Wireless Communication Systems

HW1

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1.

(a)Source Code Description

Erlang_B.m:

From the original Erlang B function $B(\rho, m) = \frac{\rho^m}{m! \sum_{k=0}^{m} \frac{\rho^k}{k!}}$,we can first simplify the function s.t $B(\rho, m) = \frac{1}{\sum_{k=0}^{m} \frac{m!}{k!} \rho^{k-m}}$. However, if we directly compute factorial(m) when m is large, the floating point value will be too large to represent, thus, we should modify the function to $B(\rho, m) = \frac{1}{\sum_{k=0}^{m} \frac{(m-k+1)*(m-k+2)*...*m}{\rho^{m-k}}} = \frac{1}{\sum_{k=0}^{m} \frac{m-k+1}{\rho} * \frac{m-k+2}{\rho} * ... * \frac{m}{\rho}}$. After modified the original function, we can derive the differential of the function $B'(\rho, m) = \frac{dB(\rho, m)}{d\rho} = \frac{-\sum_{k=0}^{m} (k-m) * \frac{1}{\rho} * (\frac{m-k+1}{\rho} * \frac{m-k+2}{\rho} * ... * \frac{m}{\rho})}{(\sum_{k=0}^{m} \frac{m-k+1}{\rho} * \frac{m-k+2}{\rho} * ... * \frac{m}{\rho})^2}$, in order to find rho by Newton Method.

Newton_Method.m:

The Newton Method requires iterations and the differential function, we set the iteration time to 200 and use the differentiated ErlangB function we derived above, also we set the tolerated error to 1e-6. First we initialize x = x0, after that we derive y, y_diff from the above functions, then calculate the new x = x – (y – y_diff) / y_diff, repeat the operation for 200 times. Note that the answer rho should be nonnegative, thus, when x < 0, we initialized a different value to x0 to avoid this.

(b)Simulation Result

Channel Number: 1~20, Block rate: 1%, 3%, 5%, 10%, respectively.

	Block rate(%)					Block rate(%)			
	1	3	5	10		1	3	5	10
1	0.0101	0.0309	0.0526	0.1111	11	5.1599	6.3280	7.0764	8.4871
2	0.1526	0.2816	0.3813	0.5954	12	5.8760	7.1410	7.9501	9.4740
3	0.4555	0.7151	0.8994	1.2708	13	6.6072	7.9667	8.8349	10.4699
4	0.8694	1.2589	1.5246	2.0454	14	7.3517	8.8035	9.7295	11.4735
5	1.3608	1.8752	2.2185	2.8811	15	8.1080	9.6500	10.6327	12.4838
6	1.9091	2.5431	2.9603	3.7584	16	8.8750	10.5052	11.5436	13.5001
7	2.5009	3.2497	3.7378	4.6662	17	9.6516	11.3683	12.4613	14.5217

8	3.1276	3.9865	4.5430	5.5971	18	10.4369	12.2384	13.3852	15.5480
9	3.7825	4.7479	5.3702	6.5464	19	11.2301	13.1150	14.3147	16.5787
10	4.4612	5.5294	6.2157	7.5106	20	12.0306	13.9974	15.2493	17.6132

Channel Number: 200~220, Block rate: 1%, 3%, 5%, 10%, respectively.

	Block rate(%)					Block rate(%)			
	1	3	5	10		1	3	5	10
200	179.7381	190.8859	198.5073	214.3226	210	189.4232	200.9744	208.8933	225.3763
201	180.7059	191.8943	199.5456	215.4278	211	190.3925	201.9838	209.9323	226.4818
202	181.6739	192.9028	200.5840	216.5331	212	191.3620	202.9932	210.9714	227.5874
203	182.6420	193.9114	201.6224	217.6383	213	192.3316	204.0028	212.0105	228.6931
204	183.6103	194.9201	202.6609	218.7437	214	193.3013	205.0124	213.0497	229.7987
205	184.5788	195.9289	203.6994	219.8490	215	194.2712	206.0222	214.0889	230.9044
206	185.5474	196.9378	204.7381	220.9544	216	195.2412	207.0320	215.1283	232.0102
207	186.5161	197.9468	205.7768	222.0598	217	196.2114	208.0419	216.1676	233.1159
208	187.4850	198.9559	206.8156	223.1653	218	198.1521	209.0519	217.2071	234.2217
209	188.4540	199.9651	207.8544	224.2708	219	198.1521	210.0620	218.2466	235.3275
					220	199.1226	211.0722	219.2862	236.4334

2.

(a)Yes, it is possible that the total offered traffic load is larger than the number of available channels. From the number of available channels, we can obtain the maximum carried traffic, which is the total traffic serviced by the channels. In the system with limited capacity, the system would only be able to carry the traffic equal to its capacity if the total offered traffic exceeds the system capacity. Thus, if Blocking Probability is sufficiently large, which typically means that the total offered traffic load larger than the number of channel, i.e, capacity, is allowed.

(b)Since Blocking Probability is defined as Loss traffic / Total Offered traffic, which means that the Blocking Probability is the chance that a customer will be denied service due to lack of resources. Thus, it implies that the actual traffic that has been served can be represented as the total offered traffic * (1-Blocking Rate).

3.

(a)Since the frequency reuse factor is 5, which means that there are 600/5=120 channels per cell.

Case 1: one operator, m=120/1=120

From the Erlang B Table above, we can obtain ρ and G_C

ρ	Block rate(%)				G_C	Block rate(%)			
	1	3	5	10		1	3	5	10
120	102.6937	110.6506	115.7706	126.0824	120	0.8558	0.9221	0.9648	1.0507

Case 2: two operator, m=120/2=60

From the Erlang B Table above, we can obtain ρ and G_C

ρ	Block rate(%)				G_C	Block rate(%)			
	1	3	5	10		1	3	5	10
120	46.9497	51.5698	54.5656	60.4013	120	0.7825	0.8595	0.9094	1.0067

Case 3: three operator, m=120/3=40

From the Erlang B Table above, we can obtain ρ and G_C

ρ	Block rate(%)				G_C	Block rate(%)			
	1	3	5	10		1	3	5	10
120	29.0074	32.4118	34.5960	38.7875	120	0.7252	0.8103	0.8649	0.9697

(b)The spectral efficiency is $\eta_s = \eta_B * \eta_C * \eta_T$, where η_B denotes the bandwidth efficiency, η_C denotes spatial efficiency, and η_T denotes trunking efficiency. η_B and η_C in each case remains the same, so the spectral efficiency depends on the trunking efficiency, where $\eta_T = G_C = \frac{\rho}{m}$. From 3(a) we can obtain that when remaining the same blocking rate, the one operator case has the larger G_C , thus, it is more spectral efficient.