U.S. Army Research, Development and Engineering Command

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Connections between communications and social networks using ELICIT (Track 5)

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Motivation

Problem:

Characterization of the effects of communication networks on mission performance in social networks.

Approach:

- We are interested in studying the interaction between social and communication networks.
- Being familiar with communication networks, our approach is to take an existing social network experimental platform and consider aspects of communication networks in these experiments.

Goals:

- Study of the effect of network quality of service on performance of individual and group decision-making.
- Observing the performance in these conditions will enable modeling and design of future networks to optimize decision-making metrics.

Experimental Plan

- Use an existing social networking platform ELICIT and then implement communication networking capabilities.

- Consider several parameters of networks:
  - Scalability: size of network
  - Connectivity: density of links between nodes
  - Packet Latency: delay in packet transmission
  - Packet Loss: failure rate in packet transmission

- Conduct experiments in ELICIT using the sensemaking agents for networks of intermediate size.

- ELICIT 2.2.1 installed on a Dell Server 1950 (Quad-Duo Core, 32 GB RAM, 200 GB HDD.

Communication Network vs. Social Network

- Cross-domain networking scenarios have different terminology to represent the same parameter.

ELICIT	Communication Network	Parameter Description
Team Member, User, Player, Participant, Sensemaking agent	Nodes	Individual in the trial with certain interconnections.
Organization	Topology	Graph representation of nodes and links between nodes.
Edge Organization	Random graph	Flat network where any node can communicate with any node.
Factoid	Packet	Snippet of information being shared between nodes.
Identify	-NA-	Measure of situational awareness.

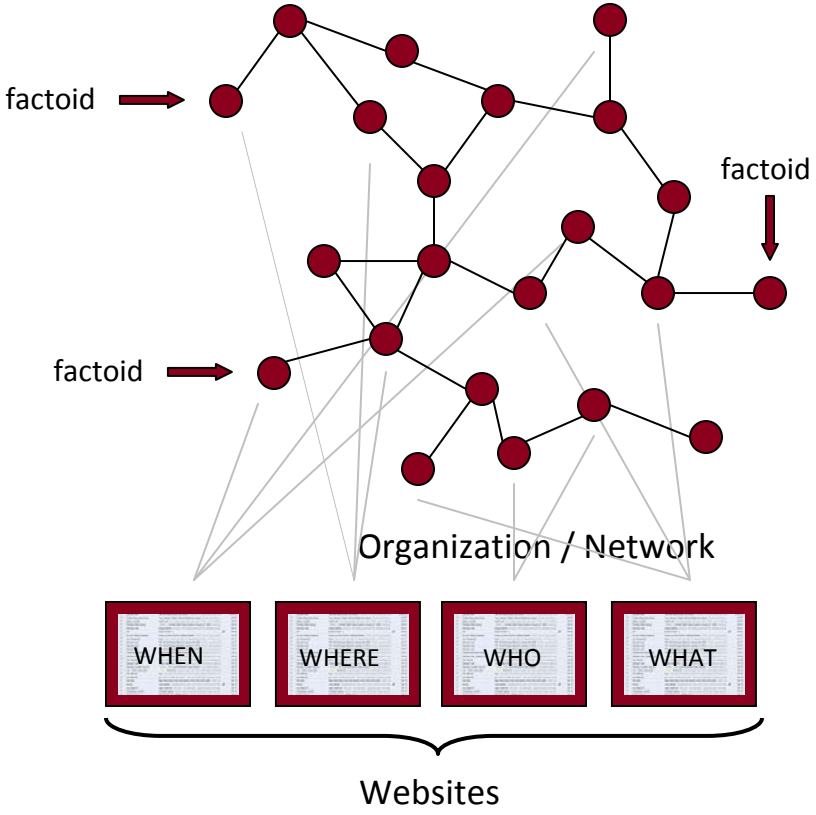
Related Work

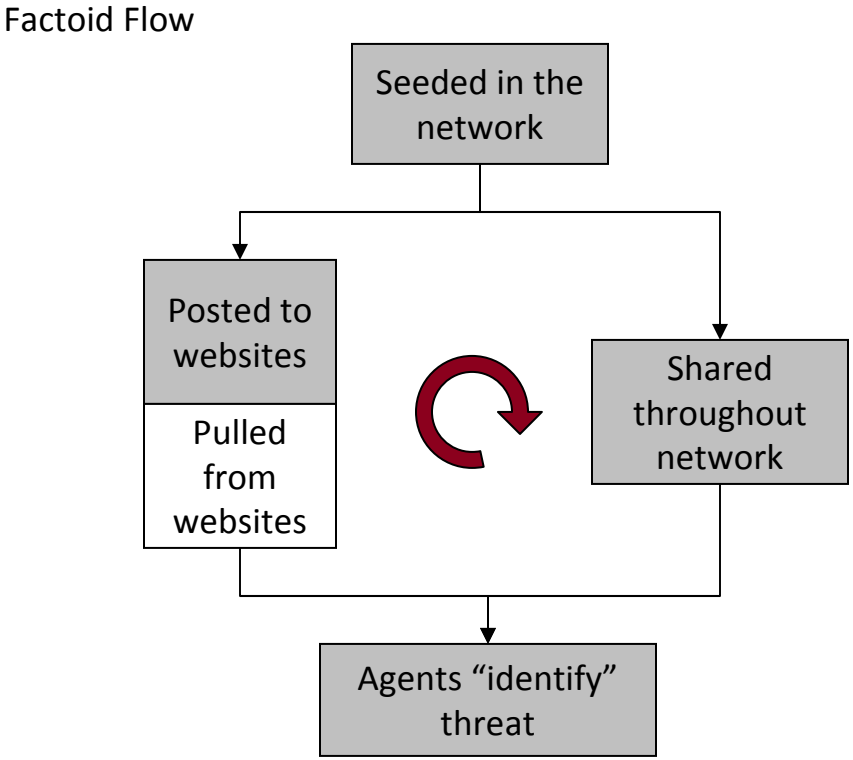
- Simulating communication errors presents a more realistic networking scenario compared to previous studies of communications within social networks. Also, scaling of ELICIT will enable future experiments with network sizes more suitable for tactical scenarios.

- This work studies communication networks on the physical layer within social networks. Existing studies consider:
  - Frequency of communications [Gloor 06]
  - Behavior of personal communications (email, chat) [Wu 09]
  - Social networking analysis metrics [Carley 05].

ELICIT Overview

- ELICIT is a social networking experimental platform that studies command and control scenarios and the effect of organization and trust on team performance in a controlled environment. Participants in the experiments are given “factoids” and are able to share information with others. The goal is to arrive at a consensus on information on a fictitious terrorist threat.





Correctness

he ELICIT fictitious terrorism plot.

The Violet (WHO) group plans to attack a financial institution (WHAT) in Psiland (WHERE) on April 5 at 11:00 AM (WHEN)

tuational awareness is measured by the claimed fraction of information of the rrorist threat.

orrectness *C = 0.25 (WHO + WHERE + WHAT + WHEN).*

- *WHO (Violet group),*
- *WHAT (financial institution),*
- *WHERE (Psiland), and*
- *WHEN (April, 5, 11:00, AM)* – partial correctness permitted

verage and Maximum correctness is considered:

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

Agent-based ELICIT

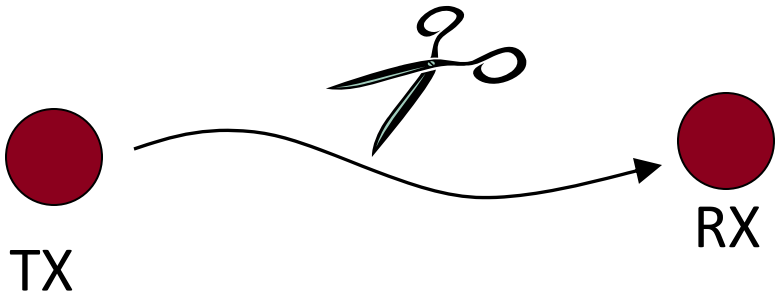
his study is unique to other research involving ELICIT.

- First extensive use of agent-based ELICIT [Ruddy 2009].
- Larger organizations/network sizes than previously used.
- Simulation of communication network parameters represented by sensemaking agent model parameters.

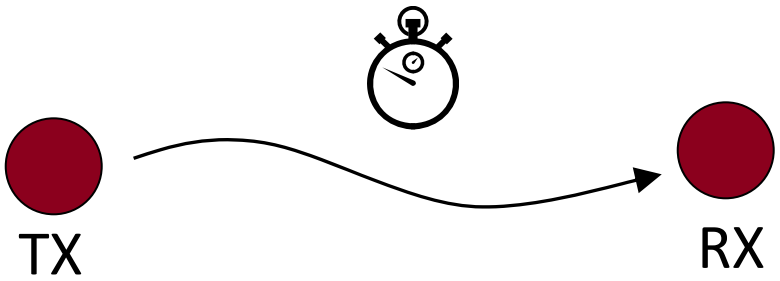
Communication Network	Sensemaking Agent
Probability of a successfully transmitted packet	ShareWithFactor
Packet latency	SharingPostingMessageDelay
Network topology	Organization

Packet Loss and Delay

acket transmission ratio represents the probability that a message that is ansmitted is successfully received by the intended recipient.

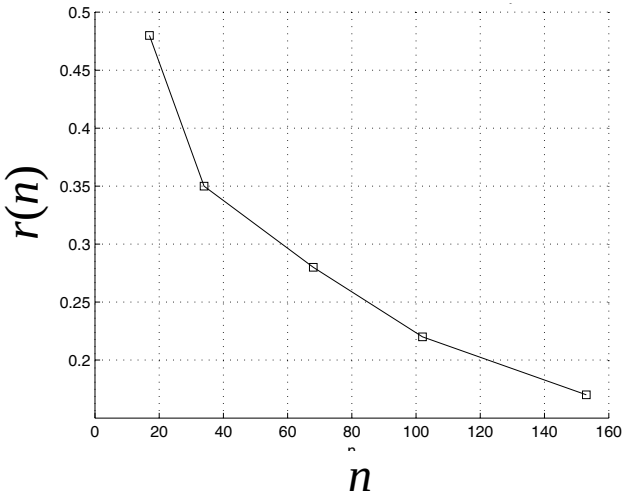


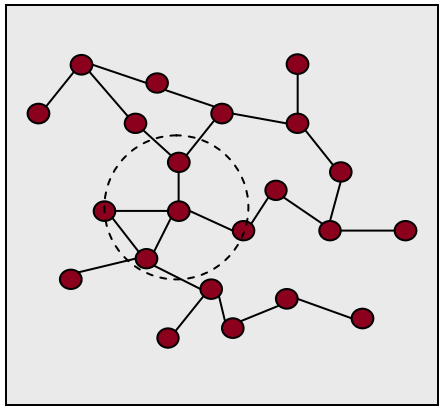
acket latency is the time it takes a packet to travel from its source to intended estination.



rganization/Network Topology:

- Use of random geometric graph $G(n,r)$
  - Network on unit square
  - n: network size
  - $r(n)$: communication radius
- Positions chosen uniformly in range [0,1]
- $r(n)$ chosen for network connectivity with high probability





Organization represented by a random geometric graph

Other Parameters

rocessing parameters set to .*1s*:

- `screeningSelectedMessageDelay, informationProcessingDelay, socialProcessingDelay, sharingPostingMessageDelay, awarenessProcessingDelay, determiningKnowledgeNeedsDelay`

actoid set:

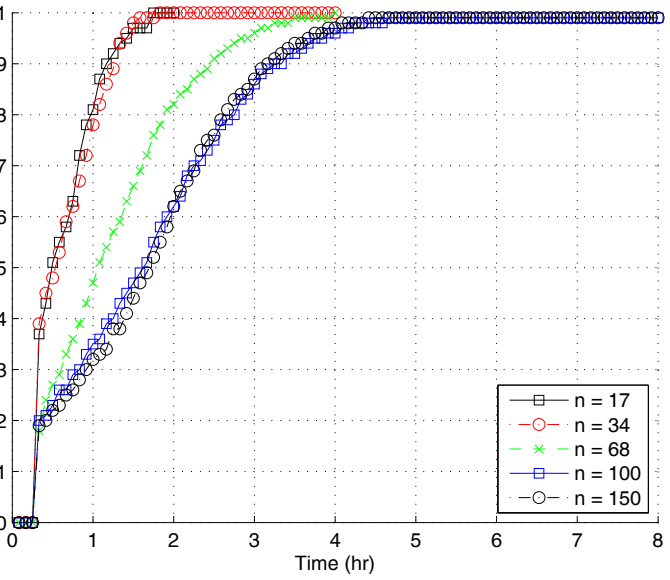
- Duplicate factoids are not seeded into the network.
- Factoids are seeded at $t = 0$ in one wave.

calability: 17 to 150 nodes

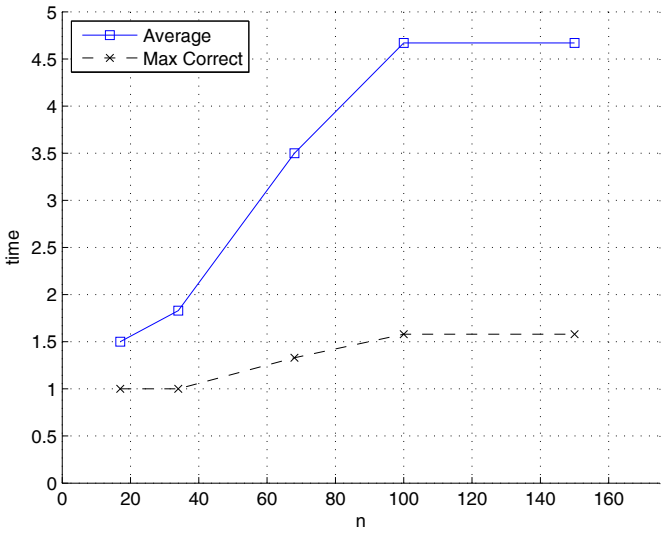
- Average finishing time (time to achieve full correctness) triples, average maximum finishing time increases by 30 min.
- Used a connected topology, generated by $G(n, r(n))$.
- Network parameters:

n	17	34	68	100	150
$r(n)$	0.5	0.4	0.3	0.25	0.2

Network sizes and communication radius.



Average Correctness vs. time for several network



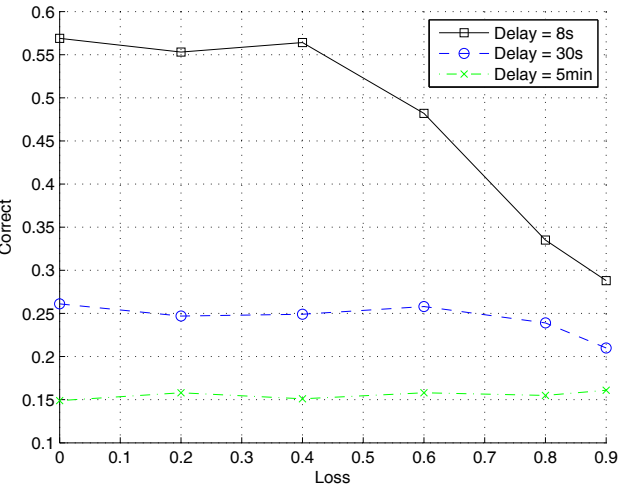
Average time to get to full correctness (= 0.99) and Average time for maximum to get full

acket loss and Packet Delay

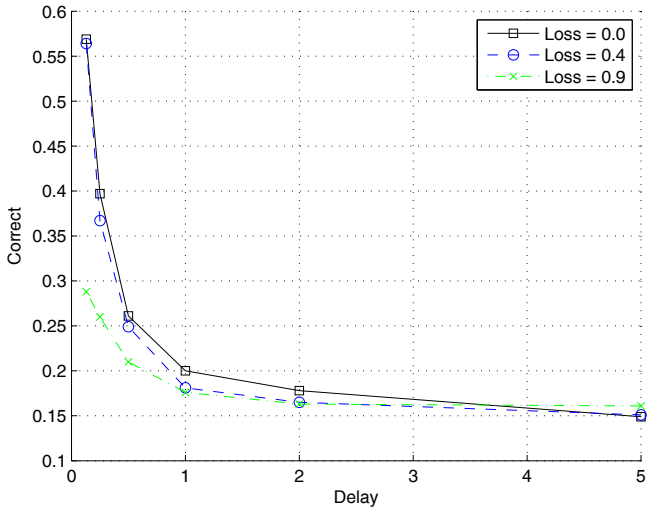
- Network parameters: $n = 68, r = 0.3$.

Loss	*0.0*	*0.2*	*0.4*	*0.6*	*0.8*	*0.9*
Delay	*8 s*	*15 s*	*30 s*	*1 min*	*2 min*	*5 min*

- Sharp drop off in task completion performance with packet delay, performance is maintained with loss < 0.5.



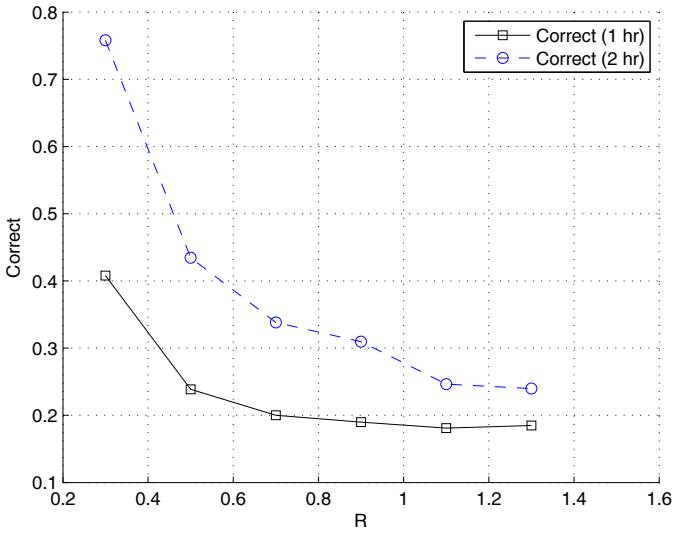
Average correctness vs. packet loss for delay = {8s, 30s, 5min}



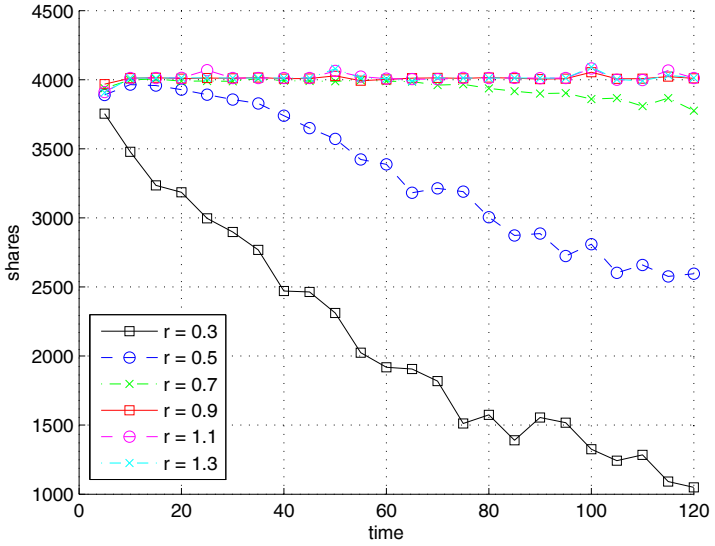
Average correctness vs. packet delay for loss = {0.0, 0.4, 0.9}

arying Connectivity

- Parameters: $n = 68$, $r = (0.3, 1.3)$.
- Decreasing performance as communication radius increases due to "information overload" of the agents.



Average correctness after 1 hr., 2 hr. vs. time



Average number of shares per 5 minute interval vs. time.

Summary

onsideration of the quality of service provided in communication links and the npact on a C2 task within a tactical network.

- First extensive ELICIT trials using sensemaking agents.
- Conducted ELICIT simulations involving organizations using large-scale networks.
- Evaluated the effect of loss/delay, connectivity, scalability of networks on information sharing / situational awareness tasks.