G-network Models to Support Planning for Disaster Relief Distribution

Supplementary Material

Product Form Proof For Full Batch Transfer For State Group S_1

We prove the product form result by substitution, and using the definitions of q_i, λ_i^+ and λ_i^-. The balance equations in Equation 5 take the form given in Equation 1 for the states in S_1.

$$\begin{aligned} p(k)\sum_i \left[\lambda_{0i}^+ + \lambda_{0i}^- + \mu_i\right] &= \sum_i p(k_i^+)\mu_i d(i) \\ &+ \sum_i p(k_i^-)\lambda_{0i}^+ \\ &+ \sum_i \lambda_{0i}^- D(i) \sum_{s=1}^{\infty} \pi_{is} p(k_i^{+s}) \\ &+ \sum_i \sum_j \left[p(k_{ij}^{+-})\mu_i p^+(i,j)\right] \\ &+ \sum_i \sum_j \sum_{s=1}^{\infty} \pi_{is} p(k_{ij}^{+s-s})\lambda_{0i}^- q(i,j) \end{aligned} \tag{1}$$

Assuming the product form result holds for all states in S_1, these balance equations reduce to Equation 2 below.

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$$
\begin{aligned}
\sum_i \left[\lambda_{0i}^+ + \lambda_{0i}^- + \mu_i\right] &= \sum_i \mu_i q_i d(i) \\
&+ \sum_i \frac{\lambda_{0i}^+}{q_i} \\
&+ \sum_i \lambda_{0i}^- D(i) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \sum_j \frac{\mu_i q_i p^+(i,j)}{q_j} \\
&+ \sum_i \sum_j \lambda_{0i}^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{q_i^s}{q_j^s} \qquad (2)
\end{aligned}
$$

$$
\sum_i \frac{\lambda_{0i}^+}{q_i} + \sum_i \sum_j \frac{\mu_j q_j p^+(j,i)}{q_i} = \sum_i \frac{\lambda_i^+}{q_i} - \sum_i \sum_j \sum_{s=1}^{\infty} \pi_{js} \frac{\lambda_j^- q(j,i) s q_j^s}{q_i} \qquad (3)
$$

We simplify the balance equations (Equation 2) by substituting Equation 3 obtained from Equation **??**. Then, we use Equation 3 and the definition of λ_i^- given by Equation **??** to obtain Equation 4.

$$
\begin{aligned}
\sum_i \left[\lambda_{0i}^+ + \lambda_{0i}^- + \mu_i\right] &= \sum_i \mu_i q_i d(i) \\
&+ \sum_i \lambda_i^- D(i) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{q_i^s}{q_j^s} \\
&- \sum_i \sum_j \sum_{s=1}^{\infty} \pi_{js} \frac{\lambda_j^- q(j,i) s q_j^s}{q_i} \\
&+ \sum_i \frac{\lambda_i^+}{q_i} \qquad (4)
\end{aligned}
$$

Next, we insert definitions for λ_i^+ and λ_i^- (Equations **??** and **??**) into the left hand side (LHS) terms, and $D(i)$ and $d(i)$ on the right hand side (RHS), to obtain Equation 5.

$$\begin{aligned}
\sum_i \lambda_i^+ - \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s + \sum_i \mu_i \quad + & \quad \sum_i \lambda_i^- = \\
& \quad \sum_i \mu_i q_i \\
+ & \quad \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
- & \quad \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
+ & \quad \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{q_i^s}{q_j^s} \\
- & \quad \sum_i \sum_j \frac{\lambda_j^- q(j,i) \sum_{s=1}^{\infty} \pi_{js} s q_j^s}{q_i} \\
+ & \quad \sum_i \frac{\lambda_i^+}{q_i} \qquad (5)
\end{aligned}$$

Next, we use the definition of q_i (from Equation **??**) to rewrite λ_i^+ on both the LHS and the RHS. We also interchange i and j in the 5th term, using the fact that both i and j are in the set $\{1, 2, ..., N\}$. Then the balance equation (Equation 5) can be written as Equation 6.

$$
\begin{aligned}
0 &= \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{q_i^s}{q_j^s} + \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} s q_i^{s-1} \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{s q_i^s}{q_j} + \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s + \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s \\
&- \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} s q_i^s - \sum_i \lambda_i^- \qquad (6)
\end{aligned}
$$

Combining common terms, we get Equation 7. Further simplification results in Equation 8.

$$
\begin{aligned}
0 &= \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \left[\frac{q_i^s}{q_j^s} - \frac{s q_i^s}{q_j} - q_i^s + s q_i^s \right] \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} \left[s q_i^{s-1} + q_i^s - s q_i^s - 1 \right] \qquad (7)
\end{aligned}
$$

$$
0 = \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} \left[s q_i^{s-1} - s q_i^{s-1} + q_i^s - q_i^s - s q_i^s + s q_i^s - 1 + 1 \right] \qquad (8)
$$

It can be seen that the equation holds for balance networks where $q_i = q_j, \forall (i,j) \in N$ given that $\sum_j q(i,j) = 1$. This completes the proof for state subset S_1.

Product Form Proof For Full Batch Transfer For State Group S_2

Recall that state group S_2 is defined as $S_2 = \{k_1(t), ..., k_i(t), ..., k_j(t), ..., k_N(t)\} : k_i(t) < s$, for at least one i and $k_i(t) \neq 0 \ \forall i \quad i,j \in \{1, 2, .., N\}$. The proof below considers the case where $k_i(t) < s, \quad \forall i$. The proof where $k_i(t) < s$ for some but not all i is a combination of the proof for this special case and the proof for states in S_1.

Proof. For the states in S_1 the balance equations given by Equation 5 take the form given in 9 following the substitution of product form $p(k) = \prod_{i=1}^{N} p(k_i)$ where $p(k_i) = (1 - q_i)(q_i^{k_i})$.

$$
\begin{aligned}
\sum_i \left[\lambda_{0i}^+ + \mu_i\right] &= \sum_i \mu_i q_i d(i) \\
&+ \sum_i \frac{\lambda_{0i}^+}{q_i} \\
&+ \sum_i \lambda_{0i}^- D(i) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \sum_j \frac{\mu_i q_i p^+(i,j)}{q_j}
\end{aligned}
\tag{9}
$$

We simplify the balance equations by using Equations 10 and obtain the balance equations given by 11.

$$
\sum_i \frac{\lambda_{0i}^+}{q_i} + \sum_i \sum_j \frac{\mu_j q_j p^+(j,i)}{q_i} = \sum_i \frac{\lambda_i^+}{q_i} - \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{s q_i^s}{q_j} \tag{10}
$$

$$
\begin{aligned}
\sum_i \left[\lambda_{0i}^+ + \mu_i\right] &= \sum_i \mu_i q_i d(i) \\
&+ \sum_i \lambda_i^- D(i) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \frac{\lambda_i^+}{q_i} \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \frac{\pi_{is} s q_i^s}{q_j}
\end{aligned}
\tag{11}
$$

Next we insert the definition for λ_i^+ given by **??** on both the LHS and the RHS while inserting the definitions of $D(i)$ and $d(i)$ to the RHS. yields Equation 12.

$$\begin{aligned}
\sum_i \lambda_i^+ - \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s + \sum_i \mu_i &= \sum_i \mu_i q_i \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{s q_i^s}{q_j} \\
&+ \sum_i \frac{\lambda_i^+}{q_i} \qquad (12)
\end{aligned}$$

Next we use the definition of q_i in Equation **??** to rewrite λ_i^+ on both the LHS and the RHS. Then the balance equations can be written as Equation 13.

$$\begin{aligned}
0 &= \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} s q_i^{s-1} \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \frac{s q_i^s}{q_j} \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s \\
&- \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} s q_i^s \qquad (13)
\end{aligned}$$

Rearranging the terms we get Equation 14 where it can be seen that the equation holds for balance networks where $q_i = q_j,\ \forall (i,j) \in N$ given that $\sum_j q(i,j) = 1\,\forall i \in N$.

$$
\begin{aligned}
0 &= \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \left[-\frac{s q_i^s}{q_j} - q_i^s + s q_i^s \right] \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} \left[s q_i^{s-1} + q_i^s - s q_i^s \right] \qquad (14)
\end{aligned}
$$

This proves the product form result for states in S_2.

□

Product Form Proof for Full Batch Departure For State Group S_3
Recall that state group S_3 is defined as $S_3 = \{k_1(t), ..., k_i(t), ..., k_j(t), ..., k_N(t)\}$: $k_i(t) = 0$, for at least one i, $i \in \{1, 2, .., N\}$. The proof below considers the case where $k_i(t) = 0, \quad \forall i$. The proof where $k_i(t) = 0$ for some but not all i is a combination of the proof for this special case and the proof for states in S_1 and S_2.

Proof. For the states in S_3 the balance equations given by Equation 5 take the form given in Equation 15 following the substitution of product form $p(k) = \prod_{i=1}^{N} p(k_i)$ where $p(k_i) = (1 - q_i)(q_i^{k_i})$.

$$
\begin{aligned}
\sum_i \lambda_{0i}^+ &= \sum_i \mu_i q_i d(i) \\
&+ \sum_i \lambda_{0i}^- D(i) \sum_{s=1}^{\infty} \pi_{is} q_i^s \qquad (15)
\end{aligned}
$$

Next we insert the definition for λ_i^+ given by **??** on the LHS terms and insert the definitions of $D(i)$ and $d(i)$ to the RHS terms yielding Equation 16.

$$
\begin{aligned}
\sum_i \lambda_i^+ - \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s &= \sum_i \mu_i q_i \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s \quad (16)
\end{aligned}
$$

Next we use the definition of q_i in Equation **??** to rewrite λ_i^+ on the LHS and the RHS. Then the balance equations can be written as Equation 17.

$$
\begin{aligned}
0 &= \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&- \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} q_i^s \\
&+ \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} s q_i^s \\
&- \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} s q_i^s \quad (17)
\end{aligned}
$$

Rearranging the terms we get Equation 18 where it can be seen that the equation holds for balance networks where $q_i = q_j$, $\forall (i,j) \in N$ given that $\sum_j q(i,j) = 1 \, \forall i \in N$.

$$
\begin{aligned}
0 &= \sum_i \sum_j \lambda_i^- q(i,j) \sum_{s=1}^{\infty} \pi_{is} \left[s q_i^s - q_i^s \right] \\
&+ \sum_i \lambda_i^- \sum_{s=1}^{\infty} \pi_{is} \left[q_i^s - s q_i^s \right] \quad (18)
\end{aligned}
$$

This proves the product form result for states in S_3. □

Table 1: Experiment Results for Full Batch Transfer: 53 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	29.98	23.02	0.50	0.12	29.98	23.02	0.50	0.11	0%	0%	0%	4%
A,2		1	4	28.93	24.07	0.31	0.15	28.90	24.10	0.32	0.13	0%	0%	5%	13%
A,3		1	6	28.57	24.43	0.25	0.17	28.44	24.56	0.28	0.13	0%	1%	11%	20%
A,4		1	8	28.56	24.44	0.24	0.18	28.30	24.70	0.27	0.14	1%	1%	15%	24%
B,5		2	1	29.93	23.07	0.48	0.11	29.93	23.07	0.48	0.11	0%	0%	0%	0%
B,6		4	1	28.27	24.73	0.27	0.14	28.27	24.73	0.27	0.14	0%	0%	0%	0%
B,7		6	1	26.78	26.22	0.19	0.17	26.78	26.22	0.19	0.17	0%	0%	0%	0%
B,8		8	1	25.44	27.56	0.15	0.23	25.44	27.56	0.15	0.23	0%	0%	0%	0%
C,9		2	2	28.44	24.56	0.28	0.14	28.44	24.56	0.28	0.13	0%	0%	0%	6%
C,10		2	3	27.56	25.44	0.22	0.17	27.53	25.47	0.22	0.15	0%	0%	4%	12%
C,11		3	2	27.11	25.89	0.20	0.18	27.11	25.89	0.20	0.16	0%	0%	0%	7%
A,12	$\beta = 0.56$	1	2	28.04	24.96	0.25	0.15	28.04	24.96	0.25	0.14	0%	0%	0%	3%
A,13		1	4	27.28	25.72	0.20	0.18	27.25	25.75	0.21	0.16	0%	0%	5%	10%
A,14		1	6	27.15	25.85	0.18	0.19	27.02	25.98	0.20	0.17	0%	0%	9%	14%
A,15		1	8	27.25	25.75	0.18	0.20	27.02	25.98	0.20	0.17	1%	1%	11%	15%
B,16		2	1	27.93	25.07	0.25	0.14	27.93	25.07	0.25	0.14	0%	0%	0%	0%
B,17		4	1	26.38	26.62	0.18	0.19	26.38	26.62	0.18	0.19	0%	0%	0%	0%
B,18		6	1	24.99	28.01	0.14	0.25	24.99	28.01	0.14	0.25	0%	0%	0%	0%
B,19		8	1	23.74	29.26	0.12	0.36	23.74	29.26	0.12	0.36	0%	0%	0%	0%
C,20		2	2	26.63	26.37	0.19	0.19	26.63	26.37	0.19	0.18	0%	0%	0%	5%
C,21		2	3	25.96	27.04	0.16	0.22	25.93	27.07	0.16	0.20	0%	0%	3%	9%
C,22		3	2	25.41	27.59	0.15	0.24	25.41	27.59	0.15	0.23	0%	0%	0%	6%

Table 2: Experiment Results for Full Batch Transfer: 50 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	28.30	21.70	0.30	0.10	28.30	21.70	0.30	0.10	0.00%	0.00%	0.02%	3.51%
A,2		1	4	27.46	22.54	0.23	0.13	27.43	22.57	0.24	0.11	0.12%	0.14%	4.95%	12.22%
A,3		1	6	27.26	22.74	0.20	0.14	27.14	22.86	0.22	0.11	0.47%	0.56%	9.82%	17.86%
A,4		1	8	27.34	22.66	0.20	0.15	27.10	22.90	0.22	0.11	0.89%	1.07%	12.23%	20.81%
B,5		2	1	28.21	21.79	0.30	0.10	28.21	21.79	0.30	0.10	0.00%	0.00%	0.01%	0.00%
B,6		4	1	26.63	23.37	0.20	0.12	26.63	23.37	0.20	0.12	0.00%	0.00%	0.00%	0.00%
B,7		6	1	25.21	24.79	0.16	0.15	25.21	24.79	0.16	0.15	0.00%	0.00%	0.00%	0.00%
B,8		8	1	23.94	26.06	0.13	0.18	23.94	26.06	0.13	0.18	0.00%	0.00%	0.00%	0.00%
C,9		2	2	26.86	23.14	0.21	0.13	26.86	23.14	0.21	0.12	0.00%	0.00%	0.00%	5.60%
C,10		2	3	26.12	23.88	0.18	0.15	26.10	23.90	0.18	0.13	0.11%	0.12%	3.33%	11.17%
C,11		3	2	25.60	24.40	0.17	0.15	25.60	24.40	0.17	0.14	0.00%	0.00%	0.00%	6.84%
A,12	$\beta = 0.56$	1	2	26.46	23.54	0.19	0.13	26.46	23.54	0.19	0.12	0.00%	0.00%	0.00%	2.81%
A,13		1	4	25.87	24.13	0.17	0.15	25.84	24.16	0.17	0.13	0.12%	0.13%	4.22%	8.99%
A,14		1	6	25.84	24.16	0.16	0.16	25.73	24.27	0.17	0.14	0.43%	0.46%	7.79%	12.30%
A,15		1	8	26.08	23.92	0.15	0.15	25.90	24.10	0.16	0.13	1%	1%	9%	13%
B,16		2	1	26.33	23.67	0.19	0.13	26.33	23.67	0.19	0.13	0.00%	0.00%	0.00%	0.00%
B,17		4	1	24.85	25.15	0.15	0.15	24.85	25.15	0.15	0.15	0.00%	0.00%	0.00%	0.00%
B,18		6	1	23.53	26.47	0.12	0.19	23.53	26.47	0.12	0.19	0.00%	0.00%	0.00%	0.00%
B,19		8	1	22.40	27.60	0.10	0.23	22.40	27.60	0.10	0.23	0.00%	0.00%	0.00%	0.00%
C,20		2	2	25.14	24.86	0.15	0.16	25.14	24.86	0.15	0.15	0.00%	0.00%	0.00%	4.53%
C,21		2	3	24.59	25.41	0.14	0.18	24.57	25.43	0.14	0.16	0.11%	0.11%	3.00%	8.63%
C,22		3	2	23.99	26.01	0.13	0.19	23.99	26.01	0.13	0.18	0.00%	0.00%	0.00%	5.56%

Table 3: Experiment Results for Full Batch Transfer: 47 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	26.67	20.33	0.19	0.09	26.67	20.33	0.19	0.09	0%	0%	0%	3%
A,2		1	4	26.10	20.90	0.16	0.10	26.06	20.94	0.17	0.09	0%	0%	4%	10%
A,3		1	6	26.07	20.93	0.15	0.11	25.96	21.04	0.17	0.09	0%	1%	8%	15%
A,4		1	8	26.22	20.78	0.15	0.11	26.04	20.96	0.17	0.09	1%	1%	9%	16%
B,5		2	1	26.54	20.46	0.18	0.09	26.54	20.46	0.18	0.09	0%	0%	0%	0%
B,6		4	1	25.07	21.93	0.14	0.10	25.07	21.93	0.14	0.10	0%	0%	0%	0%
B,7		6	1	23.75	23.25	0.12	0.11	23.75	23.25	0.12	0.11	0%	0%	0%	0%
B,8		8	1	22.56	24.44	0.11	0.13	22.56	24.44	0.11	0.13	0%	0%	0%	0%
C,9		2	2	25.36	21.64	0.15	0.10	25.36	21.64	0.15	0.10	0%	0%	0%	5%
C,10		2	3	24.82	22.18	0.13	0.11	24.79	22.21	0.14	0.10	0%	0%	3%	10%
C,11		3	2	24.21	22.79	0.13	0.12	24.21	22.79	0.13	0.11	0%	0%	0%	6%
A,12	$\beta = 0.56$	1	2	24.93	22.07	0.14	0.10	24.93	22.07	0.14	0.10	0%	0%	0%	3%
A,13		1	4	24.55	22.45	0.13	0.11	24.52	22.48	0.13	0.11	0%	0%	3%	8%
A,14		1	6	24.62	22.38	0.13	0.12	24.54	22.46	0.13	0.10	0%	0%	6%	10%
A,15		1	8	24.80	22.20	0.13	0.12	24.67	22.33	0.14	0.10	1%	1%	7%	10%
B,16		2	1	24.77	22.23	0.14	0.10	24.77	22.23	0.14	0.10	0%	0%	0%	0%
B,17		4	1	23.40	23.60	0.12	0.12	23.40	23.60	0.12	0.12	0%	0%	0%	0%
B,18		6	1	22.16	24.84	0.10	0.14	22.16	24.84	0.10	0.14	0%	0%	0%	0%
B,19		8	1	21.06	25.94	0.09	0.17	21.06	25.94	0.09	0.17	0%	0%	0%	0%
C,20		2	2	23.74	23.26	0.12	0.12	23.74	23.26	0.12	0.11	0%	0%	0%	4%
C,21		2	3	23.34	23.66	0.11	0.13	23.32	23.68	0.12	0.12	0%	0%	3%	8%
C,22		3	2	22.69	24.31	0.11	0.14	22.69	24.31	0.11	0.13	0%	0%	0%	5%

Table 4: Experiment Results for Full Batch Transfer: 44 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	25.01	18.99	0.14	0.08	25.01	18.99	0.14	0.08	0%	0%	0%	3%
A,2		1	4	24.62	19.38	0.13	0.09	24.59	19.41	0.13	0.08	0%	0%	4%	9%
A,3		1	6	24.69	19.31	0.13	0.09	24.60	19.40	0.14	0.08	0%	0%	6%	12%
A,4		1	8	24.87	19.13	0.13	0.09	24.73	19.27	0.14	0.08	1%	1%	7%	12%
B,5		2	1	24.85	19.15	0.14	0.08	24.85	19.15	0.14	0.08	0%	0%	0%	0%
B,6		4	1	23.47	20.53	0.12	0.09	23.47	20.53	0.12	0.09	0%	0%	0%	0%
B,7		6	1	22.23	21.77	0.10	0.10	22.23	21.77	0.10	0.10	0%	0%	0%	0%
B,8		8	1	21.12	22.88	0.09	0.11	21.12	22.88	0.09	0.11	0%	0%	0%	0%
C,9		2	2	23.81	20.19	0.12	0.09	23.81	20.19	0.12	0.08	0%	0%	0%	5%
C,10		2	3	23.41	20.59	0.11	0.10	23.38	20.62	0.12	0.09	0%	0%	3%	9%
C,11		3	2	22.75	21.25	0.11	0.10	22.75	21.25	0.11	0.09	0%	0%	0%	6%
A,12	$\beta = 0.56$	1	2	23.38	20.62	0.12	0.09	23.38	20.62	0.12	0.09	0%	0%	0%	2%
A,13		1	4	23.13	20.87	0.11	0.10	23.10	20.90	0.11	0.09	0%	0%	3%	7%
A,14		1	6	23.25	20.75	0.11	0.10	23.19	20.81	0.11	0.09	0%	0%	5%	8%
A,15		1	8	23.43	20.57	0.11	0.10	23.35	20.65	0.12	0.09	0%	0%	5%	8%
B,16		2	1	23.19	20.81	0.11	0.09	23.19	20.81	0.11	0.09	0%	0%	0%	0%
B,17		4	1	21.90	22.10	0.10	0.10	21.90	22.10	0.10	0.10	0%	0%	0%	0%
B,18		6	1	20.75	23.25	0.09	0.11	20.75	23.25	0.09	0.11	0%	0%	0%	0%
B,19		8	1	19.71	24.29	0.08	0.13	19.71	24.29	0.08	0.13	0%	0%	0%	0%
C,20		2	2	22.28	21.72	0.10	0.10	22.28	21.72	0.10	0.10	0%	0%	0%	4%
C,21		2	3	22.00	22.00	0.10	0.11	21.97	22.03	0.10	0.10	0%	0%	2%	7%
C,22		3	2	21.31	22.69	0.09	0.11	21.31	22.69	0.09	0.11	0%	0%	0%	5%

Table 5: Experiment Results for Partial Batch Transfer: 53 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W_1}$	$\bar{W_2}$	TH_1	TH_2	$\bar{W_1}$	$\bar{W_2}$	TH_1	TH_2	$\bar{W_1}$	$\bar{W_2}$
A,1	$\beta = 0.6$	1	2	29.98	23.01	0.49	0.12	29.98	23.02	0.50	0.11	0%	0%	1%	4%
A,2		1	4	28.72	24.28	0.31	0.15	28.72	24.28	0.31	0.13	0%	0%	0%	14%
A,3		1	6	27.96	25.04	0.25	0.18	27.96	25.04	0.25	0.14	0%	0%	0%	22%
A,4		1	8	27.50	25.50	0.22	0.21	27.50	25.50	0.22	0.15	0%	0%	0%	28%
B,5		2	1	29.93	23.07	0.48	0.11	29.93	23.07	0.48	0.11	0%	0%	1%	0%
B,6		4	1	28.27	24.73	0.27	0.14	28.27	24.73	0.27	0.14	0%	0%	0%	0%
B,7		6	1	26.78	26.22	0.19	0.17	26.78	26.22	0.19	0.17	0%	0%	0%	0%
B,8		8	1	25.44	27.56	0.15	0.23	25.44	27.56	0.15	0.23	0%	0%	0%	0%
C,9		2	2	28.44	24.56	0.28	0.14	28.44	24.56	0.28	0.13	0%	0%	0%	6%
C,10		2	3	27.37	25.63	0.22	0.18	27.37	25.63	0.22	0.16	0%	0%	0%	12%
C,11		3	2	27.11	25.89	0.20	0.18	27.11	25.89	0.20	0.16	0%	0%	0%	7%
A,12	$\beta = 0.56$	1	2	28.04	24.96	0.25	0.15	28.04	24.96	0.25	0.14	0%	0%	0%	3%
A,13		1	4	27.01	25.99	0.20	0.19	27.01	25.99	0.20	0.17	0%	0%	0%	11%
A,14		1	6	26.44	26.56	0.18	0.22	26.44	26.56	0.18	0.18	0%	0%	0%	17%
A,15		1	8	26.12	26.88	0.17	0.25	26.12	26.88	0.17	0.20	0%	0%	0%	21%
B,16		2	1	27.93	25.07	0.25	0.14	27.93	25.07	0.25	0.14	0%	0%	0%	0%
B,17		4	1	26.38	26.62	0.18	0.19	26.38	26.62	0.18	0.19	0%	0%	0%	0%
B,18		6	1	24.99	28.01	0.14	0.25	24.99	28.01	0.14	0.25	0%	0%	0%	0%
B,19		8	1	23.74	29.26	0.12	0.36	23.74	29.26	0.12	0.36	0%	0%	0%	0%
C,20		2	2	26.63	26.37	0.19	0.19	26.63	26.37	0.19	0.18	0%	0%	0%	5%
C,21		2	3	25.74	27.26	0.16	0.23	25.74	27.26	0.16	0.21	0%	0%	0%	10%
C,22		3	2	25.41	27.59	0.15	0.24	25.41	27.59	0.15	0.23	0%	0%	0%	6%

Table 6: Experiment Results for Partial Batch Transfer: 50 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	28.30	21.70	0.30	0.10	28.30	21.70	0.30	0.10	0.00%	0.00%	0.02%	3.51%
A,2		1	4	27.21	22.79	0.23	0.13	27.21	22.79	0.23	0.11	0.00%	0.00%	0.00%	13.11%
A,3		1	6	26.58	23.42	0.20	0.15	26.58	23.42	0.20	0.12	0.00%	0.00%	0.00%	20.63%
A,4		1	8	26.22	23.78	0.19	0.17	26.22	23.78	0.19	0.13	0.00%	0.00%	0.00%	25.58%
B,5		2	1	28.21	21.79	0.30	0.10	28.21	21.79	0.30	0.10	0.00%	0.00%	0.01%	0.00%
B,6		4	1	26.63	23.37	0.20	0.12	26.63	23.37	0.20	0.12	0.00%	0.00%	0.00%	0.00%
B,7		6	1	25.21	24.79	0.16	0.15	25.21	24.79	0.16	0.15	0.00%	0.00%	0.00%	0.00%
B,8		8	1	23.94	26.06	0.13	0.18	23.94	26.06	0.13	0.18	0.00%	0.00%	0.00%	0.00%
C,9		2	2	26.86	23.14	0.21	0.13	26.86	23.14	0.21	0.12	0.00%	0.00%	0.00%	5.60%
C,10		2	3	25.91	24.09	0.18	0.15	25.91	24.09	0.18	0.13	0.00%	0.00%	0.00%	11.71%
C,11		3	2	25.60	24.40	0.17	0.15	25.60	24.40	0.17	0.14	0.00%	0.00%	0.00%	6.84%
A,12	$\beta = 0.56$	1	2	26.46	23.54	0.19	0.13	26.46	23.54	0.19	0.12	0.00%	0.00%	0.00%	2.81%
A,13		1	4	25.58	24.42	0.17	0.16	25.58	24.42	0.17	0.14	0.00%	0.00%	0.00%	10.15%
A,14		1	6	25.11	24.89	0.15	0.18	25.11	24.89	0.15	0.15	0.00%	0.00%	0.00%	15.76%
A,15		1	8	24.95	25.05	0.14	0.18	24.95	25.05	0.14	0.14	0%	0%	0%	19%
B,16		2	1	26.33	23.67	0.19	0.13	26.33	23.67	0.19	0.13	0.00%	0.00%	0.00%	0.00%
B,17		4	1	24.85	25.15	0.15	0.15	24.85	25.15	0.15	0.15	0.00%	0.00%	0.00%	0.00%
B,18		6	1	23.53	26.47	0.12	0.19	23.53	26.47	0.12	0.19	0.00%	0.00%	0.00%	0.00%
B,19		8	1	22.40	27.60	0.10	0.23	22.40	27.60	0.10	0.23	0.00%	0.00%	0.00%	0.00%
C,20		2	2	25.14	24.86	0.15	0.16	25.14	24.86	0.15	0.15	0.00%	0.00%	0.00%	4.53%
C,21		2	3	24.35	25.65	0.14	0.19	24.35	25.65	0.14	0.17	0.00%	0.00%	0.00%	9.35%
C,22		3	2	23.99	26.01	0.13	0.19	23.99	26.01	0.13	0.18	0.00%	0.00%	0.00%	5.56%

Table 7: Experiment Results for Partial Batch Transfer: 47 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	26.67	20.33	0.19	0.09	26.67	20.33	0.19	0.09	0%	0%	0%	3%
A,2		1	4	25.80	21.20	0.16	0.10	25.80	21.20	0.16	0.09	0%	0%	0%	12%
A,3		1	6	25.33	21.67	0.15	0.12	25.33	21.67	0.15	0.10	0%	0%	0%	18%
A,4		1	8	25.09	21.91	0.14	0.13	25.09	21.91	0.14	0.10	0%	0%	0%	22%
B,5		2	1	26.54	20.46	0.18	0.09	26.54	20.46	0.18	0.09	0%	0%	0%	0%
B,6		4	1	25.07	21.93	0.14	0.10	25.07	21.93	0.14	0.10	0%	0%	0%	0%
B,7		6	1	23.75	23.25	0.12	0.11	23.75	23.25	0.12	0.11	0%	0%	0%	0%
B,8		8	1	22.56	24.44	0.11	0.13	22.56	24.44	0.11	0.13	0%	0%	0%	0%
C,9		2	2	25.36	21.64	0.15	0.10	25.36	21.64	0.15	0.10	0%	0%	0%	5%
C,10		2	3	24.58	22.42	0.13	0.12	24.58	22.42	0.13	0.10	0%	0%	0%	11%
C,11		3	2	24.21	22.79	0.13	0.12	24.21	22.79	0.13	0.11	0%	0%	0%	6%
A,12	$\beta = 0.56$	1	2	24.93	22.07	0.14	0.10	24.93	22.07	0.14	0.10	0%	0%	0%	3%
A,13		1	4	24.23	22.77	0.13	0.12	24.23	22.77	0.13	0.11	0%	0%	0%	9%
A,14		1	6	23.89	23.11	0.12	0.13	23.89	23.11	0.12	0.11	0%	0%	0%	14%
A,15		1	8	23.72	23.28	0.12	0.14	23.72	23.28	0.12	0.11	0%	0%	0%	17%
A,16		2	1	24.77	22.23	0.14	0.10	24.77	22.23	0.14	0.10	0%	0%	0%	0%
A,17		4	1	23.40	23.60	0.12	0.12	23.40	23.60	0.12	0.12	0%	0%	0%	0%
A,18		6	1	22.16	24.84	0.10	0.14	22.16	24.84	0.10	0.14	0%	0%	0%	0%
A,19		8	1	21.06	25.94	0.09	0.17	21.06	25.94	0.09	0.17	0%	0%	0%	0%
A,20		2	2	23.74	23.26	0.12	0.12	23.74	23.26	0.12	0.11	0%	0%	0%	4%
A,21		2	3	23.09	23.91	0.11	0.14	23.09	23.91	0.11	0.12	0%	0%	0%	9%
A,22		3	2	22.69	24.31	0.11	0.14	22.69	24.31	0.11	0.13	0%	0%	0%	5%

Table 8: Experiment Results for Partial Batch Transfer: 44 victims/hour

Case No	β	Variables		Markov Chain Result				G-Network Result				Absolute Error Percentage (E_p)			
		λ_1^-	B_1	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$	TH_1	TH_2	$\bar{W}_1$	$\bar{W}_2$
A,1	$\beta = 0.6$	1	2	25.01	18.99	0.14	0.08	25.01	18.99	0.14	0.08	0%	0%	0%	3%
A,2		1	4	24.29	19.71	0.13	0.09	24.29	19.71	0.13	0.08	0%	0%	0%	10%
A,3		1	6	23.95	20.05	0.12	0.10	23.95	20.05	0.12	0.08	0%	0%	0%	16%
A,4		1	8	23.78	20.22	0.12	0.11	23.78	20.22	0.12	0.08	0%	0%	0%	19%
B,5		2	1	24.85	19.15	0.14	0.08	24.85	19.15	0.14	0.08	0%	0%	0%	0%
B,6		4	1	23.47	20.53	0.12	0.09	23.47	20.53	0.12	0.09	0%	0%	0%	0%
B,7		6	1	22.23	21.77	0.10	0.10	22.23	21.77	0.10	0.10	0%	0%	0%	0%
B,8		8	1	21.12	22.88	0.09	0.11	21.12	22.88	0.09	0.11	0%	0%	0%	0%
C,9		2	2	23.81	20.19	0.12	0.09	23.81	20.19	0.12	0.08	0%	0%	0%	5%
C,10		2	3	23.15	20.85	0.11	0.10	23.15	20.85	0.11	0.09	0%	0%	0%	10%
C,11		3	2	22.75	21.25	0.11	0.10	22.75	21.25	0.11	0.09	0%	0%	0%	6%
A,12	$\beta = 0.56$	1	2	23.38	20.62	0.12	0.09	23.38	20.62	0.12	0.09	0%	0%	0%	2%
A,13		1	4	22.80	21.20	0.11	0.10	22.80	21.20	0.11	0.09	0%	0%	0%	8%
A,14		1	6	22.55	21.45	0.11	0.11	22.55	21.45	0.11	0.09	0%	0%	0%	12%
A,15		1	8	22.43	21.57	0.10	0.11	22.43	21.57	0.10	0.10	0%	0%	0%	14%
B,16		2	1	23.19	20.81	0.11	0.09	23.19	20.81	0.11	0.09	0%	0%	0%	0%
B,17		4	1	21.90	22.10	0.10	0.10	21.90	22.10	0.10	0.10	0%	0%	0%	0%
B,18		6	1	20.75	23.25	0.09	0.11	20.75	23.25	0.09	0.11	0%	0%	0%	0%
B,19		8	1	19.71	24.29	0.08	0.13	19.71	24.29	0.08	0.13	0%	0%	0%	0%
C,20		2	2	22.28	21.72	0.10	0.10	22.28	21.72	0.10	0.10	0%	0%	0%	4%
C,21		2	3	21.73	22.27	0.10	0.11	21.73	22.27	0.10	0.10	0%	0%	0%	8%
C,22		3	2	21.31	22.69	0.09	0.11	21.31	22.69	0.09	0.11	0%	0%	0%	5%

Table 9: Change in Victim Needs (Tarpaulin to Cash): Results

Experiment	RC	Item	Utilization	Effective Arrivals	TH	L	W
1	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.832	16.73	15.89	7.05	0.44
	3	T2	0.832	16.73	15.89	7.05	0.44
	4	T3	0.832	16.73	15.89	7.05	0.44
	5	C	0.786	50.55	50.55	3.67	0.07
2	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.807	16.73	15.41	7.05	0.45
	3	T2	0.807	16.73	15.41	7.05	0.45
	4	T3	0.807	16.73	15.41	7.05	0.45
	5	C	0.808	51.97	51.97	4.21	0.08
3	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.796	16.73	15.20	7.05	0.46
	3	T2	0.796	16.73	15.20	7.05	0.46
	4	T3	0.796	16.73	15.20	7.05	0.46
	5	C	0.818	52.60	52.60	4.49	0.085
4	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.793	16.73	15.14	7.05	0.46
	3	T2	0.793	16.73	15.14	7.05	0.46
	4	T3	0.793	16.73	15.14	7.05	0.46
	5	C	0.821	52.80	52.80	4.59	0.087
5	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.792	16.73	15.12	7.05	0.46
	3	T2	0.792	16.73	15.12	7.05	0.46
	4	T3	0.792	16.73	15.12	7.05	0.46
	5	C	0.821	52.81	52.81	4.59	0.087
6	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.757	16.73	14.45	7.05	0.48
	3	T2	0.757	16.73	14.45	7.05	0.48
	4	T3	0.757	16.73	14.45	7.05	0.48
	5	C	0.853	54.87	54.87	5.81	0.10
7	1	B	0.850	50.44	50.44	5.57	0.11
	2	T1	0.724	16.73	13.82	7.05	0.51
	3	T2	0.724	16.73	13.82	7.05	0.51
	4	T3	0.724	16.73	13.82	7.05	0.51
	5	C	0.882	56.75	56.75	7.51	0.13

Table 10: Victim Jockeying: Results

Experiment	RC	Utilization	Effective Arrivals	TH	L	W
1	B	0.85	50.44	50.44	5.57	0.11
	T1	0.84	16.73	15.89	7.36	0.46
	T2	0.97	18.40	18.40	30.64	1.67
	T3	0.84	16.73	15.89	7.36	0.46
	C	0.75	48.06	48.06	2.96	0.06
2	B	0.85	50.44	50.44	5.57	0.11
	T1	0.81	16.73	15.41	7.36	0.48
	T2	1.02*	19.36*	N/A	N/A	N/A
	T3	0.81	16.73	15.41	7.36	0.48
	C	0.75	48.06	48.06	2.96	0.06
3	B	0.85	50.44	50.44	5.57	0.11
	T1	0.80	16.73	15.19	7.36	0.48
	T2	1.04*	19.79*	N/A	N/A	N/A
	T3	0.80	16.73	15.19	7.36	0.48
	C	0.75	48.06	48.06	2.96	0.06
4	B	0.85	50.44	50.44	5.57	0.11
	T1	0.80	16.73	15.13	7.36	0.49
	T2	1.05*	19.91*	N/A	N/A	N/A
	T3	0.80	16.73	15.13	7.36	0.49
	C	0.75	48.06	48.06	2.96	0.06
5	B	0.85	50.44	50.44	5.57	0.11
	T1	0.76	16.73	14.42	7.36	0.51
	T2	1.12*	21.34*	N/A	N/A	N/A
	T3	0.76	16.73	14.42	7.36	0.51
	C	0.75	48.06	48.06	2.96	0.06
6	B	0.85	50.44	50.44	5.57	0.11
	T1	0.75	16.73	14.21	7.36	0.52
	T2	1.14*	21.75*	N/A	N/A	N/A
	T3	0.75	16.73	14.21	7.36	0.52
	C	0.75	48.06	48.06	2.96	0.06
7	B	0.85	50.44	50.44	5.57	0.11
	T1	0.76	16.73	14.45	7.36	0.51
	T2	1.12*	21.29*	N/A	N/A	N/A
	T3	0.76	16.73	14.45	7.36	0.51
	C	0.75	48.06	48.06	2.96	0.06
8	B	0.85	50.44	50.44	5.57	0.11
	T1	0.72	16.73	13.64	7.36	0.54
	T2	1.21*	22.91*	N/A	N/A	N/A
	T3	0.72	16.73	13.64	7.36	0.54
	C	0.75	48.06	48.06	2.96	0.06
9	B	0.85	50.44	50.44	5.57	0.11
	T1	0.71	16.73	13.50	7.36	0.55
	T2	1.22*	23.18*	N/A	N/A	N/A
	T3	0.71	16.73	13.50	7.36	0.55
	C	0.75	48.06	48.06	2.96	0.06