MESSAGE TRAFFIC SIMULATIONS - I: SIMPLEST VERSION TO FIX IDEAS

This is the first of two installments to pin down a concrete formulation of message traffic simulations. Please feel free to perturb this formulation to a point where real output can be generated. I would welcome all suggestions regarding what we should send to Edo.

I. A 2 - MODULE SPECIFICATION

We begin with this elementary formulation as it contains nearly all of the ingredients necessary to specify a more general m - module structure ($m > 2$) within which individual modules will represent clutter and where there can be one or more covert networks operating simultaneously.

Let **C** be a covert network, and identify **H** as the middle manager responsible for overseeing the planning of a terrorist event. Assume that there are modules $\mathbf{M_1}$ and $\mathbf{M_2}$ of individuals who are part of a total population represented as $\mathbf{M_1} \vee \mathbf{M_2} \vee \mathbf{C} \vee \mathbf{H}$. On any given day, we assume that x% of the total population will initiate calls, where $5 \leq x \leq 90$, depending on the intensity of calling desired in a simulation.

On each day we sample from a list identifying all individuals in the population, and do the sampling without replacement to reach the designated x% of the total population as callers. Now suppose that a caller is labeled $j \in \mathbf{M_1}$. The message transmission steps for this individual are as follows:

1. Select k = # of calls j will make by generating an integer valued deviate from the distribution p(k) with support on the integers [1,2,..., 10]. We start with p(k) to be a monotone decreasing quadratic, or possibly even an exponential function, $a \exp(-bk)$, with k = 1,2,..., 10.

2. Select l = # of calls within $\mathbf{M_1}$ by choosing a deviate from the binomial distribution Prob(# calls in $\mathbf{M_1}$ = l | k calls) = Binom (k;l) $s^l (1 - s)^{[k - l]} = q(l)$, l = 0,1,...,k, where $s > .5$ (e.g. s = .75, .8, .9). Then k - l calls will go to $\mathbf{M_2}$.

3. For each call within $\mathbf{M_1}$, select a recipient by sampling from $|\mathbf{M_1}| - 1$ individuals equally sequentially and equally likely *without* replacement. This assumes that $|\mathbf{M_1}| > 10$. .

4. Each call is of duration $t_{j,v}$, which is a deviate drawn from a Beta distribution with unimodal density.

5. For each of k - l calls in $\mathbf{M_2}$, draw recipients equally likely but in sequence without replacement. Select call durations as deviates from a Beta distribution with unimodal density as in step 4.

6. For each outgoing call the message has $p(G)$ of being a good message and $p(B) = 1 - p(G)$ of being a bad message. If B = [bad message] is selected, draw message B_i with probability 1/7 from the list $B_1, \ldots\ B_7$.

If H is selected to be a caller on a given day and his k is determined from p(k), k= 1,2,...,10, he samples from $\mathbf{M_1}$, $\mathbf{M_2}$, or **C** with probability $[k!/(l_1!l_2!<k - l_1 - l_2>!]\ s_1^{l1}s_2^{l2}(1 - s_1 - s_2\}^{\{k-l1-l2]}$
We take $s_1 + s_2$ to be on the order of .75 or .8, thereby ensuring that **H** does not transmit messages to **C** very frequently. Given l_1, l_2, $(k - l_1 - l_2)$, he sends l_1 messages to $\mathbf{M_1}$, l_2 messages to $\mathbf{M_2}$, and $(k - l_1 - l_2)$ messages to **C**. For $\mathbf{M_i}$, i = 1,2, recipients are selected by equally likely draws without replacement. For messages going to **C,** they are sent to apriori selected target recipients who each receive 1 bad message, regardless of the value of $k - l_1 - l_2$. Over time, messages are sent from **H** to these individuals in the order $B_1, B_2, \ldots, B_7$. Message durations for transmission to $\mathbf{M_1}$ and $\mathbf{M_2}$ proceed as in step 4. Message durations for the bad message transmission to designated members of **C** are all of duration 1 minute -- corresponding to a small value on the horizontal axis of the Beta density used to select general call durations. Units on this axis are in hours, and the longest possible call is 1 hour no matter who is the recipient.

Finally, consider the case where j ε **C**. We assume, just for the case of simplicity here, that **C =** $\mathbf{C_1}$ v $\mathbf{C_2}$, where $\mathbf{C_1}$ and $\mathbf{C_2}$ are distinct cliques of individuals, both of which will receive assignments via the bad messages for their roles in a terrorist event. If j ε $\mathbf{C_1}$, he selects a member of $\mathbf{C_2}$ with probability $1/\{|\mathbf{C_2}|]$ and sends a good message with probability p(G) and a bad message with probability 1 - p(G) = p(B). A bad message can only be sent if **H** has previously sent at least one bad message to someone in $\mathbf{C_1}$. If no such messages have been transmitted into $\mathbf{C_1}$, then j just sends a good message to a randomly selected individual in $\mathbf{C_2}$**.** If a bad message is transmitted, its duration is 1 minute. For a good message, the duration is drawn as described in item 4 above.

At the end of each day, the message traffic from every sender to the corresponding receivers is placed in a log, together with the duration of the messages and their type. This is the information that an observer will work with in an effort to use the message traffic to identify **C** and **H.**