



U.S. Army Research, Development and
Engineering Command

Integration of Communication and Social Network Modeling Platforms using ELICIT and the Wireless Emulation Laboratory



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Kevin Chan, Ryan Pressley, Brian Rivera (US ARL/CISD)

Mary Ruddy, Azigo

16th ICCRTS : Topic 8: Architectures, Technologies, and Tools

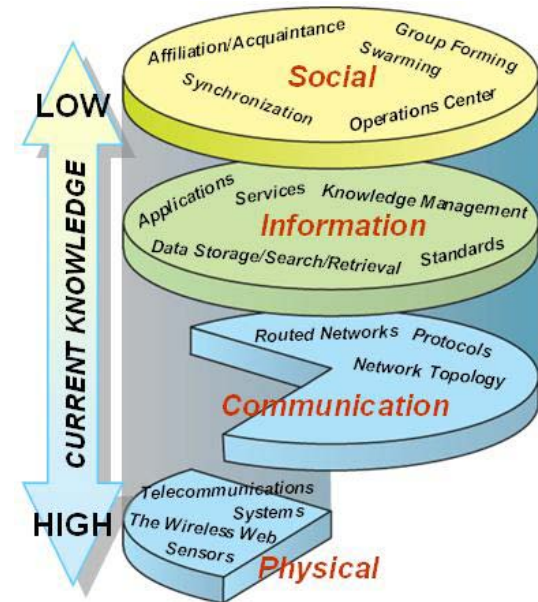
Paper 097

June 22, 2011

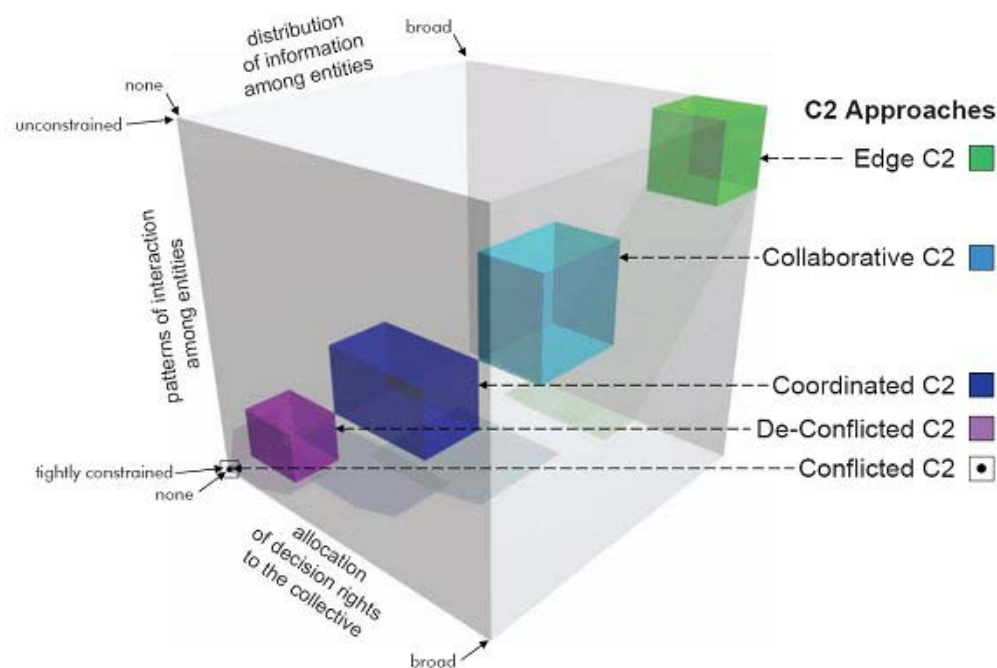
- Tactical networks are comprised of many dynamic elements that focus on providing support to the Warfighter
- Need to understand, model, predict and analyze Warfighter performance in a complex environment:
 - *i.e.* Military assets, physical environment, social structures



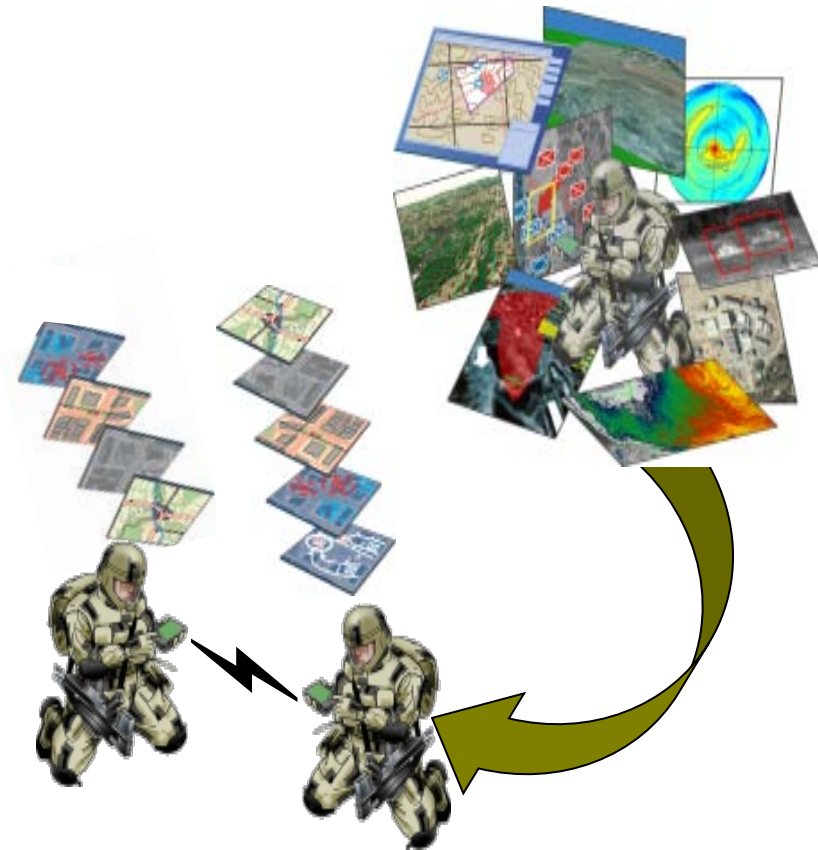
- Network science
 - Understand the dynamics and relationships between complex network layers
 - Enhance human performance for network-enabled warfare
 - Enhance speed and precision for complex military operations.



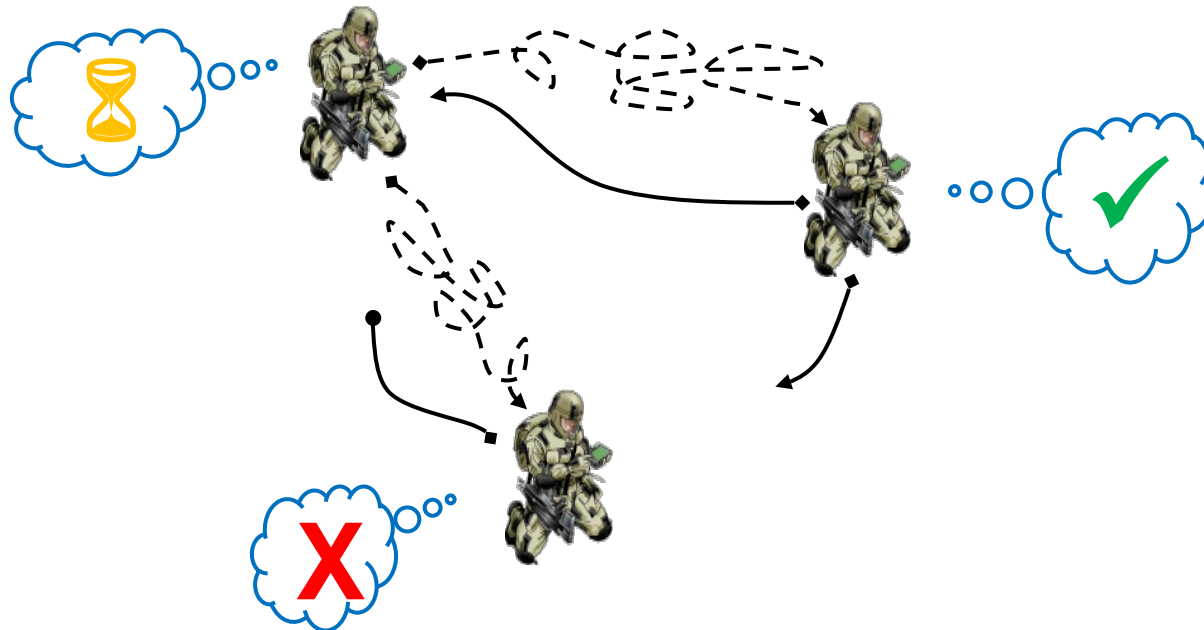
- Command and Control Maturity, Agility
 - Complex endeavors
 - Organizations operate within the C2 maturity space
 - distribution of information, patterns of interaction, allocation of decision rights
 - C2 Agility
 - robustness of operating conditions, adaptation of varying conditions



- **Goal:** Develop experimental capability that address difficulties/shortcomings for complex networks
- Current lack of models for complex networks
- Difficulties:
 - Meaningful variation of network effects
 - Lack of inclusion of multiple complex network layers
 - Measuring human performance

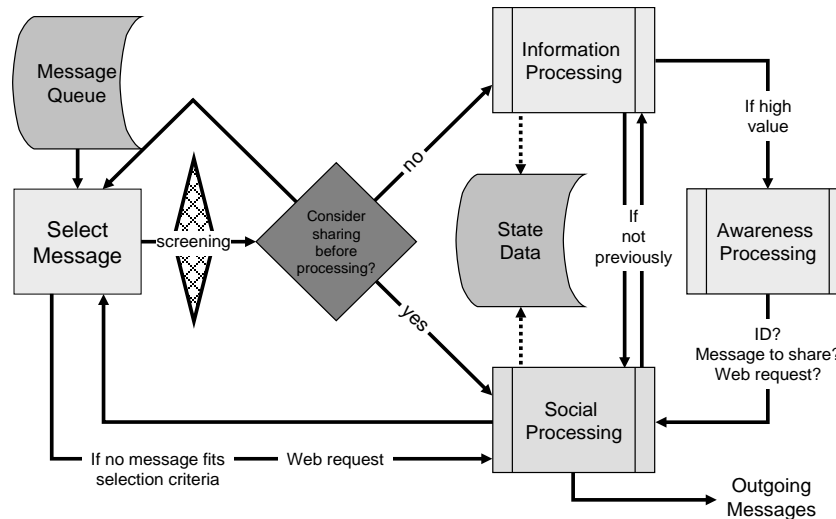


- Ability to differentiate between types of delays to further increase the fidelity of the simulation
 - Communication network effects vs. cognitive / social effects
- Leverage existing experiment tools (i.e. ELICIT part of the complex network)
 - Add representation for other layers



- **ELICIT**

- Experimental Laboratory for Investigating Collaboration, Information-sharing and Trust
- Sponsored by CCRP to test principles of C2 / organizational theory
- Initially designed for people to participate in an exercise to identify a fictional terrorist threat
- Modified to enable sensemaking agents run in place of people



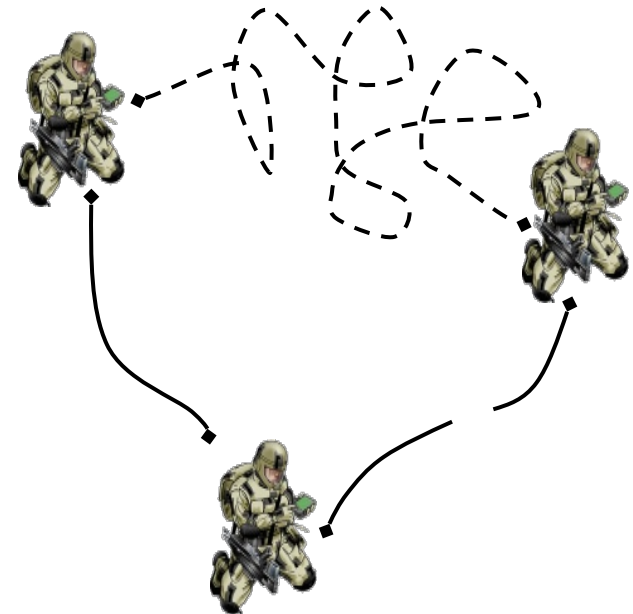
- The ELICIT fictitious terrorism plot: situational awareness is measured by the claimed fraction of information about the terrorist threat
- Correctness $C = 0.25 (WHO + WHERE + WHAT + WHEN)$
- Average and Maximum correctness is considered:

$$\bar{C}(t) = \frac{1}{n} \sum C_i(t) \qquad \max C(t) = \max_C C_i(t) \quad \forall i \in n$$

- Time first agent arrives at full correctness (timeliness)

- Represent communication network properties using ELICIT sensemaking agent parameters
 - scalability
 - connectivity
 - communication loss and delay

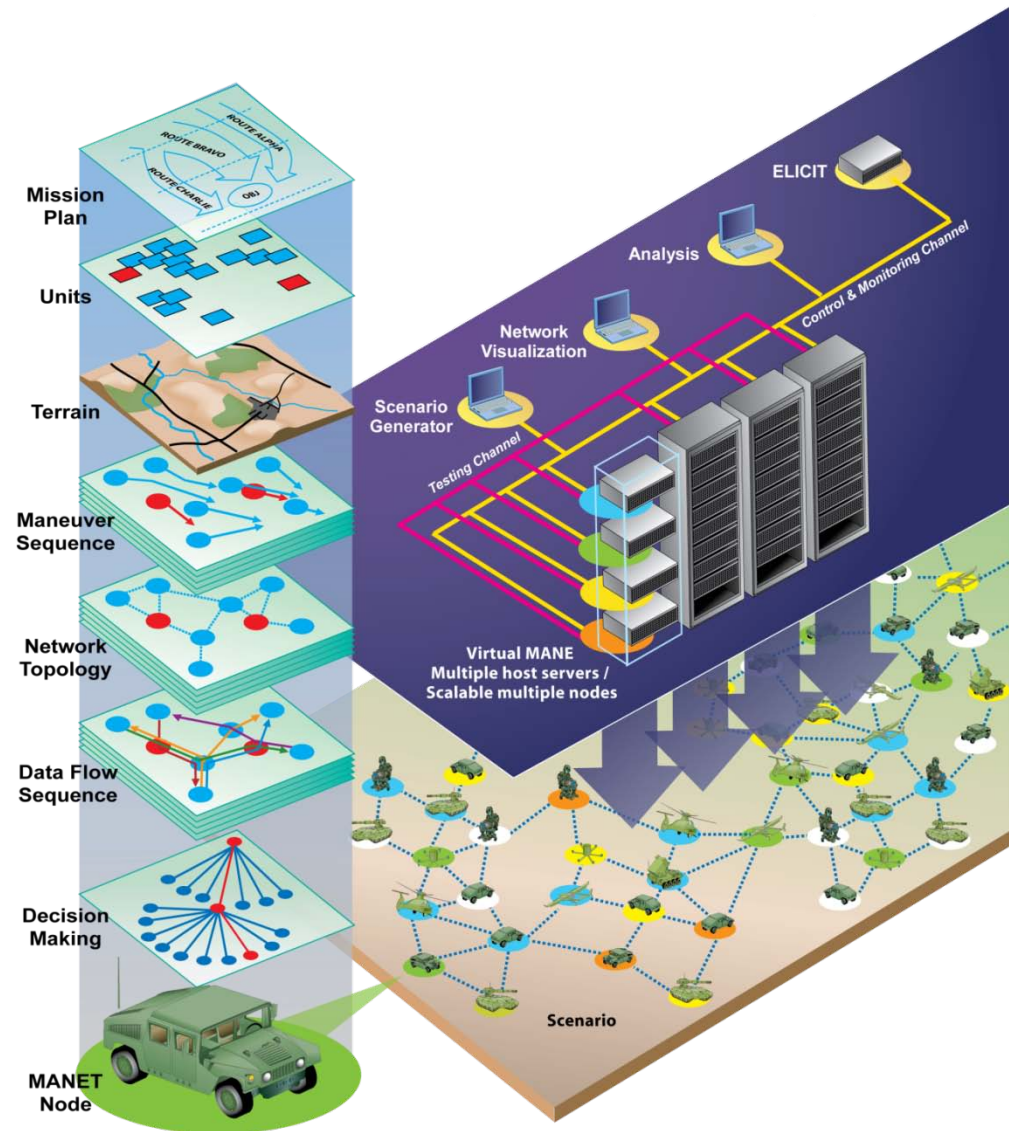
Communication Network	Sensemaking Agent
Probability of a successfully transmitted packet	ShareWithFactor
Packet latency	SharingPostingMessageDelay
Network topology	Organization



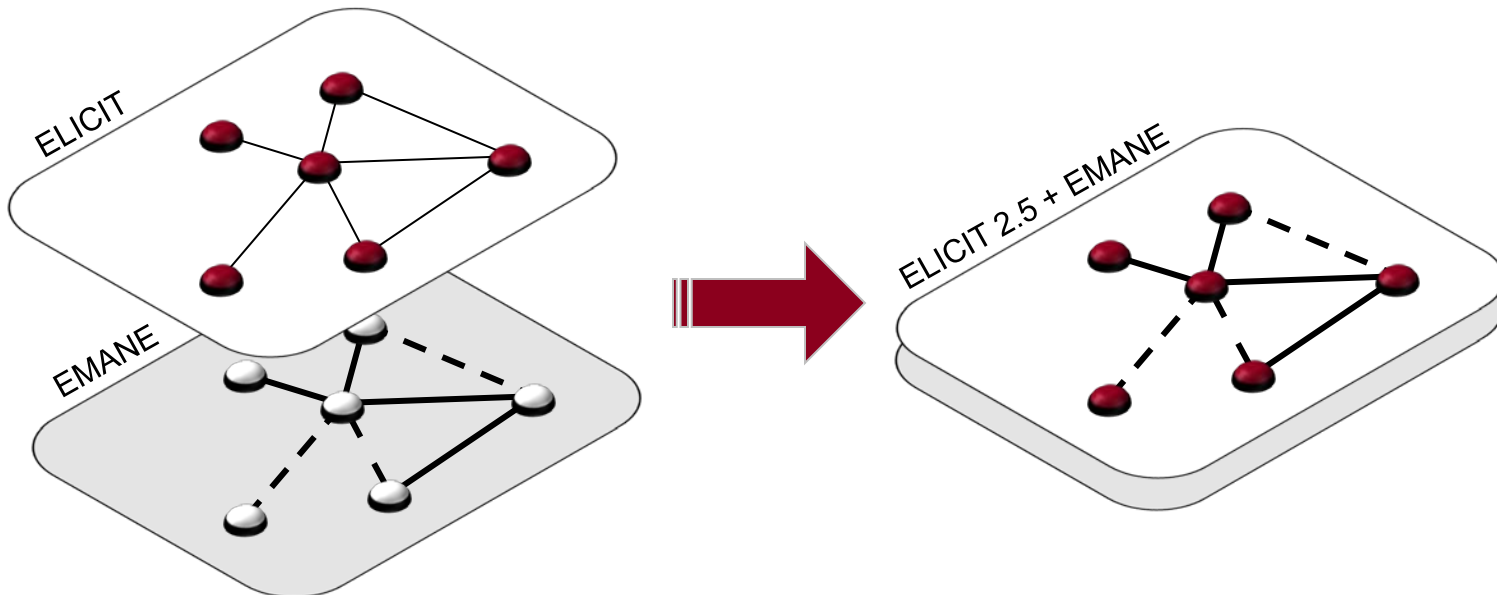
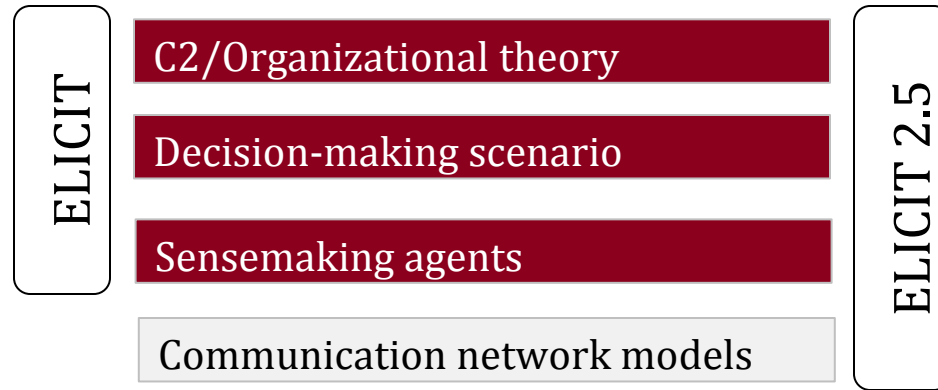
- Meaning of similar parameters across complex network layers
 - Rosetta Stone between complex network layers

Communication Network	Social/Cognitive Network	ELICIT Parameter
information loss rate of network	decision to broadcast or share information	<code>postFactor, shareWithFactor</code>
encoding, encryption, decoding	cognitive processing delay	<code>informationProcessingDelay</code>
packet formatting, routing overhead	social/cognitive workload	<code>socialProcessingDelay</code>
network topology	organizational structure	<code>accessibleAgents, accessibleSites</code>
trust in network performance	trust in individuals	<code>trustInIndividuals</code>

- WEL: a controlled, repeatable emulation environment for tactical wireless Mobile Ad hoc Networks (MANETs) and Information Assurance (IA) experiments
 - EMANE
 - up to 600 virtual nodes
 - runs actual communication radio code, routing protocols, medium access control protocols
 - transmission medium is emulated
 - Topodef: specifies topology and mobility over duration of experiment



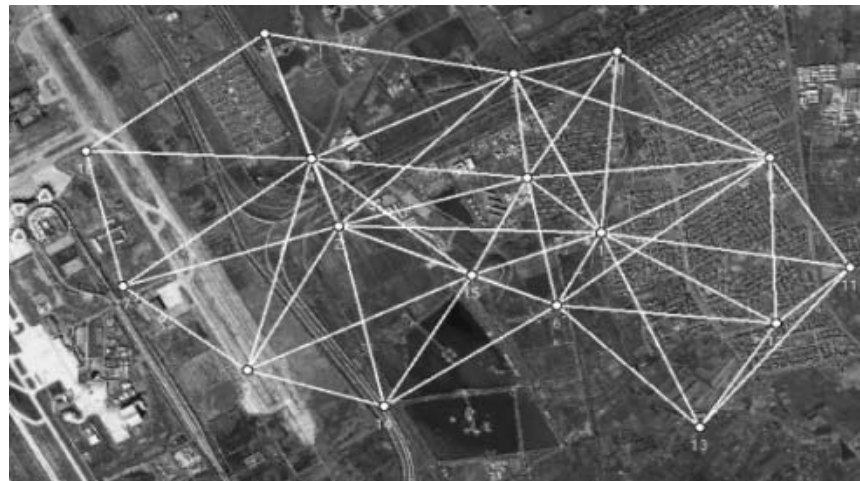
- **Integration:** Adding the EMANE communication network models into ELICIT



ELICIT enhancements for EMANE integration are generally available in ELICIT 2.5

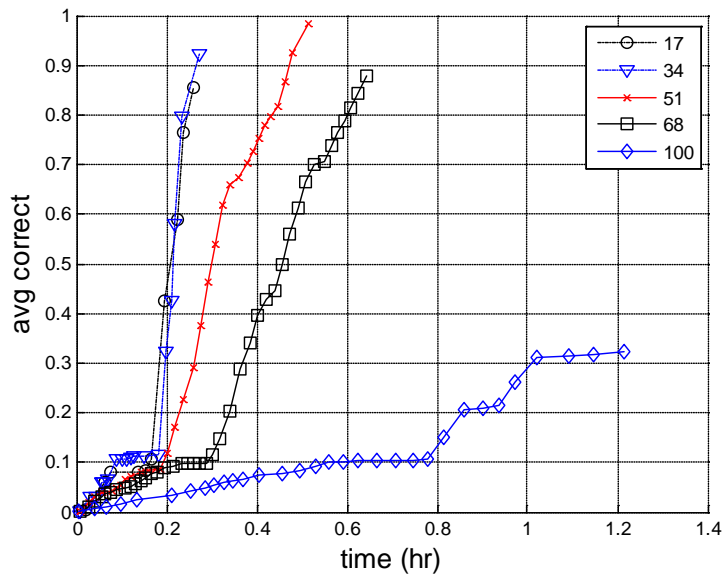
- Support for distributed agents (agents can access ELICIT via http, just as humans do)
- EMANE integration compatibility
 - Shim communications with EMANE
 - Shares can be delayed until explicitly released
- Can schedule human/distributed agent runs in batch mode
- Additional source information recorded for agent use in trust calculations

- Experiments conducted using the integrated ELICIT/EMANE platform
- Experiments similar to previous work using sensemaking agent parameters as the communication network parameters
 - Scalability: n ELICIT nodes, n EMANE nodes
 - Connectivity: $G(n, r)$ – transmit power (TX power) controlled by EMANE RF pipe physical model

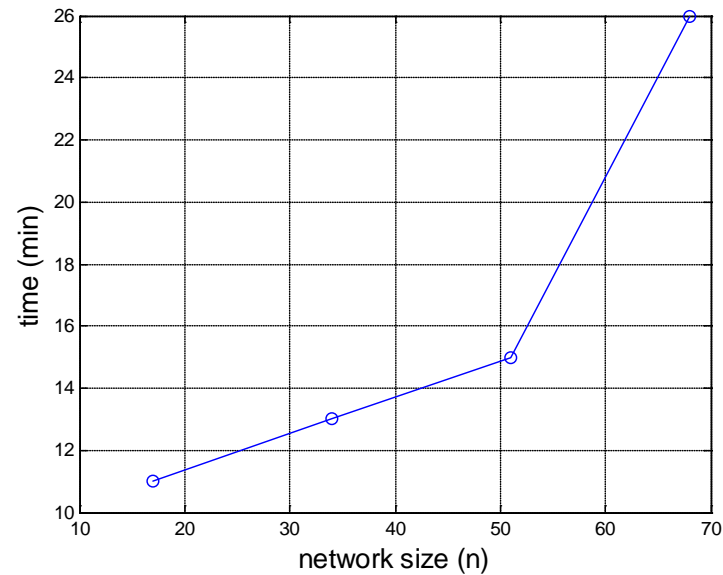


- Average correctness vs. time for $n = \{17, 34, 51, 68, 100\}$
- Expected/validated degradation of average correctness as network size increases
- Exponential increase of time required for first full correctness as n increases

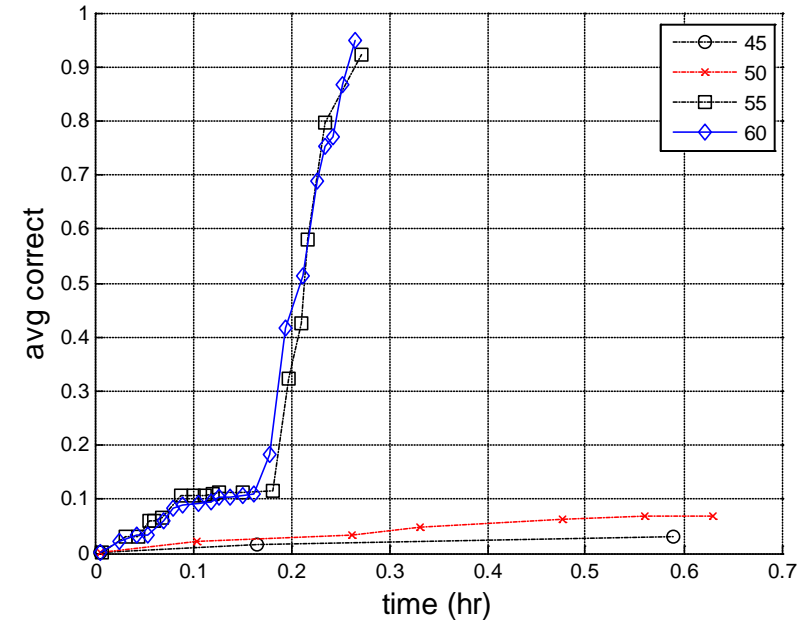
Avg Correctness vs. Time (min)



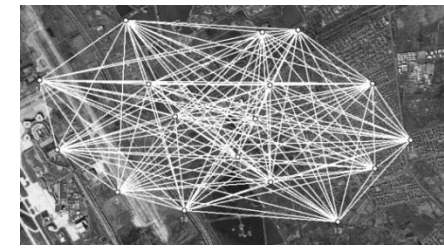
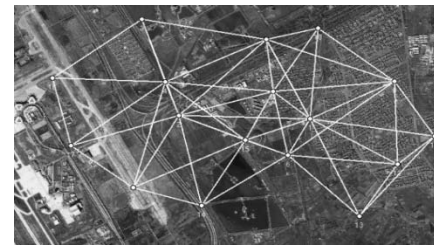
Time (min) until first full correct



- Threshold effect of performance once connectivity is established
- Observation: routing overhead caused nodes to be unresponsive at moderate to high link density. Network becomes overloaded



Increasing TX power, connectivity →



- Established an integrated ELICIT/EMANE experiment platform that can represent both communication network and social/cognitive network effects
 - Preliminary experimental results match the previous work using ELICIT agent parameters
 - Integrated model demonstrates existence of phenomena similar to network overload and cognitive overload
 - Integrated platform enables simultaneous experimentation of both communication and social/cognitive networks

Thank You

Questions?