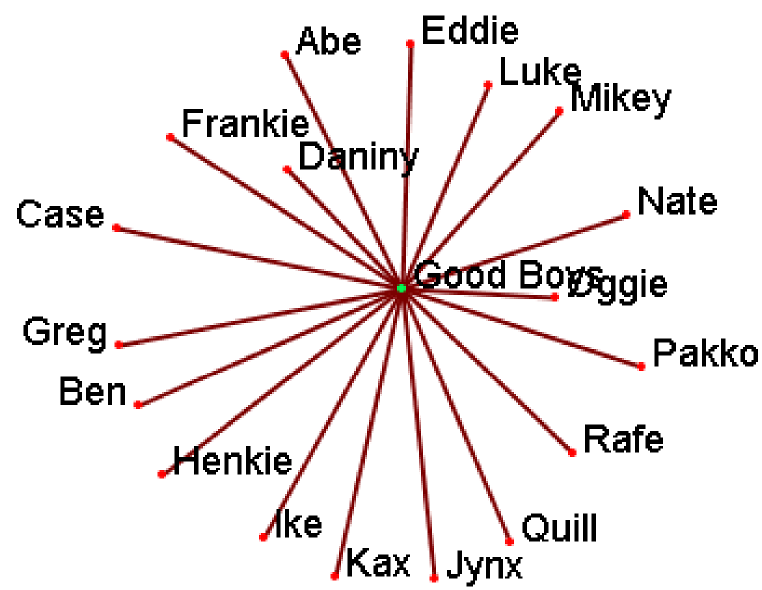


Example 2

A Tale of Two Gangs

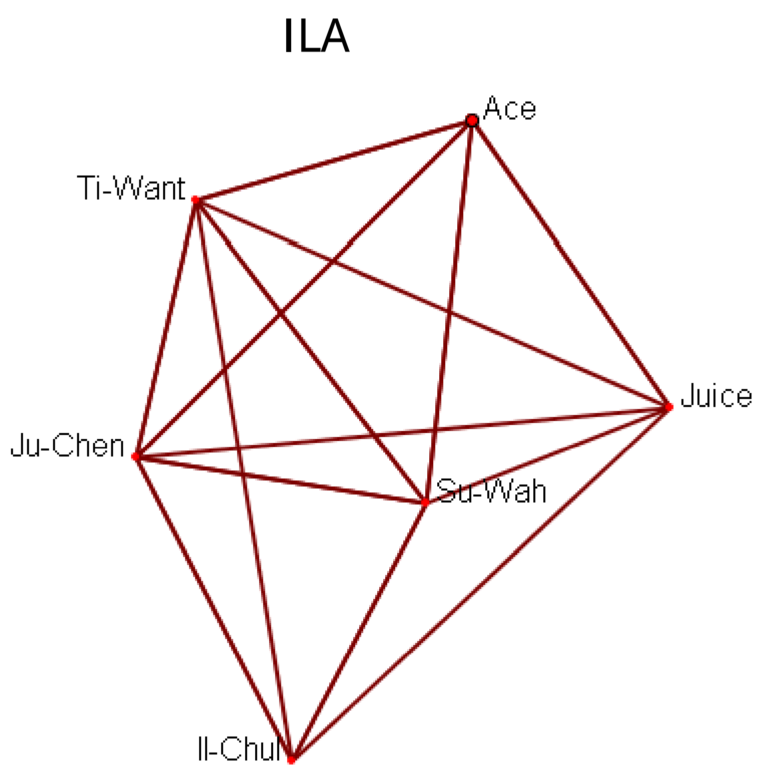
Two Gangs

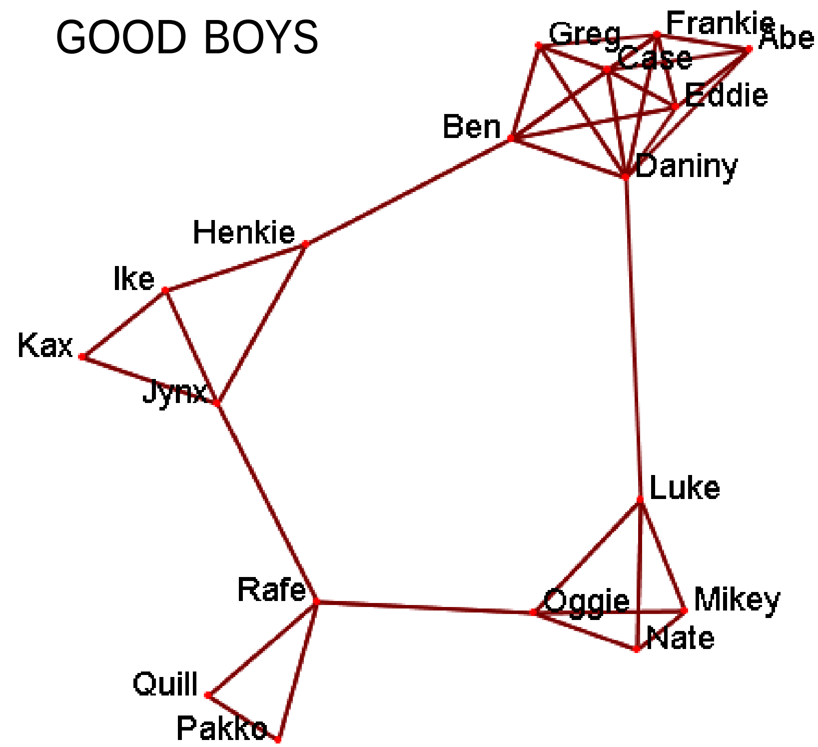




Notice – there are two gangs with very different members

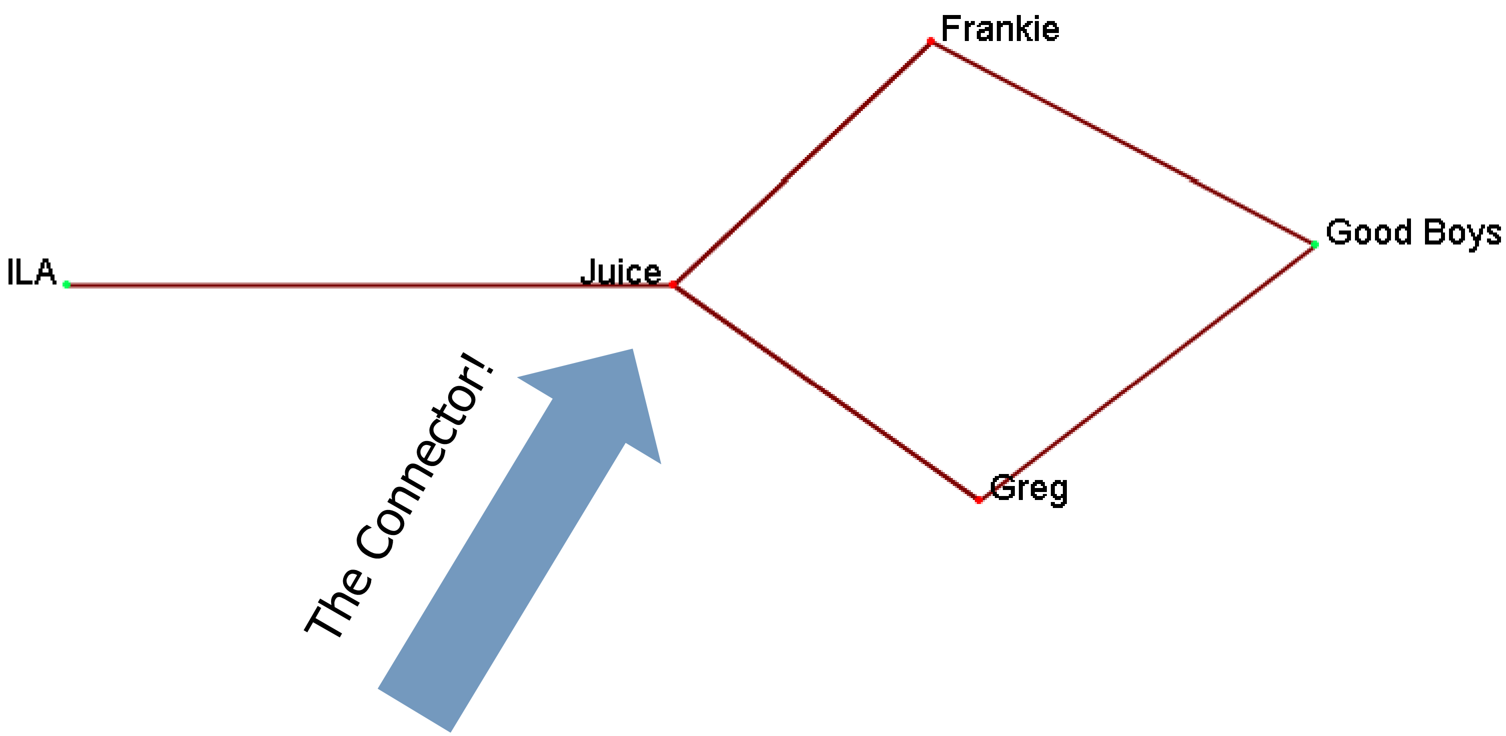
Internal Structure



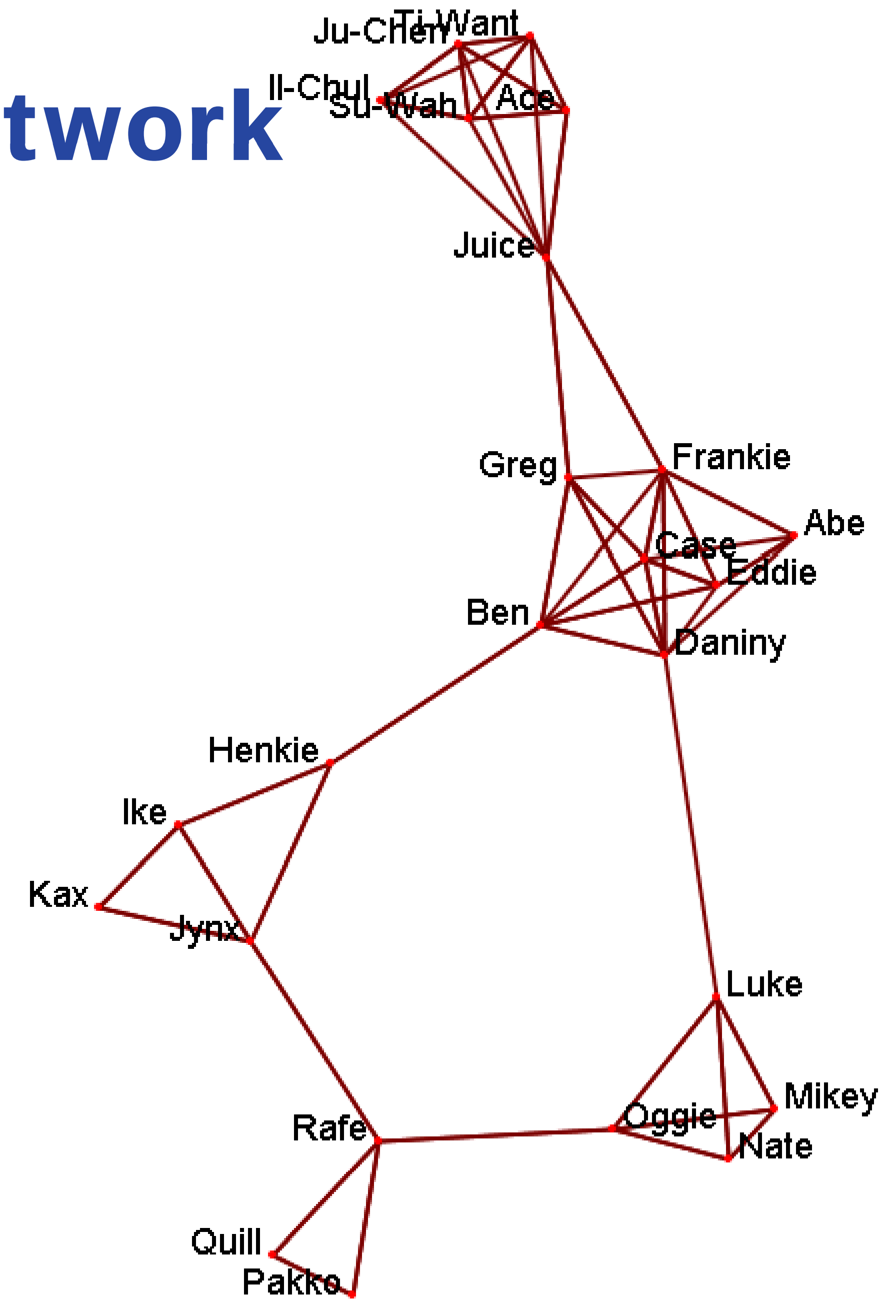


Notice – the two gangs have different structures
Derived from case files and co-presence

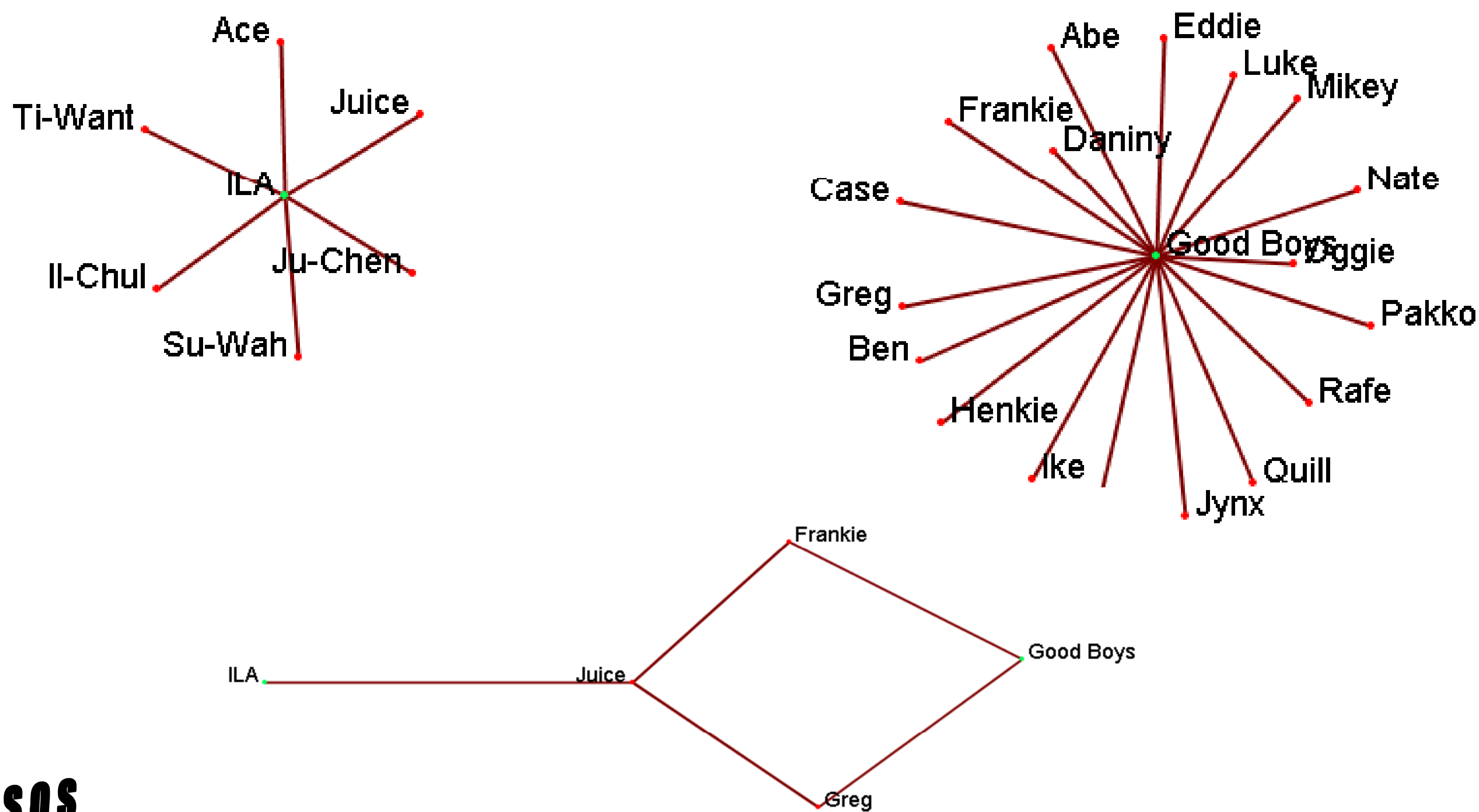
Are the gangs connected? Yes!



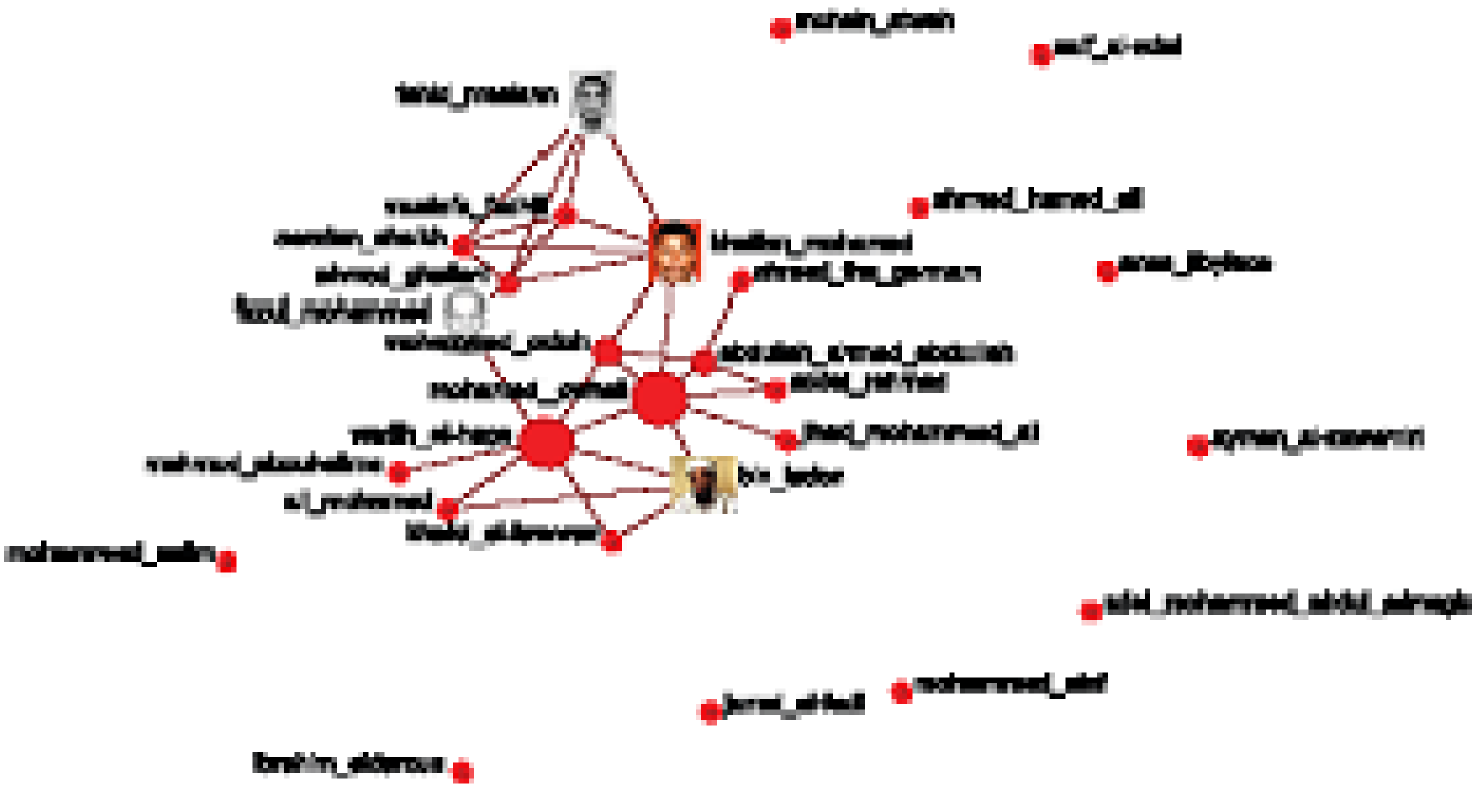
Overall Gang Network



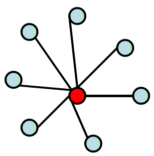
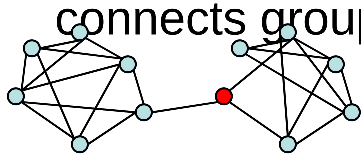
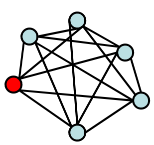
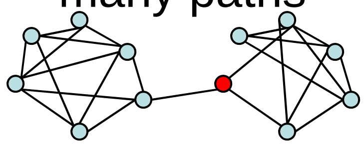
From Gang Membership to Key Bridge



3: Identification of Key Actors



Meta-Network KEY ACTORS

Degree Centrality in the know 	High Betweenness and not Degree connects groups 
Eigenvector central core 	Betweenness many paths 

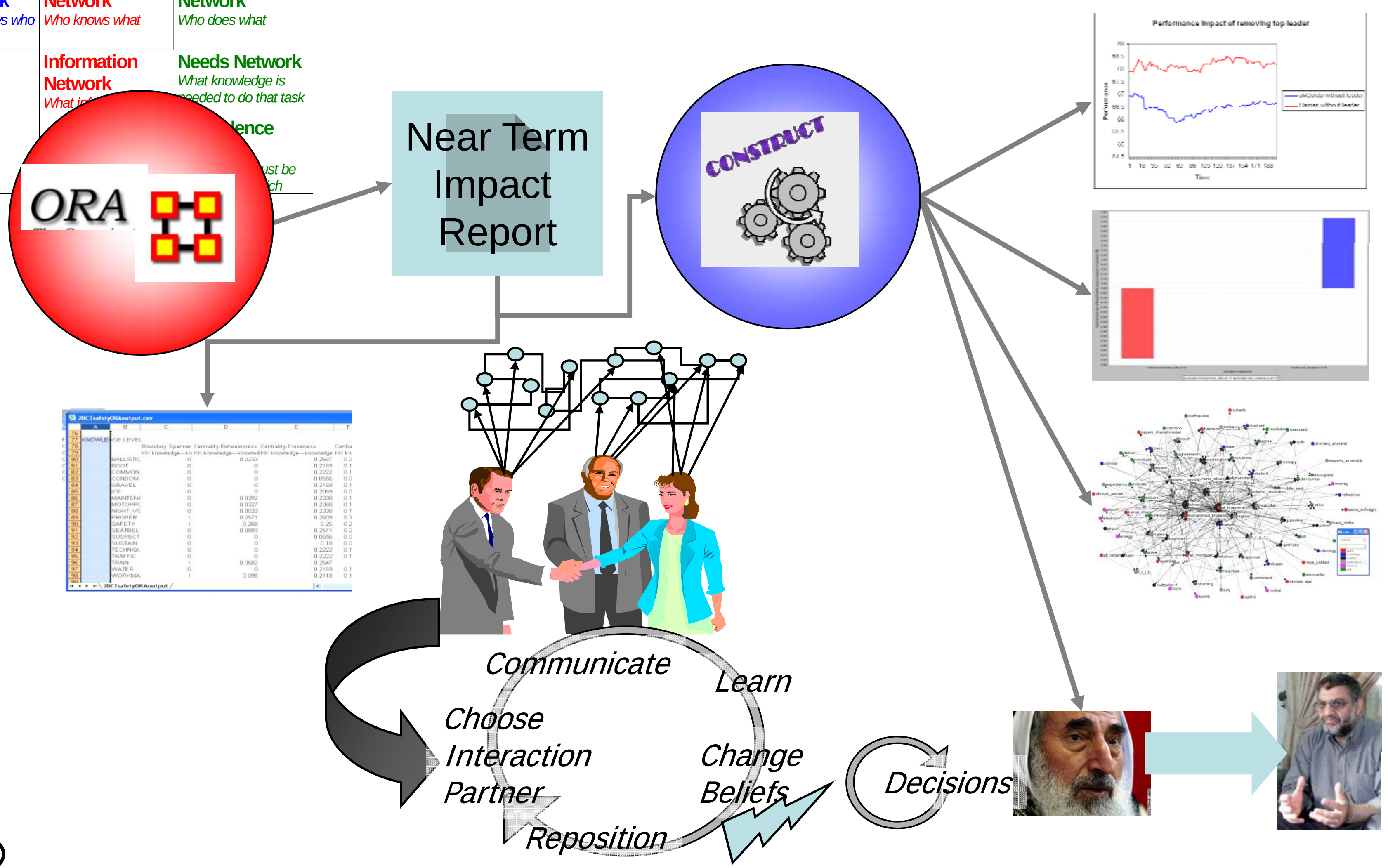
Immediate Impact - Prediction

- *What if ? Remove top 5 emergent leaders*
- Change in performance
  – Anticipated drop – 4% percentage difference
- Change in information diffusion
  – Anticipated increase – 67% percentage difference
- New emergent leaders
  1. 0.0174   said_mortazavi
  2. 0.0137   kamal_kharazi
  3. 0.0127   reza_asefi
  4. 0.0120   morteza_sarmadi
  5. 0.0100   hashemi_shahroudi
- Value of "lowest" old emergent leader was .0246

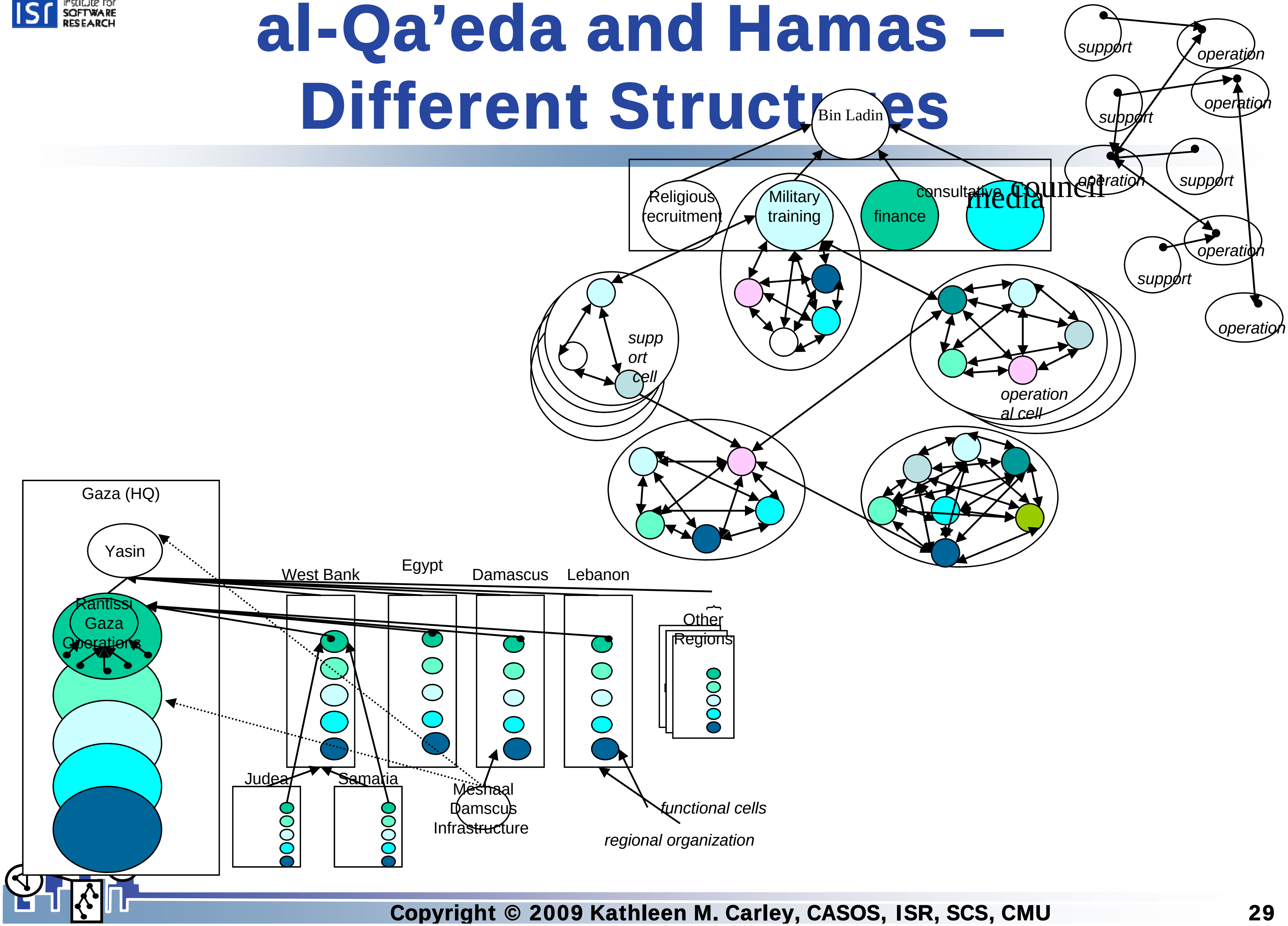
Immediate Impact

Forecast - from Patterns to Prediction

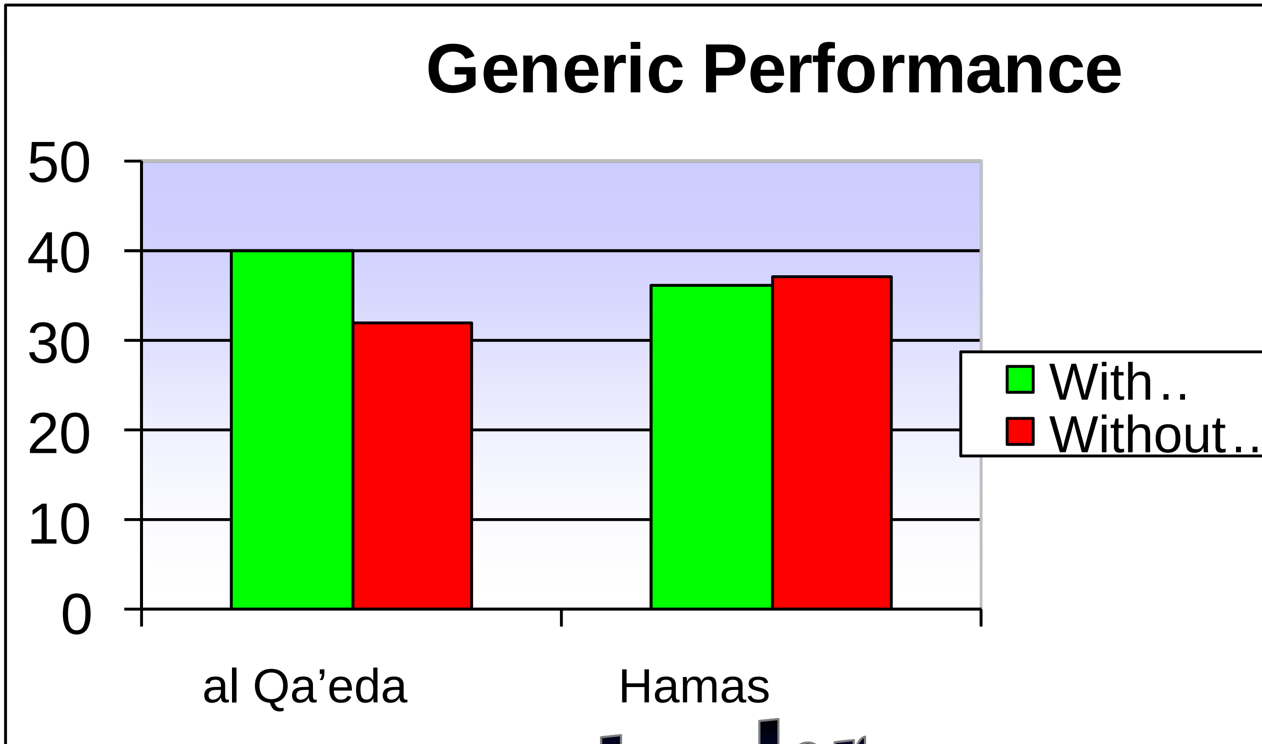
	People	Knowledge	Tasks
People Relation	**Social Network** *Who knows who*	**Knowledge Network** *Who knows what*	**Assignment Network** *Who does what*
Knowledge Relation		**Information Network** *What inf*	**Needs Network** *What knowledge is eeded to do that task*
Tasks Relation			**ence** *ust be ch*



al-Qa'eda and Hamas – Different Structures



What If Analysis



Bin Laden

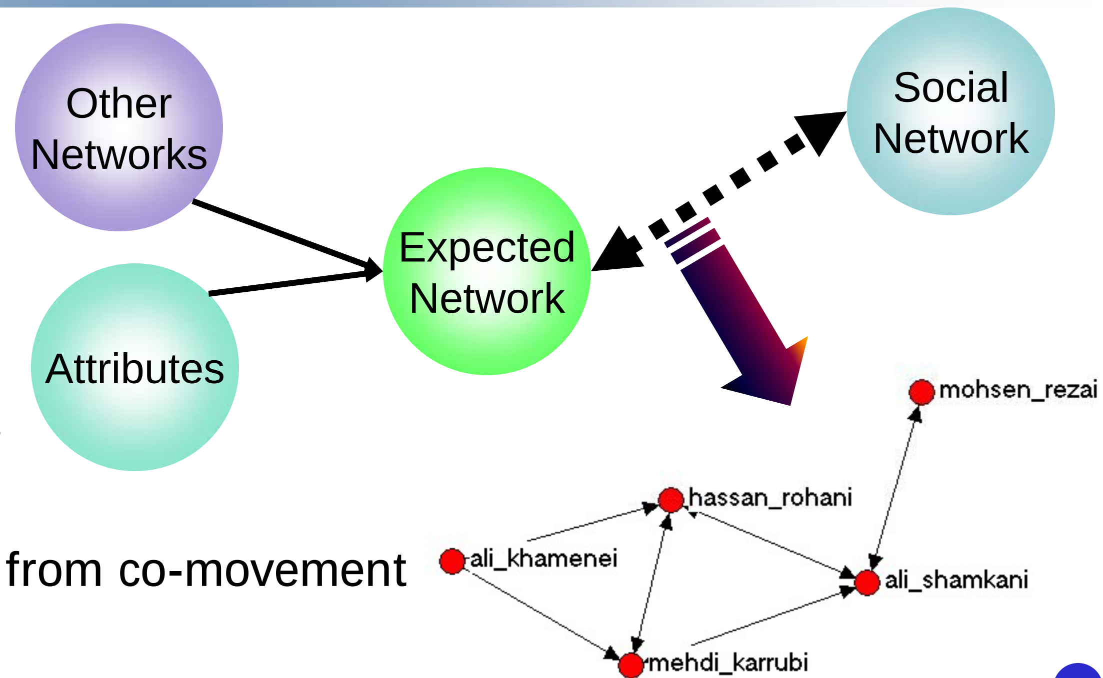
al-Zawahiri

Yassin

New Emergent Leader

Estimating possible missing data or errors E.g., Who Should be Interacting?

- Interaction Logics –
  - Similarity
  - Expertise
  - Shared experience/local
- Social Logics
  - Inheritance of social beliefs
- Spatio-Temporal
  - Estimate potential network from co-movement and co-presence
- Static –
  - Estimate potential network from attributes and other networks
- Dynamic –
  - Simulate network evolution – learning and communication logics



Meta-Network data or attributes can be used to predict possible missing data

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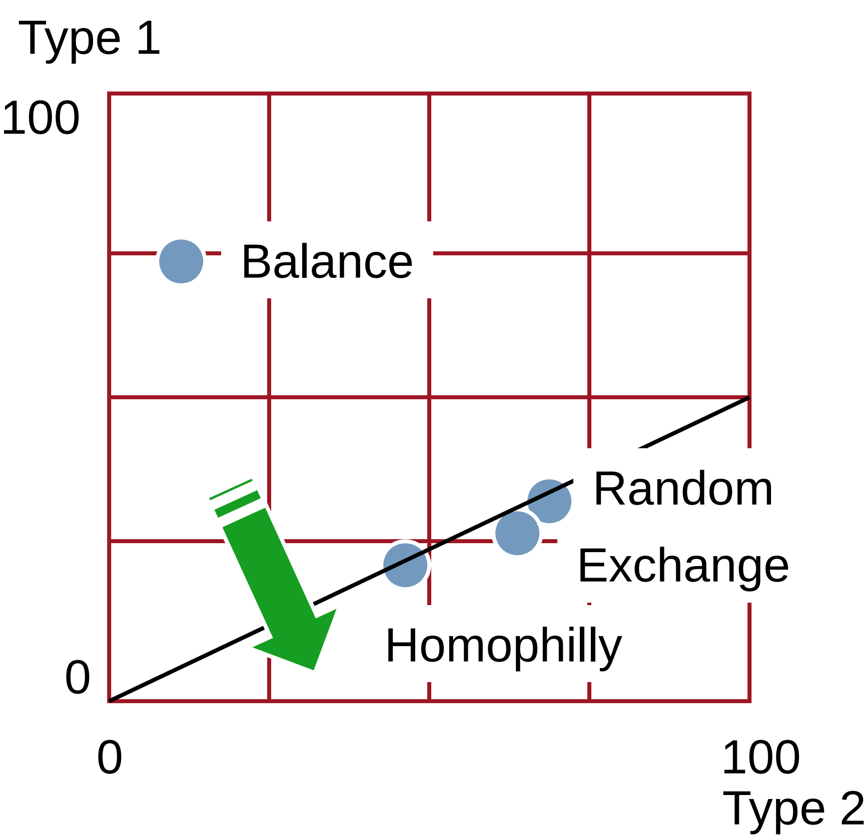
Edge inference based on meta-network theories works best!

- Type 1:
- Predicted no edge but there is an edge
- Type 2:
- Predicted an edge but there is no edge



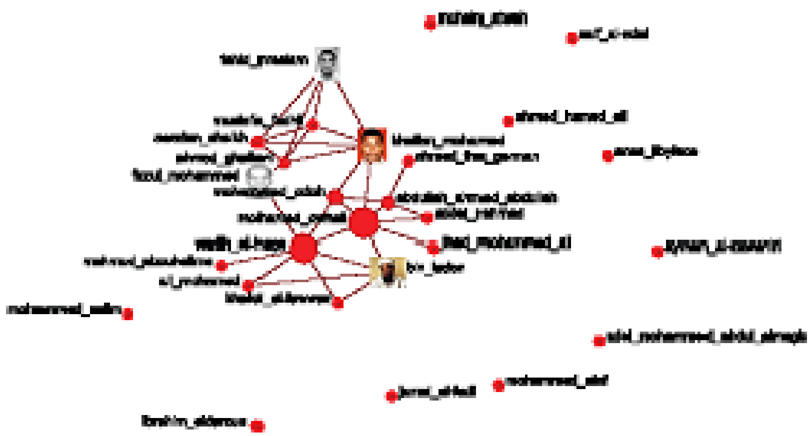
But – no theory is great – Type 2 twice as likely as type 1

CASOS

Integration

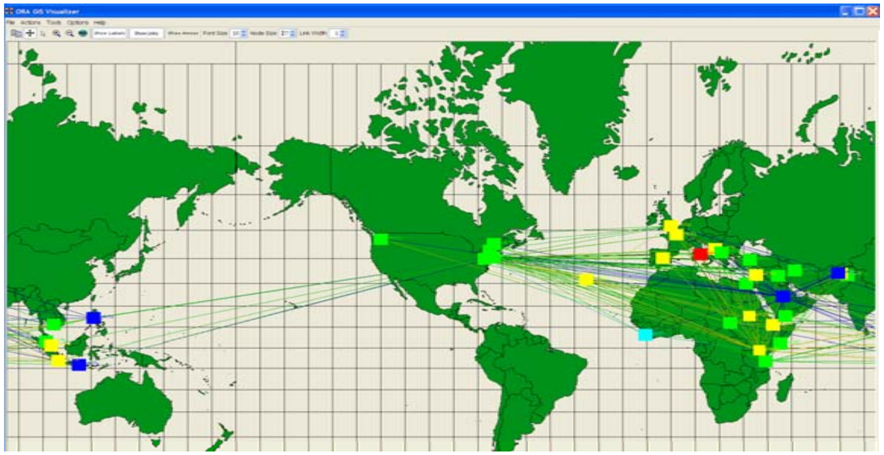
- Each of the logics generates an indication of whether there is a missing link
- These need to be combined
- Next step is creating a Bayesian update system for combining alternative inferences
  - Challenge – culturally sensitive
  - Challenge – node/edge type sensitive

Impact of Inference - Illustration



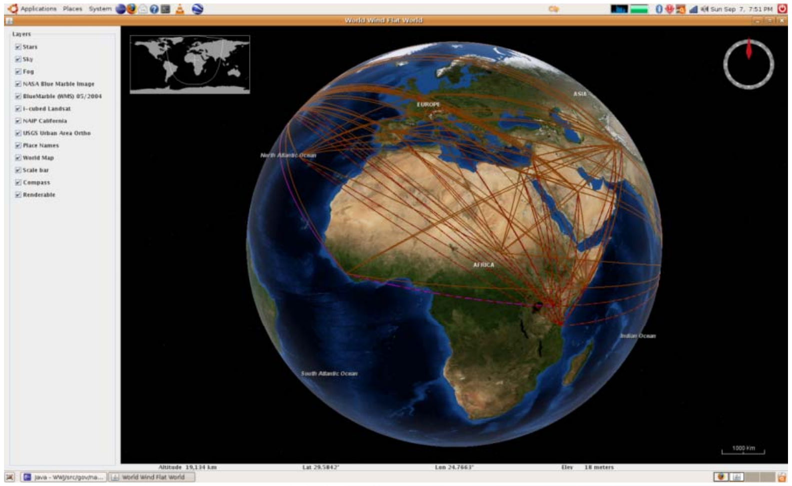
Metric	Base Data	With Inferred Edges
Probable Leader	Bin Laden	Bin Laden (stronger)
Leader of Sub-group	Khalfan Mohamed	Wadih el-Hage
Links disconnected groups	Mohamed Owahali	Abdullah Ahmed Abdullah
Density	.07	.37
Fragmentation	.61	0
Generic Performance	.23	.32

4: Geo-Spatial Networks



ArcGIS

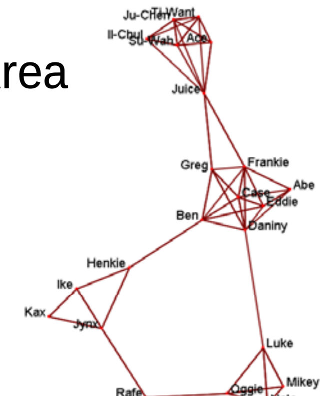
Google Earth

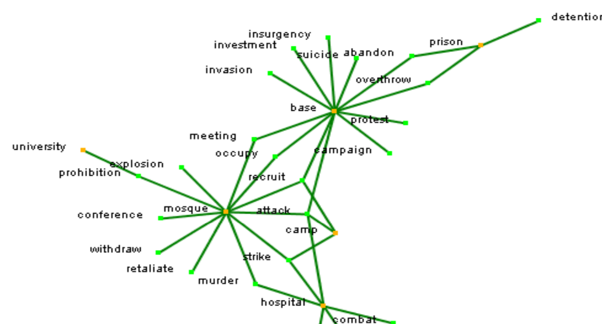


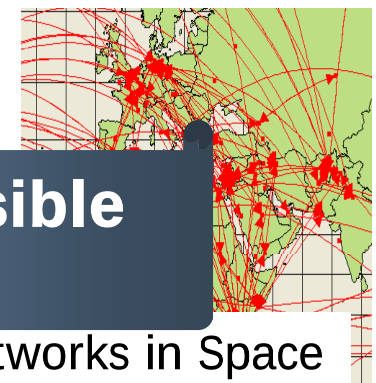
NASA WWJ

Geo-Enabled Network Analysis

Networks In an Area





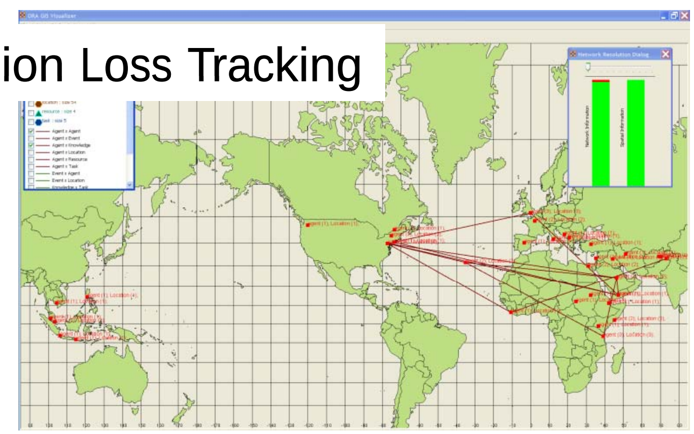


Layering Networks on Maps is Possible
Geo-constraints on Networks

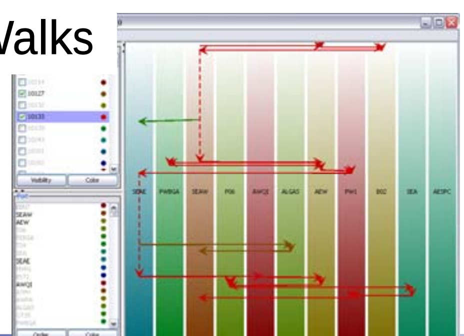
ORA
The Organizational Risk Analyzer

Visualizing Networks in Space

Information Loss Tracking

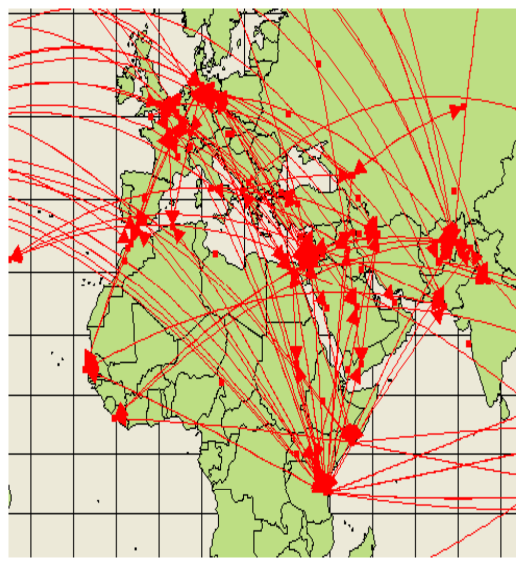


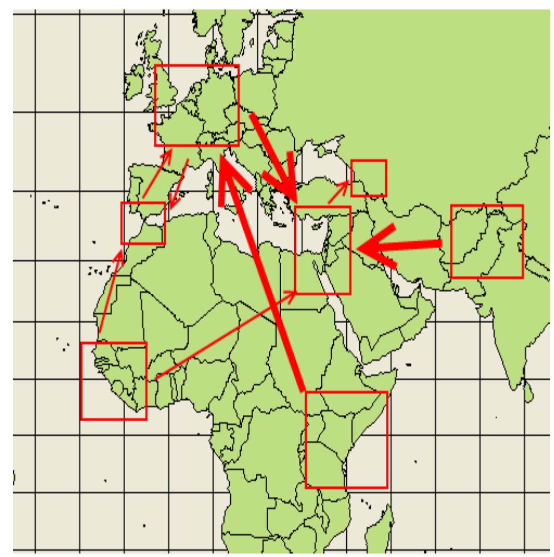
Walks



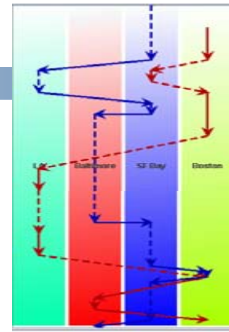
Implementing Geo-Spatial Network Resolution

- Want to combine nearby Locations into useful Places
- Density-Based Clustering (DBSCAN)
  – Single parameter: desired density
  – Computationally efficient
  – Deals well with outliers

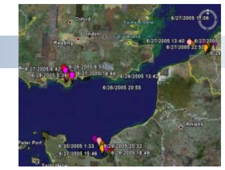


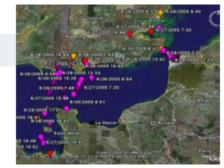


Merchant Marine Vessels

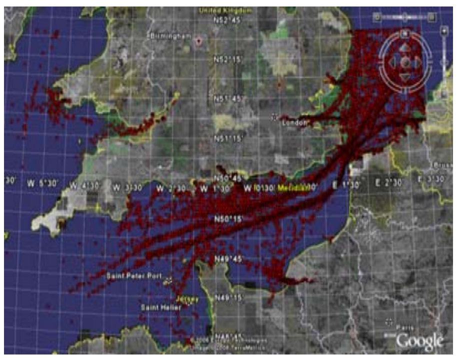


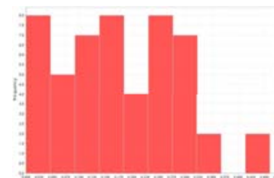
Trail Format
What Ship is Where When



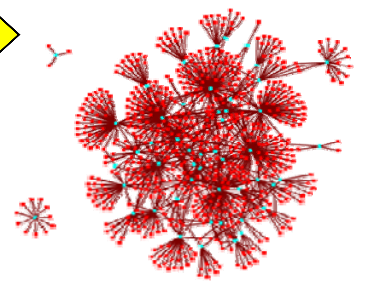


Behavioral Clustering
e.g. – Offshore Meetings



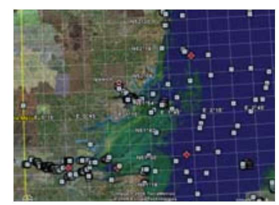


Spatial/Temporal Data
e.g. AIS, Boarding Reports



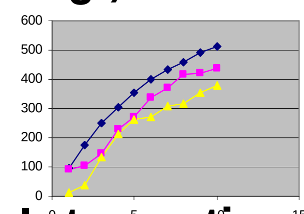
Relational Format
Co-work, Owner-Links

Network Analysis
e.g., Critical Actors



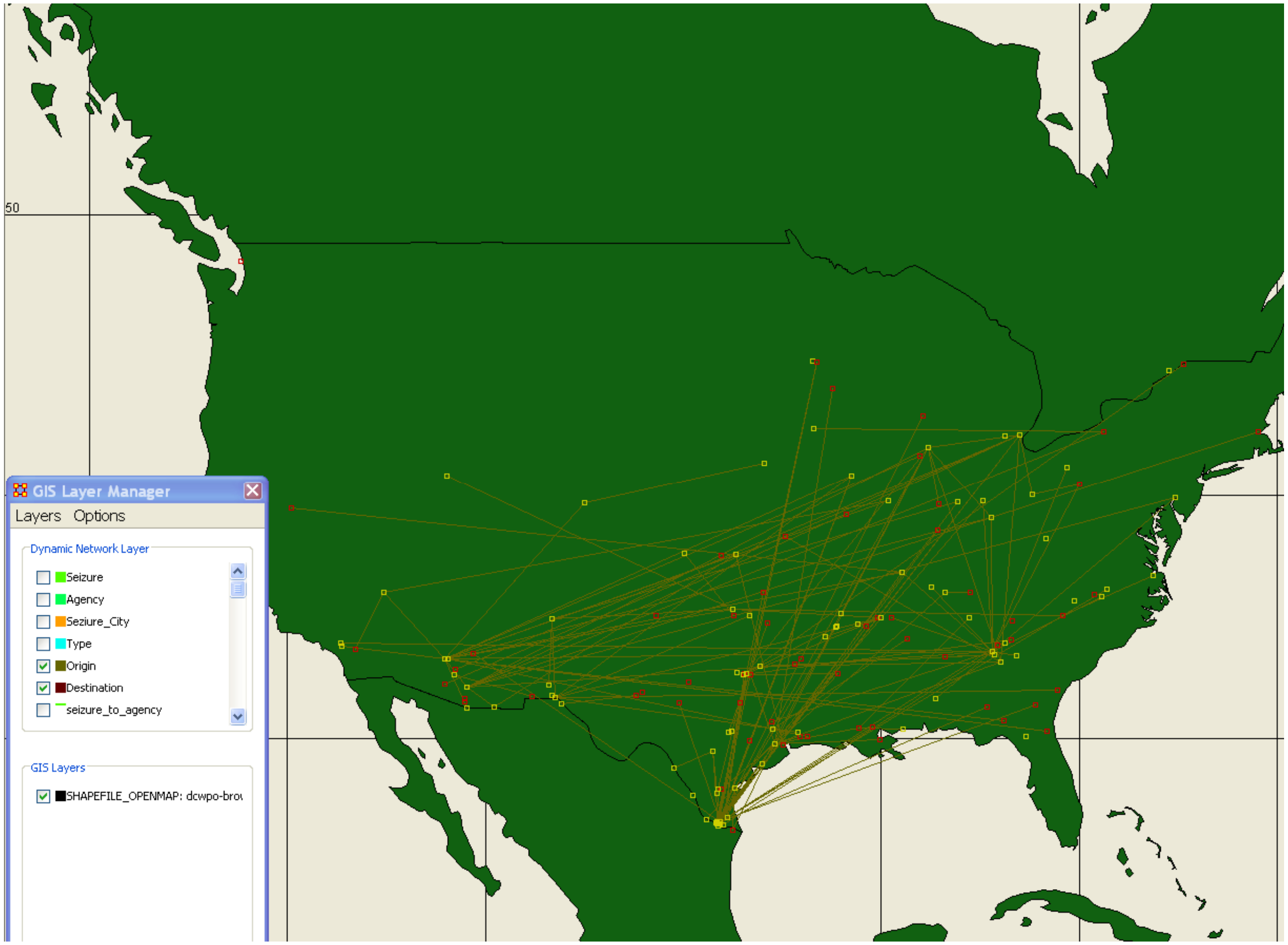
Inferred Locations
e.g., Hidden Ports

ML Algorithms for
Entity / Relation
Inference
Geo-Temporal Blocking
for creating snapshots

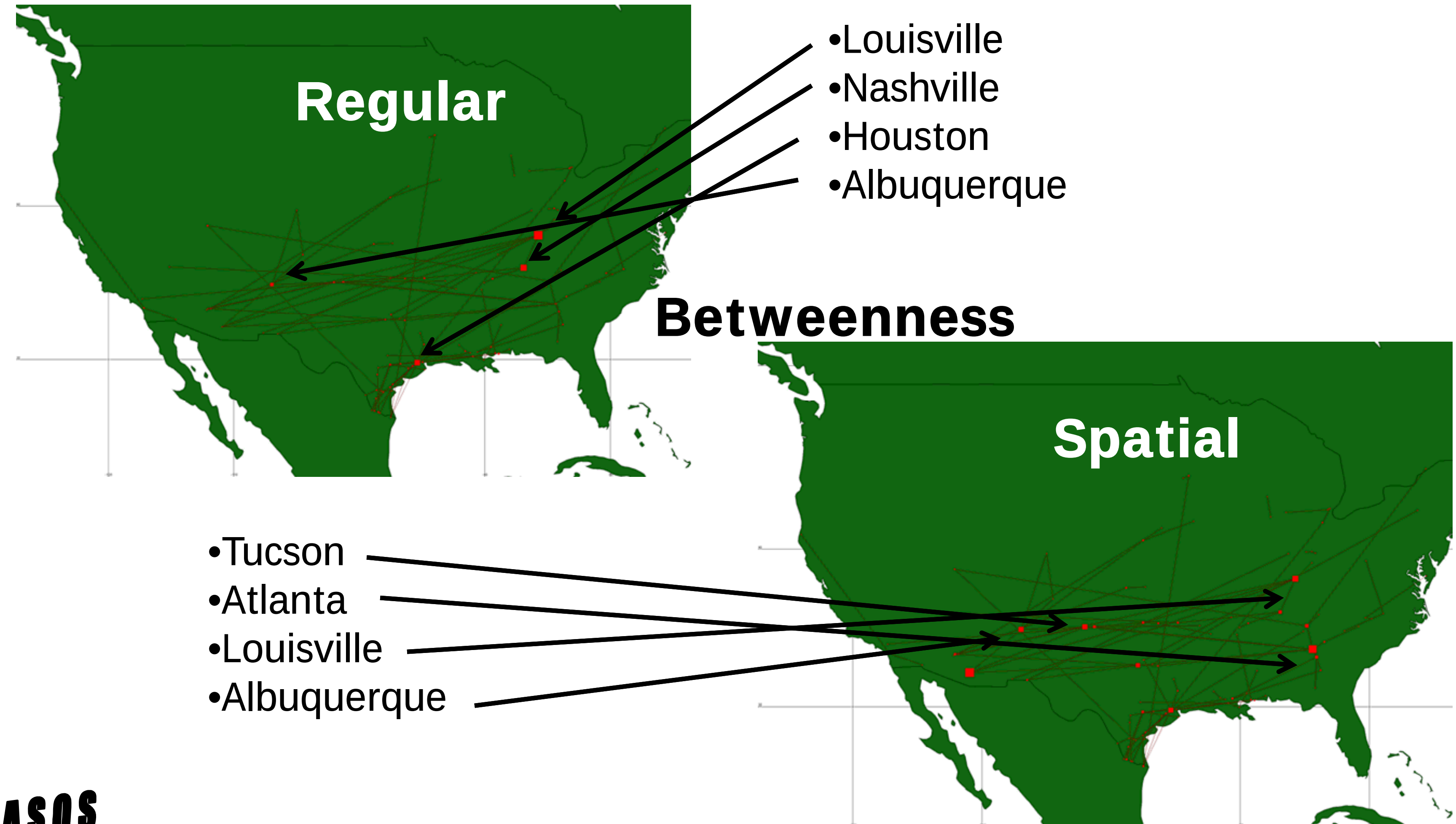


Intervention Analysis
e.g., Assess COA

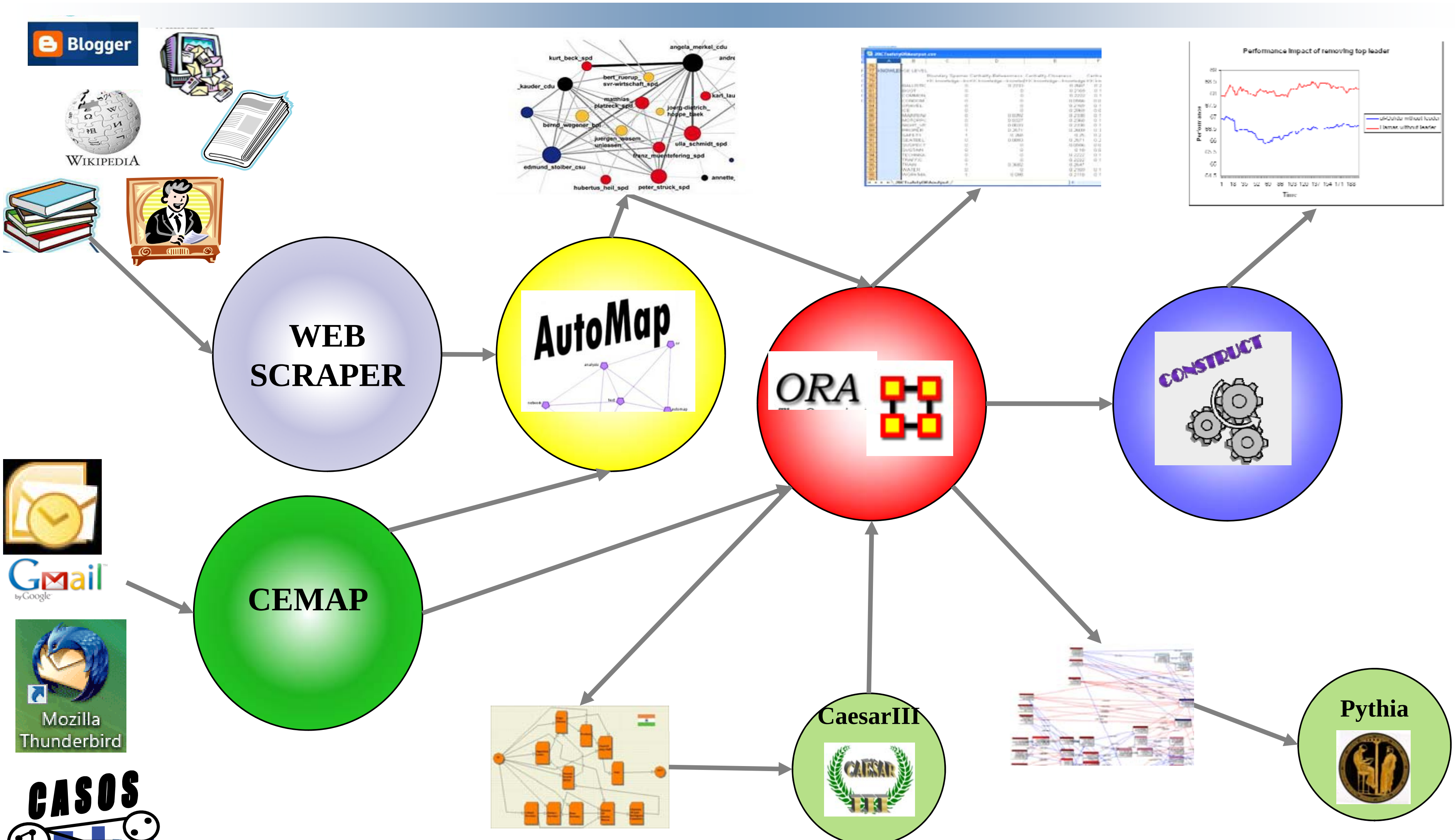
Drug Seizure: Origins to Destinations



Drug Seizures



A Useful Workflow



A look toward the future

- Focusing on simple network models is misleading
- Need a meta-network approach
  - But – pick networks based on problem
  - And – need specialized role metrics for these meta-network data
- Key areas
  - Communication + social networks
  - Geo-spatial + social + resource networks