

Hyper-network with Uncertainties

Dr. Margaret Varga

Integrated Surveillance Systems

QinetiQ,

St. Andrew's Road,

Worcestershire, WR14 3PS, U.K.

Dr. Jan Terje Bjørke

Norwegian Defence Research Establishment,

P O Box 115, NO-3191 Horten

Norway.

NATO Network of Experts Workshop on

Network analysis & visualisation for simulation & prediction

6th – 8th November 2007, Aerospace Corp. El. Segundo, USA.

QinetiQ

Hyper-networks with Uncertainties

- Generalized models of networks can be constructed as hyper-networks from reordering of the adjacency matrix of the network.
- The algorithm was previously formulated on the basis of a crisp representation of networks, i.e. without uncertainty.
- However, uncertainty is an unavoidable accomplice in networks which poses a challenge in:
 - analysing and
 - visualising the networks.
- More nodes \Rightarrow more links together with uncertainty needs networks generalization to:
 - keep the visual clarity of the image while
 - taking into account the degree of uncertainties and
 - their effect on the topological structure of the network.

Representation of Uncertainties



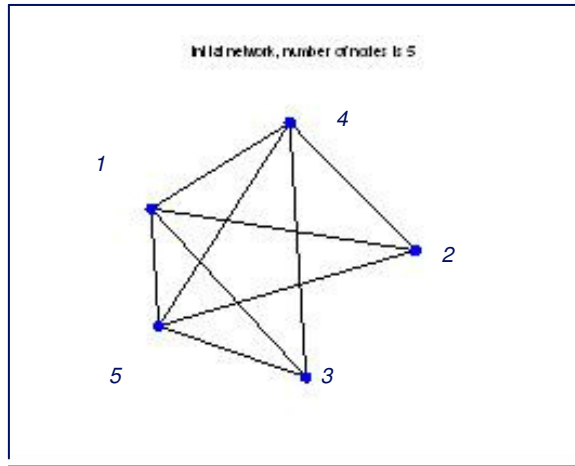
Uncertainty

[0.6,1.0]

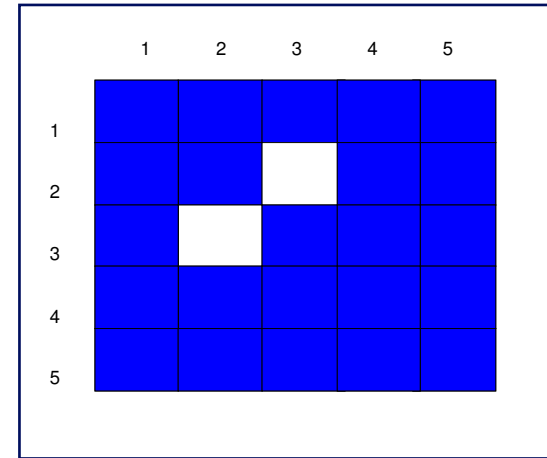
[0.2,0.6]

[0.0,0.2]

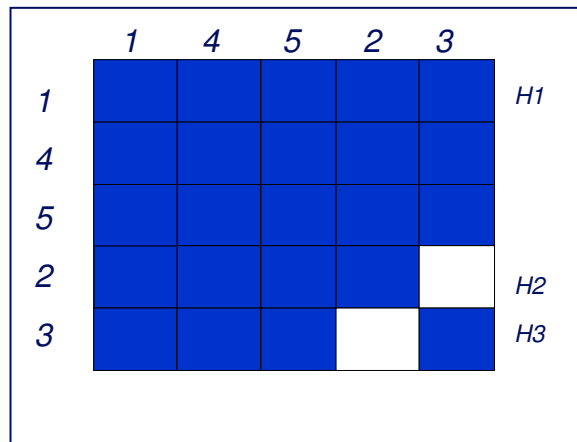
Hyper-network – with no uncertainty



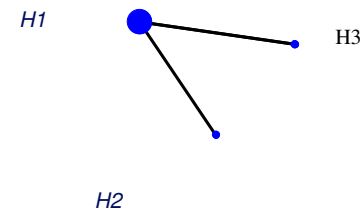
Network with 5 nodes



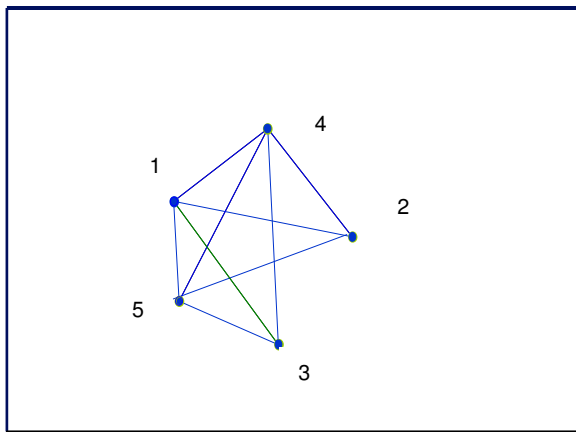
Adjacency Matrix



Re-ordered Matrix



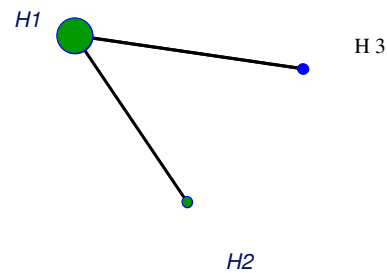
Hyper-network – with low uncertainty



Network with 5 nodes

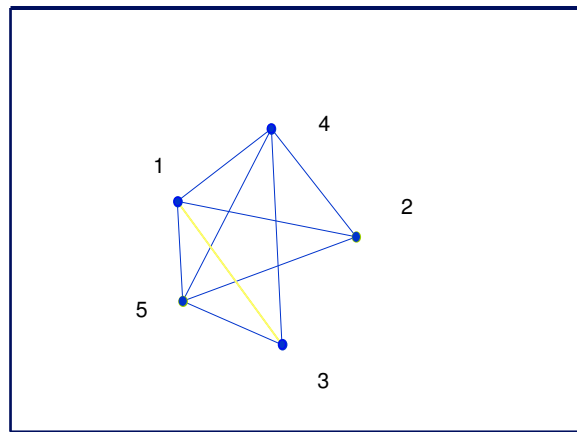
	1	4	5	2	3	
1	Blue	Blue	Blue	Blue	Green	H1
4	Blue	Blue	Blue	Blue	Blue	
5	Blue	Blue	Blue	Blue	Blue	
2	Blue	Blue	Blue	Blue	White	H2
3	Green	Blue	Blue	White	Blue	H3

Adjacency Matrix

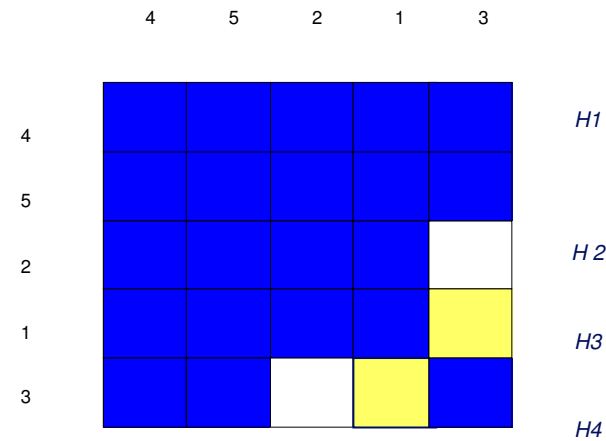


Uncertainty representation using the traffic light

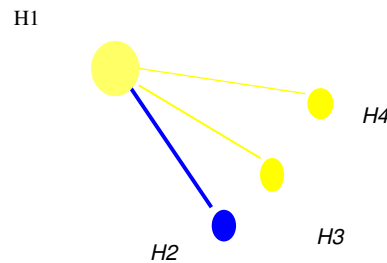
Hyper-network – with moderate uncertainty (1)



Network with 5 nodes

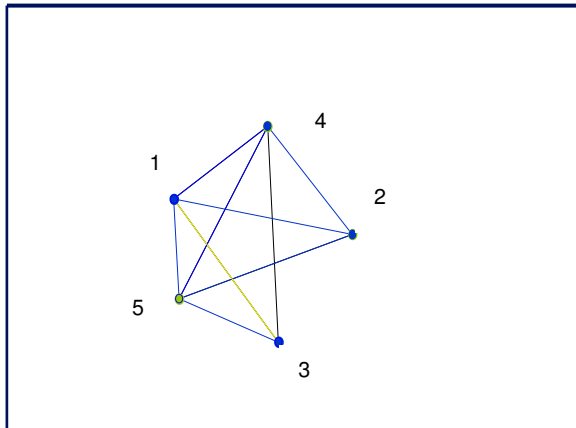


Re-ordered Matrix



The uncertain link can be represented as an entirely different entity with its own strength and thus generate different colour coded associated hyper-nodes, i.e. the uncertainty

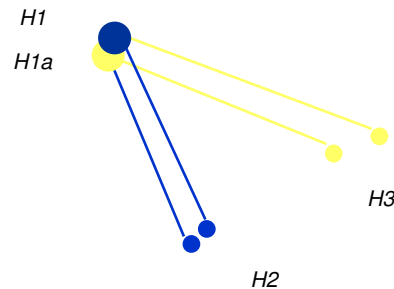
Hyper-network – with moderate uncertainty (2)



Network with 5 nodes

	4	5	1	2	3	
4						H1
5						H1
1						H1a
2						H2
3						H3

Adjacency Matrix

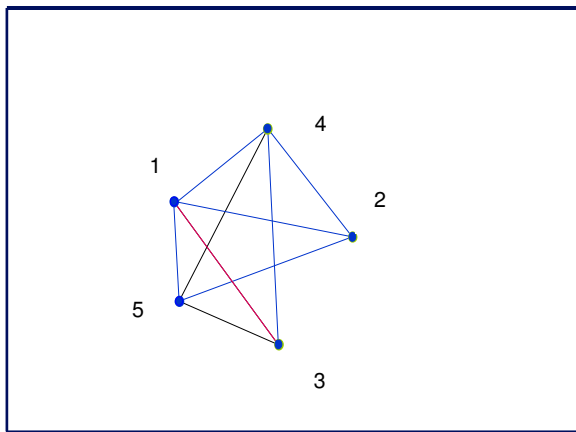


- 3-dimensional representation is used to display the information associated with the uncertain link;
- 2 hyper-nodes, namely H1 & H1a, share many properties and the uncertainty is represented in a separate layer, i.e. associated with H1a

The difference between these two approaches:

- (1) Uncertain links are independent entities
- (2) An interdependence relationship is maintained between the links through common links.

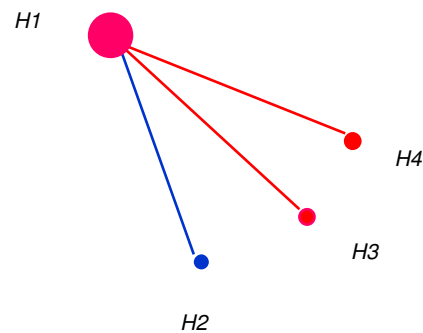
Hyper-network – with high uncertainty (1)



Network with 5 nodes

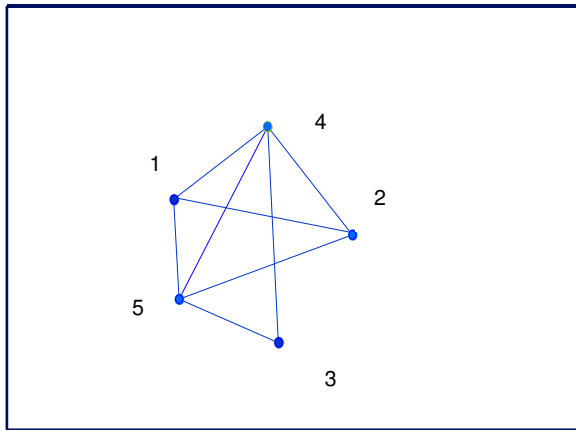
	4	5	2	3	1	
4	Blue	Blue	Blue	Blue	Blue	H1
5	Blue	Blue	Blue	Blue	Blue	
2	Blue	Blue	Blue	White	Light Blue	H2
3	Blue	Blue	White	Blue	Red	H3
1	Light Blue	Blue	Light Blue	Red	Blue	H4

Adjacency Matrix



- Uncertain link between node 1 and node 3 are represented in red
- Treated in the same manner as for moderate uncertainty.

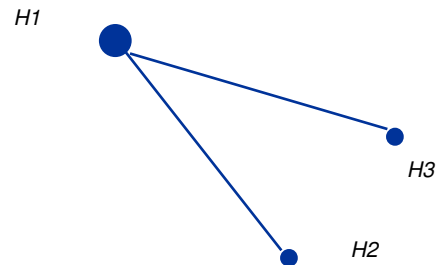
Hyper-network – with high uncertainty (2)



Network with 5 nodes

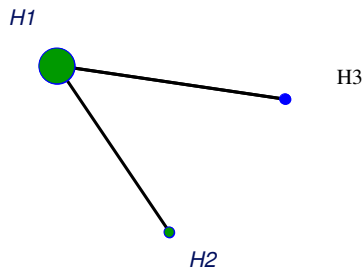
	4	5	2	1	3	
4	Blue	Blue	Blue	Blue	Blue	H1
5	Blue	Blue	Blue	Blue	Blue	
2	Blue	Blue	Blue	Blue	White	H2
1	Blue	Blue	Blue	Blue	White	
3	Blue	Blue	White	White	Blue	H3

Adjacency Matrix

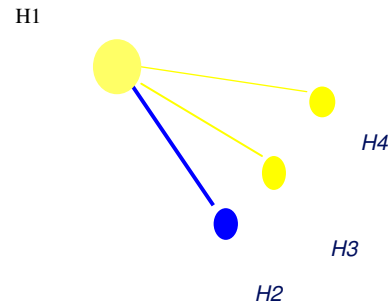


Eliminate the link altogether

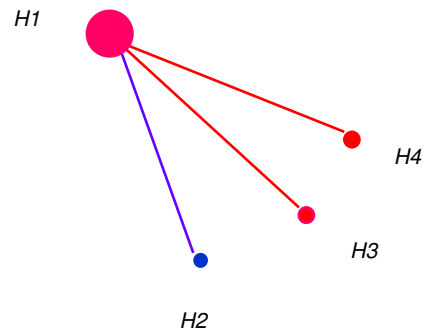
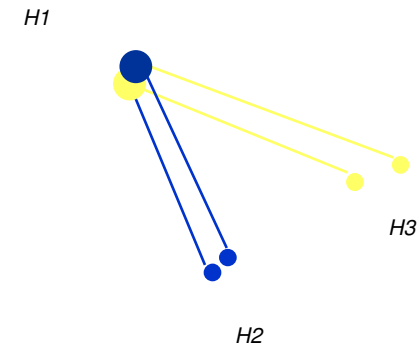
Hyper-network with different uncertainties



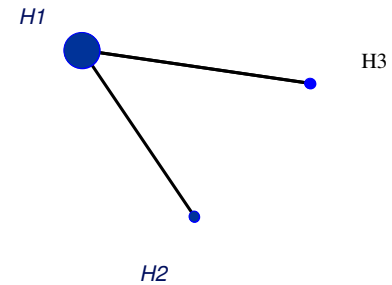
Low uncertainty



Moderate uncertainty



High uncertainty



Conclusions

- A traffic light representation has been proposed to:
 - simplify the representation of the uncertainty and
 - provide information about the nature of the uncertainty on the hyper-node.
- Different approaches to handling and presenting uncertainty have also be presented.
- Uncertainty in one link in a simple network can change the topology and meaning of the hyper-node considerably.
- The representation and management of uncertainties has significant impact on the interpretation and the understanding of the data, which in turn will result in different decisions being made.
- The examples in this paper illustrate the importance of managing uncertainties and how uncertainties affect the network.

Questions

- Traffic light is a simple and intuitive way of representing uncertainty. Is it too simplistic?
- What is the advantage of representing uncertainties in greater detail?
- How do the users decide which is the most appropriate approach to managing and visualising uncertainties?
- How does one represent the propagation of uncertainties in a complex network?