Original Article

Approximating the Probability of Traffic Sharing by Numerical Analysis Techniques between Two Operators in a Computer Network

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ABSTRACT

Many authors have derived the expressions for the probability of traffic sharing between two operators in computer networking environment. The mathematical expressions for these probabilities are generally in quadratic function of blocking probabilities of computer network along with the probability of initial choice of customer. The expressions are not easily integrated and, therefore, effort is difficult to obtain the total bounded area under the probability curve. It is a challenging problem to obtain the probability density computation of the traffic sharing parameter. This paper presents a methodology to obtain the approximate bounded area and probability computation using methods of numerical analysis. The main focus is on utilization of Simpson 1/3 rule and Weddle rule along with the mutual comparisons.

Keywords: Probability, Area estimation, Trapezoidal rule, Network blocking, Operator. Markov chain, Simpson 1/3 rule, Weddle's rule.

INTRODUCTION

The internet management problem is a burning avenue of research the field of computer sciences and network management. The dial-up connection for Internet services are being utilized by many under-developed countries around the world with special reference to operator based network services for customers. The Internet services are provided by operators, and users are free to adopted either of them. It develops competition into market for capturing more and more customers-share in order to earn the maximum profit.[1] has developed a Markov chain model for the study of relationship between traffic sharing probability and network blocking probability faced by operators. The same was extended by[2-4] using the Markov chain model.

Moreover,[5-7] has developed multiple relations for traffic sharing and blocking probability in the presence of dis-connectivity effect, rest state effect, cyber-crime effect and iso-share effect analysis. All these have extended wider applicability of network analysis with special context to establishing the mathematical relationship among various model parameters.[8-11] examined the elasticity variations along with reattempt connectivity aspect.

The[1] has expressed following basic relation,

$$\overline{P_1} = (1 - L_1)\frac{p + (1-p)(1-p_A)L_2}{1 - L_1 L_2 (1-p_A)^2}$$

Where $\overline{P_1}$ is traffic share by first operatorO_1, p is user preference, L_1, L_2 are the network blocking probabilities experienced by both operators O_1 and O_2.

Have[12-14] estimated the bounded area of the curve generated by above expression using the trapezoidal rule available in the literature of numerical analysis.

The trapezoidal rule of numerical integration theory is weak in the sense that it requires strictly the linearity in the relationship. For curvilinear relationship, this method in not suitable enough. This paper presents the estimation of bounded area by the Simpson 1/3 rule and Weddle rule. A comparative approach has been adopted for evaluating of computation of bounded area by two methodologies. Some other similar contribution are by[15-30] presents Probability Density Estimation Function of Browser Share Curve for Users Web Browsing Behaviour and Two-Call Index Based Internet Traffic Sharing Analysis.[31,32], D. has Developed Area Computation of Internet Traffic Share Problem with Special Reference to Cyber Crime Environment.

Computational methodologies

In the literature of numerical analysis we have two computational approaches listed below: Consider the following integral

$$I = \int_b^a f(x)dx$$

Where a to b is range of integration and f(x) is a function to be integrated. Let us divide the range a to b into 20 equal partsy_0, y_1,y_2 y_3, y_4,y_5 ……… y_{11},y_{20}each of length h = (y_i-y_{i-1}), i=1,2,3,4….20.

Simpson 1/3 rule: (for n=20)

$$I = \int_b^a f(x)dx = \int_b^a ydx = \frac{h}{3}\begin{bmatrix}(y_0 + y_n) \\ +4(y_1 + y_3 + \ldots + y_{n-1}) \\ +2(y_2 + y_4 + \ldots + y_{n-2})\end{bmatrix}$$

Weddle's rule

$$I=\int_{b}^{a} f(x)dx=\frac{3h}{10}\left[y_0+5y_1+y_2+6y_3+y_4+5y_5+2y_6+5y_7+y_8+.....\right]+\frac{3h}{10}\left[y_6+5y_7+y_8+6y_9+y_{10}+5y_{11}+y_{12}+.....\right]$$

APPLICATIONS

Consider the formula,

$$\overline{P_1}=f(L_1)=(1-L_1)\frac{p+(1-p)(1-p_A)L_2}{1-L_1L_2(1-p_A)^2}$$

Where L_1 is variable but all other parameters p, p_A, $L_2$are constants. While L_1 is varying, the different values of corresponding $\overline{P_1}$ are given in tables. The total bounded area is computed by using Simpson 1/3 rule and weddles rule and both are compound. Graphs are also shown in different figure containing the bounded area between L_1=0.0 to L_1=1.0 at X-axis.

As per table 1 the traffic share is a linearly decreasing function of self network blocking probability. But when L_2 increases, the first operator gains the traffic share. The total bounded area is a function of $L_{2,}$ but this area is almost independent of $L_{2.}$ It is because very little fluctuation observed.

The figure 1 supports facts as observed in table 1 displaying linearly increasing trend between P_1 and L_2

The bounded area level increases with the increase of initial choice probality p. Moreover, it seems the traffic share is function of L_2 and p both. Figure 2 reveals that bounded area below the curve increases with increment to p.

With respect to p_A variation, the bounded area total reduces from 2.4% to 1.9% using Simpson 1/3 rule. It supports the fact that total bounded area is a function of L_2, p, and $p_{A.}$

Figure 3 is in favour of the downward trend towards over the variation of p_A over the computation of bounded area.

With reference to table 4, using weddle's rule, the bounded area estimation range is 16% to 42% which is higher than pattern observed by Simpson's rule.

The figure 4.0 support the fact that while opponent operator O_2 suffers with high blocking probability, the first operator gains the bounded area in the linear increasing pattern.

With reference to table 4, the bounded area variation is between 19% to 52% which is higher than obtained by the Simpson 1/3 rule.

The figure 5.0 shows almost straight line increase in the pattern with respect to variation over initial choice.

In above table, the area estimate decreases from 29% to 10 %. The area is inversionaly proportional to the parameter p_A.

The figure 6 supports the downward trend of the computation of bounded area using Weddle's rule.

CONCLUDING REMARKS

The bounded area under the probability curve is a function of many input parameters. Most of cases, it bears the linearly increasing or decreasing trend on the variation of model parameters. The L_2 and p, if increases, the corresponding area also increases but with the increase of p_A the reverse pattern exists. Area computation by Weddles method is constantly higher than the Simpson 1/3 rule. The highest bounded area computation by Simpson procedure is 39% at p=0.9 while the highest by Weddle rule is 52% at p=0.9. Overall Weddle rule based computed values are constantly above than the Simpson 1/3 rule.

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Table 1. Using Simpson 1/3 rule

Table 1 -For Fig. (1) [Where Fixed p=0.25, p_A = 0.35, , h=0.05]									
L_2	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L_1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.299	0.348	0.396	0.445	0.494	0.543	0.591	0.64	0.689
0.05	0.284	0.332	0.379	0.426	0.474	0.522	0.57	0.618	0.667
0.1	0.27	0.315	0.361	0.407	0.454	0.501	0.548	0.596	0.644
0.15	0.256	0.299	0.343	0.388	0.433	0.479	0.526	0.573	0.621
0.2	0.241	0.283	0.325	0.368	0.412	0.457	0.503	0.549	0.596
0.25	0.226	0.266	0.307	0.348	0.391	0.434	0.479	0.524	0.571
0.3	0.212	0.25	0.288	0.328	0.369	0.411	0.454	0.499	0.544
0.35	0.197	0.233	0.27	0.307	0.347	0.387	0.429	0.472	0.516
0.4	0.182	0.216	0.25	0.286	0.324	0.362	0.402	0.444	0.487
0.45	0.167	0.199	0.231	0.265	0.3	0.337	0.375	0.415	0.457
0.5	0.153	0.181	0.212	0.243	0.276	0.311	0.347	0.385	0.425
0.55	0.138	0.164	0.192	0.221	0.251	0.284	0.318	0.354	0.392
0.6	0.123	0.146	0.172	0.198	0.226	0.256	0.288	0.321	0.357
0.65	0.108	0.129	0.151	0.175	0.2	0.227	0.256	0.287	0.32
0.7	0.092	0.111	0.13	0.151	0.174	0.198	0.224	0.252	0.282
0.75	0.077	0.093	0.109	0.127	0.147	0.167	0.19	0.214	0.241
0.8	0.062	0.075	0.088	0.103	0.119	0.136	0.155	0.175	0.198
0.85	0.046	0.056	0.067	0.078	0.09	0.104	0.118	0.135	0.153
0.9	0.031	0.038	0.045	0.052	0.061	0.07	0.081	0.092	0.105
0.95	0.016	0.019	0.023	0.027	0.031	0.036	0.041	0.047	0.054
Area(A)	0.021	0.022	0.022	0.023	0.024	0.025	0.026	0.027	0.027

Table 2. Using Simpson 1/3 rule

Table 2 -For Fig. (2) [Where Fixed p_A=0.25, L_2 = 0.35, , h=0.05]									
p	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L_1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.336	0.41	0.484	0.558	0.631	0.705	0.779	0.853	0.926
0.05	0.323	0.393	0.464	0.535	0.606	0.676	0.747	0.818	0.889
0.1	0.309	0.376	0.444	0.512	0.58	0.647	0.715	0.783	0.85
0.15	0.295	0.359	0.424	0.488	0.553	0.617	0.682	0.747	0.811
0.2	0.28	0.341	0.403	0.464	0.526	0.587	0.649	0.71	0.771
0.25	0.265	0.323	0.382	0.44	0.498	0.556	0.614	0.672	0.731
0.3	0.25	0.305	0.36	0.415	0.47	0.524	0.579	0.634	0.689
0.35	0.235	0.286	0.338	0.389	0.441	0.492	0.544	0.595	0.647
0.4	0.219	0.267	0.315	0.363	0.411	0.459	0.507	0.555	0.603
0.45	0.203	0.247	0.292	0.336	0.381	0.425	0.47	0.514	0.559
0.5	0.186	0.227	0.268	0.309	0.35	0.391	0.432	0.473	0.514
0.55	0.17	0.207	0.244	0.281	0.319	0.356	0.393	0.43	0.467
0.6	0.153	0.186	0.219	0.253	0.286	0.32	0.353	0.387	0.42
0.65	0.135	0.165	0.194	0.224	0.253	0.283	0.313	0.342	0.372
0.7	0.117	0.143	0.168	0.194	0.22	0.245	0.271	0.297	0.322
0.75	0.099	0.12	0.142	0.164	0.185	0.207	0.228	0.25	0.272
0.8	0.08	0.097	0.115	0.132	0.15	0.167	0.185	0.202	0.22
0.85	0.061	0.074	0.087	0.1	0.114	0.127	0.14	0.154	0.167
0.9	0.041	0.05	0.059	0.068	0.077	0.086	0.095	0.104	0.113
0.95	0.021	0.025	0.03	0.034	0.039	0.043	0.048	0.052	0.057
Area(A)	0.021	0.023	0.024	0.025	0.026	0.028	0.029	0.03	0.031

Table 3. Using Simpson 1/3 rule

Table 3 -For Fig. (3) [Where Fixed p=0.15, L_2 = 0.45, , h=0.05]									
p_A	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L_1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.494	0.456	0.418	0.38	0.341	0.303	0.265	0.227	0.188
0.05	0.478	0.44	0.401	0.363	0.326	0.289	0.252	0.215	0.179
0.1	0.462	0.423	0.384	0.347	0.311	0.275	0.239	0.204	0.17
0.15	0.444	0.405	0.367	0.331	0.295	0.26	0.226	0.193	0.16
0.2	0.426	0.387	0.35	0.314	0.279	0.246	0.214	0.182	0.151
0.25	0.408	0.369	0.332	0.297	0.263	0.231	0.201	0.171	0.141
0.3	0.388	0.349	0.313	0.279	0.247	0.217	0.188	0.159	0.132
0.35	0.368	0.33	0.294	0.262	0.231	0.202	0.175	0.148	0.123
0.4	0.347	0.309	0.275	0.243	0.214	0.187	0.161	0.137	0.113
0.45	0.325	0.288	0.255	0.225	0.198	0.172	0.148	0.126	0.104
0.5	0.302	0.266	0.235	0.206	0.181	0.157	0.135	0.114	0.094
0.55	0.278	0.244	0.214	0.187	0.164	0.142	0.122	0.103	0.085
0.6	0.253	0.221	0.193	0.168	0.146	0.127	0.109	0.092	0.076
0.65	0.227	0.196	0.171	0.148	0.129	0.111	0.095	0.08	0.066
0.7	0.199	0.171	0.148	0.128	0.111	0.096	0.082	0.069	0.057
0.75	0.17	0.145	0.125	0.108	0.093	0.08	0.068	0.057	0.047
0.8	0.14	0.119	0.101	0.087	0.075	0.064	0.055	0.046	0.038
0.85	0.107	0.091	0.077	0.066	0.057	0.048	0.041	0.035	0.028
0.9	0.074	0.062	0.052	0.044	0.038	0.032	0.027	0.023	0.019
0.95	0.038	0.031	0.026	0.022	0.019	0.016	0.014	0.012	0.009
Area(A)	0.024	0.023	0.023	0.022	0.022	0.021	0.02	0.02	0.019

Table 4. Using Weddle's rule

Table 4 -For Fig. (4) [Where Fixed p_A=0.35, p = 0.25, h=0.05]									
L_2	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L_1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.299	0.348	0.396	0.445	0.494	0.543	0.591	0.64	0.689
0.05	0.284	0.332	0.379	0.426	0.474	0.522	0.57	0.618	0.667
0.1	0.27	0.315	0.361	0.407	0.454	0.501	0.548	0.596	0.644
0.15	0.256	0.299	0.343	0.388	0.433	0.479	0.526	0.573	0.621
0.2	0.241	0.283	0.325	0.368	0.412	0.457	0.503	0.549	0.596
0.25	0.226	0.266	0.307	0.348	0.391	0.434	0.479	0.524	0.571
0.3	0.212	0.25	0.288	0.328	0.369	0.411	0.454	0.499	0.544
0.35	0.197	0.233	0.27	0.307	0.347	0.387	0.429	0.472	0.516
0.4	0.182	0.216	0.25	0.286	0.324	0.362	0.402	0.444	0.487
0.45	0.167	0.199	0.231	0.265	0.3	0.337	0.375	0.415	0.457
0.5	0.153	0.181	0.212	0.243	0.276	0.311	0.347	0.385	0.425
0.55	0.138	0.164	0.192	0.221	0.251	0.284	0.318	0.354	0.392
0.6	0.123	0.146	0.172	0.198	0.226	0.256	0.288	0.321	0.357
0.65	0.108	0.129	0.151	0.175	0.200	0.227	0.256	0.287	0.32
0.7	0.092	0.111	0.13	0.151	0.174	0.198	0.224	0.252	0.282
0.75	0.077	0.093	0.109	0.127	0.147	0.167	0.19	0.214	0.241
0.8	0.062	0.075	0.088	0.103	0.119	0.136	0.155	0.175	0.198
0.85	0.046	0.056	0.067	0.078	0.09	0.104	0.118	0.135	0.153
0.9	0.031	0.038	0.045	0.052	0.061	0.07	0.081	0.092	0.105
Area(A)	0.161	0.19	0.219	0.25	0.282	0.314	0.348	0.384	0.42

Table 5. Using Weddle's rule

Table 5 -For Fig. (5) [Where Fixed p_A=0.25, L_2 = 0.35, h=0.05]									
p	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.336	0.41	0.484	0.558	0.631	0.705	0.779	0.853	0.926
0.05	0.323	0.393	0.464	0.535	0.606	0.676	0.747	0.818	0.889
0.1	0.309	0.376	0.444	0.512	0.58	0.647	0.715	0.783	0.85
0.15	0.295	0.359	0.424	0.488	0.553	0.617	0.682	0.747	0.811
0.2	0.28	0.341	0.403	0.464	0.526	0.587	0.649	0.71	0.771
0.25	0.265	0.323	0.382	0.44	0.498	0.556	0.614	0.672	0.731
0.3	0.25	0.305	0.36	0.415	0.47	0.524	0.579	0.634	0.689
0.35	0.235	0.286	0.338	0.389	0.441	0.492	0.544	0.595	0.647
0.4	0.219	0.267	0.315	0.363	0.411	0.459	0.507	0.555	0.603
0.45	0.203	0.247	0.292	0.336	0.381	0.425	0.47	0.514	0.559
0.5	0.186	0.227	0.268	0.309	0.35	0.391	0.432	0.473	0.514
0.55	0.17	0.207	0.244	0.281	0.319	0.356	0.393	0.43	0.467
0.6	0.153	0.186	0.219	0.253	0.286	0.32	0.353	0.387	0.42
0.65	0.135	0.165	0.194	0.224	0.253	0.283	0.313	0.342	0.372
0.7	0.117	0.143	0.168	0.194	0.22	0.245	0.271	0.297	0.322
0.75	0.099	0.12	0.142	0.164	0.185	0.207	0.228	0.25	0.272
0.8	0.08	0.097	0.115	0.132	0.15	0.167	0.185	0.202	0.22
0.85	0.061	0.074	0.087	0.1	0.114	0.127	0.14	0.154	0.167
0.9	0.041	0.05	0.059	0.068	0.077	0.086	0.095	0.104	0.113
Area(A)	0.191	0.233	0.275	0.316	0.358	0.4	0.442	0.484	0.526

Table 6. Using Weddle's rule

Table 6 -For Fig. (6) [Where Fixed p=0.15, L_2 = 0.45, h=0.05]									
P_A	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
L_1	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$	$\overline{P}_1$
0	0.494	0.456	0.418	0.38	0.341	0.303	0.265	0.227	0.188
0.05	0.478	0.44	0.401	0.363	0.326	0.289	0.252	0.215	0.179
0.1	0.462	0.423	0.384	0.347	0.311	0.275	0.239	0.204	0.17
0.15	0.444	0.405	0.367	0.331	0.295	0.26	0.226	0.193	0.16
0.2	0.426	0.387	0.35	0.314	0.279	0.246	0.214	0.182	0.151
0.25	0.408	0.369	0.332	0.297	0.263	0.231	0.201	0.171	0.141
0.3	0.388	0.349	0.313	0.279	0.247	0.217	0.188	0.159	0.132
0.35	0.368	0.33	0.294	0.262	0.231	0.202	0.175	0.148	0.123
0.4	0.347	0.309	0.275	0.243	0.214	0.187	0.161	0.137	0.113
0.45	0.325	0.288	0.255	0.225	0.198	0.172	0.148	0.126	0.104
0.5	0.302	0.266	0.235	0.206	0.181	0.157	0.135	0.114	0.094
0.55	0.278	0.244	0.214	0.187	0.164	0.142	0.122	0.103	0.085
0.6	0.253	0.221	0.193	0.168	0.146	0.127	0.109	0.092	0.076
0.65	0.227	0.196	0.171	0.148	0.129	0.111	0.095	0.08	0.066
0.7	0.199	0.171	0.148	0.128	0.111	0.096	0.082	0.069	0.057
0.75	0.17	0.145	0.125	0.108	0.093	0.08	0.068	0.057	0.047
0.8	0.14	0.119	0.101	0.087	0.075	0.064	0.055	0.046	0.038
0.85	0.107	0.091	0.077	0.066	0.057	0.048	0.041	0.035	0.028
0.9	0.074	0.062	0.052	0.044	0.038	0.032	0.027	0.023	0.019
Area(A)	0.299	0.268	0.239	0.213	0.188	0.165	0.142	0.121	0.1

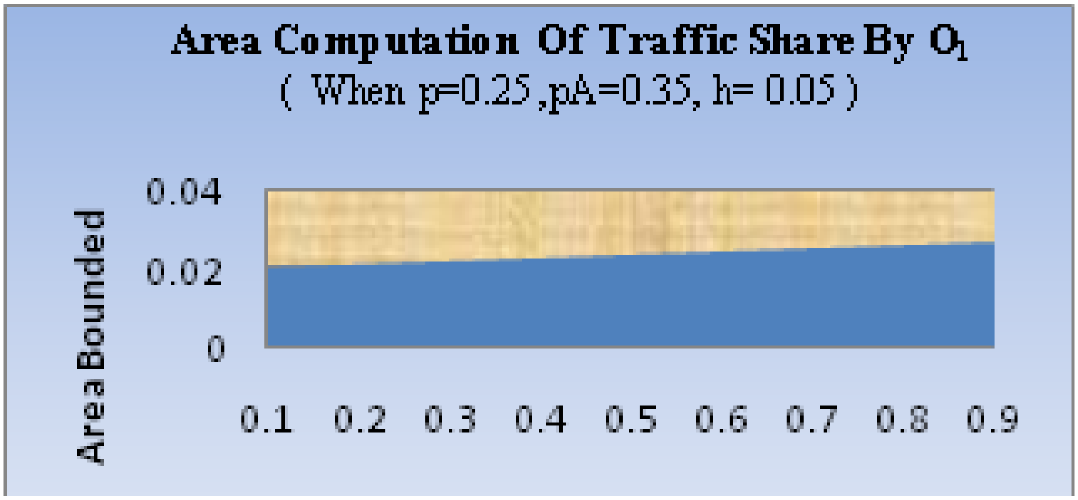

Figure 1. Variation over L2

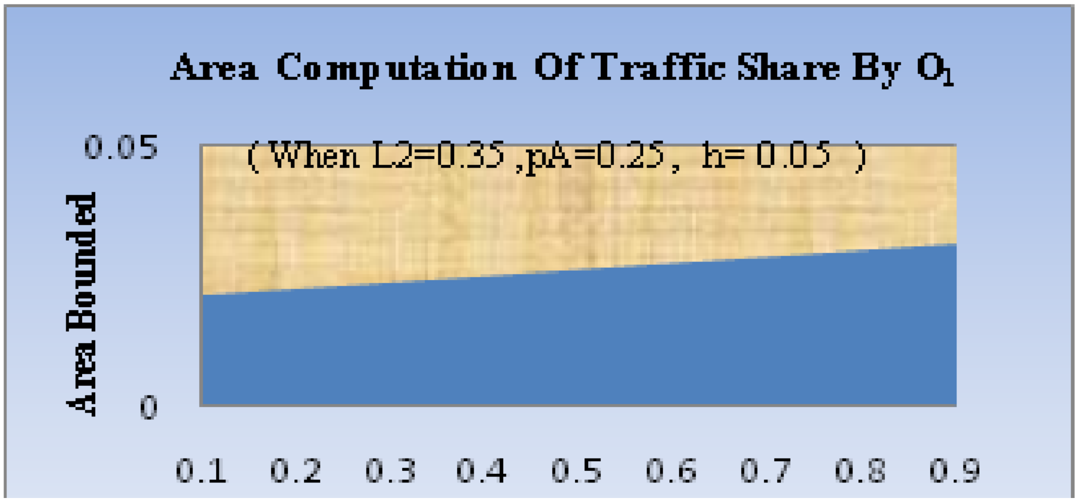

Figure 2. Variation over P

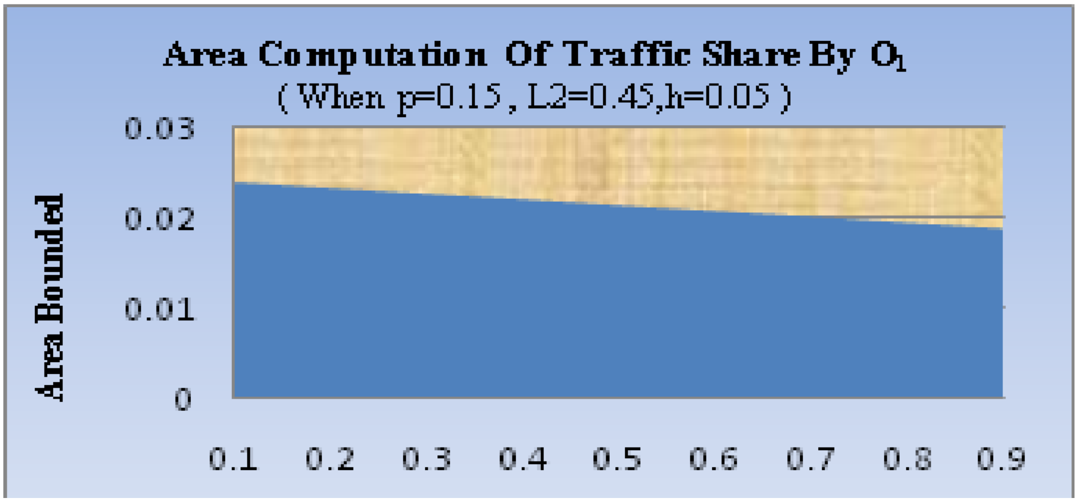

Figure 3. Variation over pA

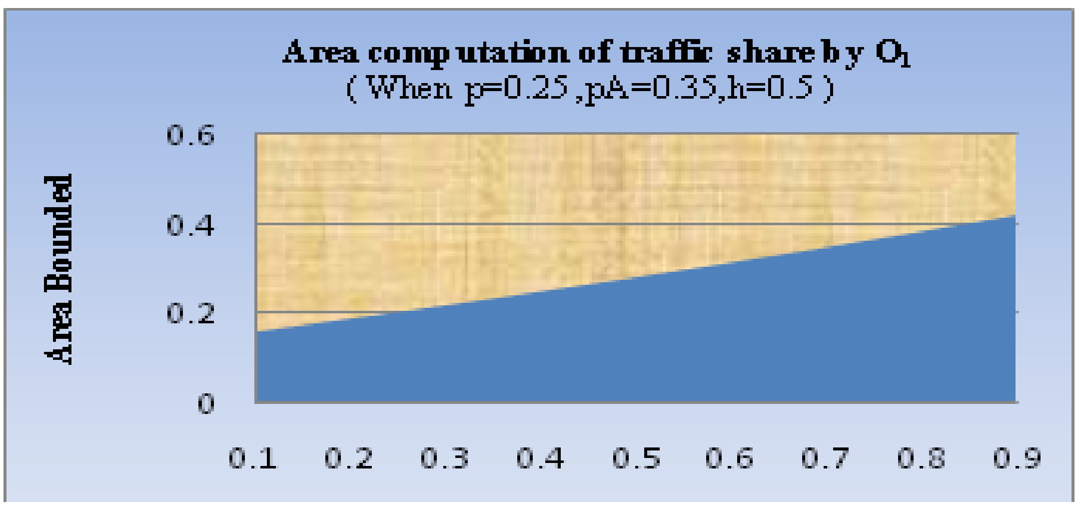

Figure 4. Variation over L2

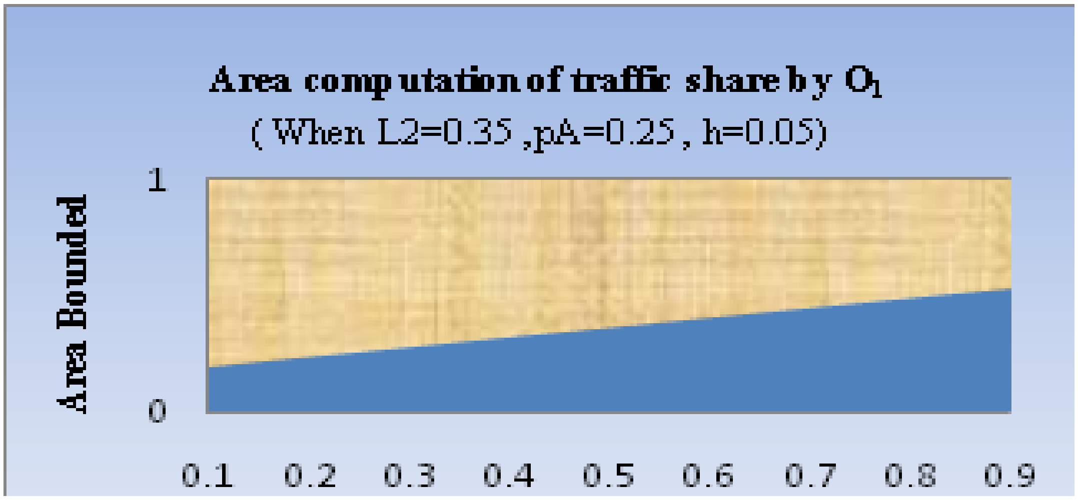

Figure 5. Variation over p

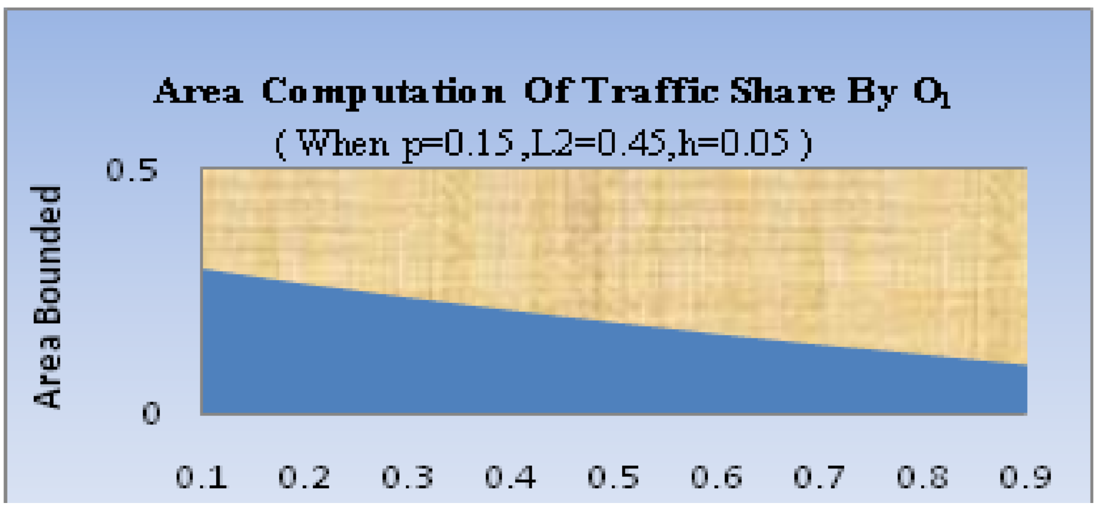

Figure 6. Variation over pA