institute of telecommunications

TECHNISCHE UNIVERSITÄT WIEN
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Homework 5

VU Wireless Communications 1, 389.157, SS 2014,
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Important for getting a grade:

- Answer all questions tagged with boxes such as XY short and precise, and state the question number next to the solution.
- Put the homework into the box located at the 1st floor of the *Institute of Telecommunication*, or send it to veronika.shivaldova@nt.tuwien.ac.at.
- Attend the exercise lecture and be prepared to be called to the blackboard for presenting your results.
- In case questions arise, do not hesitate to contact me!

1 Free-Space Propagation and Two-Ray Model

Consider a mobile communication system operating at the central frequency of 2 GHz. At the base station a direction antenna with gain of 5 dBi is used, which is mounted at height of $h_t = 40$ m and the feeder losses of the transmitter were measured to be 8 dB. At the receiver an isotropic lossless antenna is used and the height of the receiver is assumed to be $h_r = 1.5$ m. We define the speech quality as acceptable, when the signal-to-noise ration (SNR) at the input of the receiving device is not lower than 10 dB for distance separation between the transmitter and the receiver of 10 km.

5 p 1 ⇒ Assuming noise figure of the receiver equal to 6 dB, effective noise bandwidth of 0.1 MHz and the average temperature of 20°C calculate the received power required for acceptable speech quality.

5 p 2 ⇒ Assuming the free space loss, how large should the transmit power (in W) be to achieve the acceptable speech quality at the receiver?

10 p 3 ⇒ Assuming the plane earth loss (two-ray model), how large should the transmit power (in W) be to achieve the acceptable speech quality at the receiver? Note, that the exact expression for the plane earth loss is given as:

$$PL(d) = \left(\frac{2\pi d}{\lambda \cdot \sin(\Theta_\Delta/2)} \right)^2,$$

where $\Theta_\Delta = \frac{2\pi \cdot \Delta}{\lambda}$ is the phase difference between the E-field of the line-of-sight and ground reflection components.

2 Cellular Principle

5 p 4 Consider a duplex cellular system with total spectrum of 42 MHz. Assuming that each simplex channel has 25 kHz radio frequency bandwidth, find the total number of channels per cell for all valid cluster sizes $1 < N \leq 7$.

Your first results show that the smaller cluster size provides larger capacity (larger amount of voice channels per cell). However transmission quality in the systems with smaller cluster size is reduced, due to a larger level of co-channel interference. Let i_0 be the number of co-channel interfering cells, D_i the distance between the i^{th} interfering base station and the mobile station and R the radius of the cell. If the transmit power of each base station is equal and the path loss exponent n is the same throughout the coverage area, signal-to-interference (SIR) for a mobile station can be approximated as:

$$SIR = \frac{R^{-n}}{\sum_{i=0}^{i_0} (D_i)^{-n}},$$

5 p 5 Assume that the mobile station of interest is located exactly in the middle of the cell, as well as all base stations, so that all D_i are equal. Considering only interfering base stations in the first tier[1] derive a closed form relationship between the SIR, the cluster size N and the number of co-channel cells i_0. Calculate the SIR in dB assuming the path loss exponent $n = 4$.

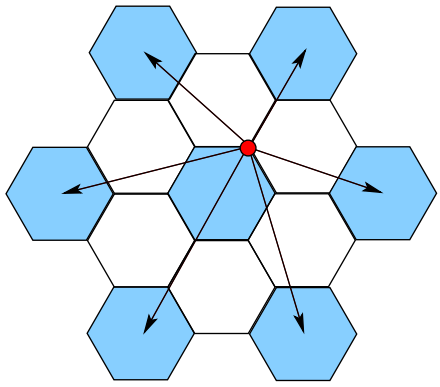

Figure 1: First tier of co-channel cells for a cluster size N=3.

[1] Tier of a cell is the collection of all co-channel cells that are more-or-less the same distance away from the mobile station within the serving cell.

10 p 6 Now consider the worst-case co-channel interference on the forward channel, i.e., when the mobile station is located exactly at the boundary of the cell as shown in Fig. 1. Express the distances D_i between the mobile station and the base stations of the first tier as a function of cell radius R and calculate SIR (in dB) for all valid cluster sizes $1 < N \leq 7$.

10 p 7 Suppose that the currently deployed cellular radio system with cluster size $N = 7$, and omnidirectional antennas at base stations just reached its maximum system capacity. Aiming to increase the carried traffic of the system, the mobile network provider decides to reduce the cluster size, however without SIR reduction. One possible approach to achieve this, is sectoring. In this case a single omnidirectional antenna at the base station is replaced with several directional antennas, each radiating within the specified sector. Consider two sectorized antenna types: with beam width of 60° and 120° together with all valid cluster sizes $N < 7$. Use the relationship derived in Question [5] and assume path loss exponent $n = 4$, to find out which configurations (cluster size N and number of sectors/sectorized antenna type) are feasible regarding the co-channel interference, i.e., SIR is equal to or exceeds that of initial system (with $N = 7$ and omnidirectional antennas).

5 p 8 If SIR decrease of up to 0.3 dB compared to that of initial system is allowed, which configuration should be used? *Hint: Consider trunking efficiency.*

3 Traffic Theory I

Consider a loss system equipped with 30 traffic channels per cell. In such system all call requests, connection for which cannot be established immediately, are cleared. During the busy hour, an average duration of the voice call generated by a mobile phone subscriber is 1.2 minutes[2].

5 p 9 How many mobile users should be active simultaneously within one cell to obtain a blocking probability of:

i) 0.1 %

ii) 5 %

iii) 30 %

5 p 10 How many mobile users within one cell can be served simultaneously for the blocking probabilities specified in Question [9]?

[2] You should use Erlang B and Erlang C tables available at the end of this problem set.

Now assume that a queuing approach is applied instead of a loss approach. In a queuing system all call requests, connection for which cannot be established immediately, will have to wait.

5 p 11 How large is the probability that a delayed call will have to wait for 20 seconds for a delay probability of:

i) 0.1 %

ii) 5 %

iii) 30 %

10 p 12 What is the probability that a call will be delayed for more than 20 seconds or the delay probabilities specified in Question [11]?

5 p 13 Comparing loss and queuing systems with different blocking and delay probabilities, which system is the most efficient in terms of an average channel load?

4 Traffic Theory II

A mobile system operator has launched a network called Net1 with central frequency of 900 MHz and 36 carriers. The reuse factor of the system equals 9 and there are 8 channels per carrier frequency. The blocking probability of the Net1 is assumed to be 2 %.

5 p 14 For a system with homogeneously distributed traffic and equally large cells, how large is the traffic per cell in Net1?

5 p 15 To meet the increasing capacity demand the operator releases an additional network Net2 with central frequency of 1800 MHz and 72 carriers. This network is using the same base stations as Net1 and the same reuse factor, just different central frequency. The blocking probability of the Net2 is assumed to be 2 %. Assuming single band users, i.e., a user is served either by Net1 or by Net2, how large is the traffic per cell carried by Net1 and Net2 together?

5 p 16 If all users are dual band and therefore can use both frequency bands and the blocking probability is still 2 % how large is the traffic per cell?

Erlang B Traffic Table

Maximum Offered Load Versus B and N
B is in %

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111	.1765	.2500	.4286	.6667
2	.0142	.0321	.0458	.1054	.1526	.2235	.3813	.5954	.7962	1.000	1.449	2.000
3	.0868	.1517	.1938	.3490	.4555	.6022	.8994	1.271	1.603	1.930	2.633	3.480
4	.2347	.3624	.4393	.7012	.8694	1.092	1.525	2.045	2.501	2.945	3.891	5.021
5	.4520	.6486	.7621	1.132	1.361	1.657	2.219	2.881	3.454	4.010	5.189	6.596
6	.7282	.9957	1.146	1.622	1.909	2.276	2.960	3.758	4.445	5.109	6.514	8.191
7	1.054	1.392	1.579	2.158	2.501	2.935	3.738	4.666	5.461	6.230	7.856	9.800
8	1.422	1.830	2.051	2.730	3.128	3.627	4.543	5.597	6.498	7.369	9.213	11.42
9	1.826	2.302	2.558	3.333	3.783	4.345	5.370	6.546	7.551	8.522	10.58	13.05
10	2.260	2.803	3.092	3.961	4.461	5.084	6.216	7.511	8.616	9.685	11.95	14.68
11	2.722	3.329	3.651	4.610	5.160	5.842	7.076	8.487	9.691	10.86	13.33	16.31
12	3.207	3.878	4.231	5.279	5.876	6.615	7.950	9.474	10.78	12.04	14.72	17.95
13	3.713	4.447	4.831	5.964	6.607	7.402	8.835	10.47	11.87	13.22	16.11	19.60
14	4.239	5.032	5.446	6.663	7.352	8.200	9.730	11.47	12.97	14.41	17.50	21.24
15	4.781	5.634	6.077	7.376	8.108	9.010	10.63	12.48	14.07	15.61	18.90	22.89
16	5.339	6.250	6.722	8.100	8.875	9.828	11.54	13.50	15.18	16.81	20.30	24.54
17	5.911	6.878	7.378	8.834	9.652	10.66	12.46	14.52	16.29	18.01	21.70	26.19
18	6.496	7.519	8.046	9.578	10.44	11.49	13.39	15.55	17.41	19.22	23.10	27.84
19	7.093	8.170	8.724	10.33	11.23	12.33	14.32	16.58	18.53	20.42	24.51	29.50
20	7.701	8.831	9.412	11.09	12.03	13.18	15.25	17.61	19.65	21.64	25.92	31.15
21	8.319	9.501	10.11	11.86	12.84	14.04	16.19	18.65	20.77	22.85	27.33	32.81
22	8.946	10.18	10.81	12.64	13.65	14.90	17.13	19.69	21.90	24.06	28.74	34.46
23	9.583	10.87	11.52	13.42	14.47	15.76	18.08	20.74	23.03	25.28	30.15	36.12
24	10.23	11.56	12.24	14.20	15.30	16.63	19.03	21.78	24.16	26.50	31.56	37.78
25	10.88	12.26	12.97	15.00	16.13	17.51	19.99	22.83	25.30	27.72	32.97	39.44
26	11.54	12.97	13.70	15.80	16.96	18.38	20.94	23.89	26.43	28.94	34.39	41.10
27	12.21	13.69	14.44	16.60	17.80	19.27	21.90	24.94	27.57	30.16	35.80	42.76
28	12.88	14.41	15.18	17.41	18.64	20.15	22.87	26.00	28.71	31.39	37.21	44.41
29	13.56	15.13	15.93	18.22	19.49	21.04	23.83	27.05	29.85	32.61	38.63	46.07
30	14.25	15.86	16.68	19.03	20.34	21.93	24.80	28.11	31.00	33.84	40.05	47.74
31	14.94	16.60	17.44	19.85	21.19	22.83	25.77	29.17	32.14	35.07	41.46	49.40
32	15.63	17.34	18.21	20.68	22.05	23.73	26.75	30.24	33.28	36.30	42.88	51.06
33	16.34	18.09	18.97	21.51	22.91	24.63	27.72	31.30	34.43	37.52	44.30	52.72
34	17.04	18.84	19.74	22.34	23.77	25.53	28.70	32.37	35.58	38.75	45.72	54.38
35	17.75	19.59	20.52	23.17	24.64	26.44	29.68	33.43	36.72	39.99	47.14	56.04
36	18.47	20.35	21.30	24.01	25.51	27.34	30.66	34.50	37.87	41.22	48.56	57.70
37	19.19	21.11	22.08	24.85	26.38	28.25	31.64	35.57	39.02	42.45	49.98	59.37
38	19.91	21.87	22.86	25.69	27.25	29.17	32.62	36.64	40.17	43.68	51.40	61.03
39	20.64	22.64	23.65	26.53	28.13	30.08	33.61	37.72	41.32	44.91	52.82	62.69
40	21.37	23.41	24.44	27.38	29.01	31.00	34.60	38.79	42.48	46.15	54.24	64.35
41	22.11	24.19	25.24	28.23	29.89	31.92	35.58	39.86	43.63	47.38	55.66	66.02
42	22.85	24.97	26.04	29.09	30.77	32.84	36.57	40.94	44.78	48.62	57.08	67.68
43	23.59	25.75	26.84	29.94	31.66	33.76	37.57	42.01	45.94	49.85	58.50	69.34

44	24.33	26.53	27.64	30.80	32.54	34.68	38.56	43.09	47.09	51.09	59.92	71.01
45	25.08	27.32	28.45	31.66	33.43	35.61	39.55	44.17	48.25	52.32	61.35	72.67
46	25.83	28.11	29.26	32.52	34.32	36.53	40.55	45.24	49.40	53.56	62.77	74.33
47	26.59	28.90	30.07	33.38	35.22	37.46	41.54	46.32	50.56	54.80	64.19	76.00
48	27.34	29.70	30.88	34.25	36.11	38.39	42.54	47.40	51.71	56.03	65.61	77.66
49	28.10	30.49	31.69	35.11	37.00	39.32	43.53	48.48	52.87	57.27	67.04	79.32
50	28.87	31.29	32.51	35.98	37.90	40.26	44.53	49.56	54.03	58.51	68.46	80.99
51	29.63	32.09	33.33	36.85	38.80	41.19	45.53	50.64	55.19	59.75	69.88	82.65
52	30.40	32.90	34.15	37.72	39.70	42.12	46.53	51.73	56.35	60.99	71.31	84.32
53	31.17	33.70	34.98	38.60	40.60	43.06	47.53	52.81	57.50	62.22	72.73	85.98
54	31.94	34.51	35.80	39.47	41.51	44.00	48.54	53.89	58.66	63.46	74.15	87.65
55	32.72	35.32	36.63	40.35	42.41	44.94	49.54	54.98	59.82	64.70	75.58	89.31
56	33.49	36.13	37.46	41.23	43.32	45.88	50.54	56.06	60.98	65.94	77.00	90.97
57	34.27	36.95	38.29	42.11	44.22	46.82	51.55	57.14	62.14	67.18	78.43	92.64
58	35.05	37.76	39.12	42.99	45.13	47.76	52.55	58.23	63.31	68.42	79.85	94.30
59	35.84	38.58	39.96	43.87	46.04	48.70	53.56	59.32	64.47	69.66	81.27	95.97
60	36.62	39.40	40.80	44.76	46.95	49.64	54.57	60.40	65.63	70.90	82.70	97.63
61	37.41	40.22	41.63	45.64	47.86	50.59	55.57	61.49	66.79	72.14	84.12	99.30
62	38.20	41.05	42.47	46.53	48.77	51.53	56.58	62.58	67.95	73.38	85.55	101.0
63	38.99	41.87	43.31	47.42	49.69	52.48	57.59	63.66	69.11	74.63	86.97	102.6
64	39.78	42.70	44.16	48.31	50.60	53.43	58.60	64.75	70.28	75.87	88.40	104.3
65	40.58	43.52	45.00	49.20	51.52	54.38	59.61	65.84	71.44	77.11	89.82	106.0
66	41.38	44.35	45.85	50.09	52.44	55.33	60.62	66.93	72.60	78.35	91.25	107.6
67	42.17	45.18	46.69	50.98	53.35	56.28	61.63	68.02	73.77	79.59	92.67	109.3
68	42.97	46.02	47.54	51.87	54.27	57.23	62.64	69.11	74.93	80.83	94.10	111.0
69	43.77	46.85	48.39	52.77	55.19	58.18	63.65	70.20	76.09	82.08	95.52	112.6
70	44.58	47.68	49.24	53.66	56.11	59.13	64.67	71.29	77.26	83.32	96.95	114.3
71	45.38	48.52	50.09	54.56	57.03	60.08	65.68	72.38	78.42	84.56	98.37	116.0
72	46.19	49.36	50.94	55.46	57.96	61.04	66.69	73.47	79.59	85.80	99.80	117.6
73	47.00	50.20	51.80	56.35	58.88	61.99	67.71	74.56	80.75	87.05	101.2	119.3
74	47.81	51.04	52.65	57.25	59.80	62.95	68.72	75.65	81.92	88.29	102.7	120.9
75	48.62	51.88	53.51	58.15	60.73	63.90	69.74	76.74	83.08	89.53	104.1	122.6
76	49.43	52.72	54.37	59.05	61.65	64.86	70.75	77.83	84.25	90.78	105.5	124.3
77	50.24	53.56	55.23	59.96	62.58	65.81	71.77	78.93	85.41	92.02	106.9	125.9
78	51.05	54.41	56.09	60.86	63.51	66.77	72.79	80.02	86.58	93.26	108.4	127.6
79	51.87	55.25	56.95	61.76	64.43	67.73	73.80	81.11	87.74	94.51	109.8	129.3
80	52.69	56.10	57.81	62.67	65.36	68.69	74.82	82.20	88.91	95.75	111.2	130.9
81	53.51	56.95	58.67	63.57	66.29	69.65	75.84	83.30	90.08	96.99	112.6	132.6
82	54.33	57.80	59.54	64.48	67.22	70.61	76.86	84.39	91.24	98.24	114.1	134.3
83	55.15	58.65	60.40	65.39	68.15	71.57	77.87	85.48	92.41	99.48	115.5	135.9
84	55.97	59.50	61.27	66.29	69.08	72.53	78.89	86.58	93.58	100.7	116.9	137.6
85	56.79	60.35	62.14	67.20	70.02	73.49	79.91	87.67	94.74	102.0	118.3	139.3
86	57.62	61.21	63.00	68.11	70.95	74.45	80.93	88.77	95.91	103.2	119.8	140.9
87	58.44	62.06	63.87	69.02	71.88	75.42	81.95	89.86	97.08	104.5	121.2	142.6
88	59.27	62.92	64.74	69.93	72.82	76.38	82.97	90.96	98.25	105.7	122.6	144.3
89	60.10	63.77	65.61	70.84	73.75	77.34	83.99	92.05	99.41	107.0	124.0	145.9
90	60.92	64.63	66.48	71.76	74.68	78.31	85.01	93.15	100.6	108.2	125.5	147.6

91	61.75	65.49	67.36	72.67	75.62	79.27	86.04	94.24	101.8	109.4	126.9	149.3
92	62.58	66.35	68.23	73.58	76.56	80.24	87.06	95.34	102.9	110.7	128.3	150.9
93	63.42	67.21	69.10	74.50	77.49	81.20	88.08	96.43	104.1	111.9	129.8	152.6
94	64.25	68.07	69.98	75.41	78.43	82.17	89.10	97.53	105.3	113.2	131.2	154.3
95	65.08	68.93	70.85	76.33	79.37	83.13	90.12	98.63	106.4	114.4	132.6	155.9
96	65.92	69.79	71.73	77.24	80.31	84.10	91.15	99.72	107.6	115.7	134.0	157.6
97	66.75	70.65	72.61	78.16	81.25	85.07	92.17	100.8	108.8	116.9	135.5	159.3
98	67.59	71.52	73.48	79.07	82.18	86.04	93.19	101.9	109.9	118.2	136.9	160.9
99	68.43	72.38	74.36	79.99	83.12	87.00	94.22	103.0	111.1	119.4	138.3	162.6
100	69.27	7~.25	75.24	80.91	84.06	87.97	95.24	104.1	112.3	120.6	139.7	164.3

N is the number of servers. The numerical column headings indicate blocking probability B in %. Table generated by Dan Dexter

Erlang C Traffic Table

Maximum Offered Load Versus B and N
B is in %

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.0010	.0050	.0100	.0200	.0500	.1000	.1500	.2000	.3000	.4000
2	.0142	.0319	.0452	.1025	.1465	.2103	.3422	.5000	.6278	.7403	.9390	1.117
3	.0860	.1490	.1894	.3339	.4291	.5545	.7876	1.040	1.231	1.393	1.667	1.903
4	.2310	.3533	.4257	.6641	.8100	.9939	1.319	1.653	1.899	2.102	2.440	2.725
5	.4428	.6289	.7342	1.065	1.259	1.497	1.905	2.313	2.607	2.847	3.241	3.569
6	.7110	.9616	1.099	1.519	1.758	2.047	2.532	3.007	3.344	3.617	4.062	4.428
7	1.026	1.341	1.510	2.014	2.297	2.633	3.188	3.725	4.103	4.406	4.897	5.298
8	1.382	1.758	1.958	2.543	2.866	3.246	3.869	4.463	4.878	5.210	5.744	6.178
9	1.771	2.208	2.436	3.100	3.460	3.883	4.569	5.218	5.668	6.027	6.600	7.065
10	2.189	2.685	2.942	3.679	4.077	4.540	5.285	5.986	6.469	6.853	7.465	7.959
11	2.634	3.186	3.470	4.279	4.712	5.213	6.015	6.765	7.280	7.688	8.336	8.857
12	3.100	3.708	4.018	4.896	5.363	5.901	6.758	7.554	8.099	8.530	9.212	9.761
13	3.587	4.248	4.584	5.529	6.028	6.602	7.511	8.352	8.926	9.379	10.09	10.67
14	4.092	4.805	5.166	6.175	6.705	7.313	8.273	9.158	9.760	10.23	10.98	11.58
15	4.614	5.377	5.762	6.833	7.394	8.035	9.044	9.970	10.60	11.09	11.87	12.49
16	5.150	5.962	6.371	7.502	8.093	8.766	9.822	10.79	11.44	11.96	12.77	13.41
17	5.699	6.560	6.991	8.182	8.801	9.505	10.61	11.61	12.29	12.83	13.66	14.33
18	6.261	7.169	7.622	8.871	9.518	10.25	11.40	12.44	13.15	13.70	14.56	15.25
19	6.835	7.788	8.263	9.568	10.24	11.01	12.20	13.28	14.01	14.58	15.47	16.18
20	7.419	8.417	8.914	10.27	10.97	11.77	13.00	14.12	14.87	15.45	16.37	17.10
21	8.013	9.055	9.572	10.99	11.71	12.53	13.81	14.96	15.73	16.34	17.28	18.03
22	8.616	9.702	10.24	11.70	12.46	13.30	14.62	15.81	16.60	17.22	18.19	18.96
23	9.228	10.36	10.91	12.43	13.21	14.08	15.43	16.65	17.47	18.11	19.10	19.89
24	9.848	11.02	11.59	13.16	13.96	14.86	16.25	17.51	18.35	19.00	20.02	20.82
25	10.48	11.69	12.28	13.90	14.72	15.65	17.08	18.36	19.22	19.89	20.93	21.76
26	11.11	12.36	12.97	14.64	15.49	16.44	17.91	19.22	20.10	20.79	21.85	22.69
27	11.75	13.04	13.67	15.38	16.26	17.23	18.74	20.08	20.98	21.68	22.77	23.63
28	12.40	13.73	14.38	16.14	17.03	18.03	19.57	20.95	21.87	22.58	23.69	24.57
29	13.05	14.42	15.09	16.89	17.81	18.83	20.41	21.82	22.75	23.48	24.61	25.50
30	13.71	15.12	15.80	17.65	18.59	19.64	21.25	22.68	23.64	24.38	25.54	26.44
31	14.38	15.82	16.52	18.42	19.37	20.45	22.09	23.56	24.53	25.29	26.46	27.38
32	15.05	16.53	17.25	19.18	20.16	21.26	22.93	24.43	25.42	26.19	27.39	28.33
33	15.72	17.24	17.97	19.95	20.95	22.07	23.78	25.30	26.32	27.10	28.31	29.27
34	16.40	17.95	18.71	20.73	21.75	22.89	24.63	26.18	27.21	28.01	29.24	30.21
35	17.09	18.67	19.44	21.51	22.55	23.71	25.48	27.06	28.11	28.92	30.17	31.16
36	17.78	19.39	20.18	22.29	23.35	24.53	26.34	27.94	29.00	29.83	31.10	32.10
37	18.47	20.12	20.92	23.07	24.15	25.36	27.19	28.82	29.90	30.74	32.03	33.05
38	19.17	20.85	21.67	23.86	24.96	26.18	28.05	29.71	30.80	31.65	32.97	34.00
39	19.87	21.59	22.42	24.65	25.77	27.01	28.91	30.59	31.71	32.57	33.90	34.94
40	20.58	22.33	23.17	25.44	26.58	27.84	29.77	31.48	32.61	33.48	34.83	35.89
41	21.28	23.07	23.93	26.23	27.39	28.68	30.63	32.37	33.51	34.40	35.77	36.84
42	22.00	23.81	24.69	27.03	28.21	29.51	31.50	33.26	34.42	35.32	36.70	37.79
43	22.71	24.56	25.45	27.83	29.02	30.35	32.36	34.15	35.33	36.23	37.64	38.74

44	23.43	25.31	26.22	28.63	29.84	31.19	33.23	35.04	36.23	37.15	38.58	39.69
45	24.15	26.06	26.98	29.44	30.67	32.03	34.10	35.93	37.14	38.07	39.51	40.64
46	24.88	26.82	27.75	30.24	31.49	32.87	34.97	36.83	38.05	39.00	40.45	41.59
47	25.60	27.57	28.52	31.05	32.32	33.72	35.84	37.72	38.96	39.92	41.39	42.54
48	26.34	28.33	29.30	31.86	33.14	34.56	36.72	38.62	39.87	40.84	42.33	43.50
49	27.07	29.10	30.08	32.68	33.97	35.41	37.59	39.52	40.79	41.76	43.27	44.45
50	27.80	29.86	30.86	33.49	34.80	36.26	38.47	40.42	41.70	4?,69	44.21	45.40
51	28.54	30.63	31.64	34.31	35.64	37.11	39.35	41.32	42.61	43.61	45.15	46.36
52	29.28	31.40	32.42	35.12	36.47	37.97	40.23	42.22	43.53	44.54	46.10	47.31
53	30.03	32.17	33.21	35.94	37.31	38.82	41.10	43.12	44.44	45.47	47.04	48.27
54	30.77	32.95	33.99	36.76	38.15	39.67	41.99	44.02	45.36	46.39	47.98	49.22
55	31.52	33.72	34.78	37.59	38.99	40.53	42.87	44.93	46.28	47.32	48.93	50.18
56	32.27	34.50	35.57	38.41	39.83	41.39	43.75	45.83	47.20	48.25	49.87	51.13
57	33.03	35.28	36.37	39.24	40.67	42.25	44.64	46.74	48.12	49.18	50.82	52.09
58	33.78	36.06	37.16	40.07	41.51	43.11	45.52	47.64	49.04	50.11	51.76	53.05
59	34.54	36.85	37.96	40.90	42.36	43.97	46.41	48.55	49.96	51.04	52.71	54.01
60	35.30	37.63	38.76	41.73	43.20	44.83	47.29	49.46	50.88	51.97	53.65	54.96
61	36.06	38.42	39.56	42.56	44.05	45.70	48.18	50.37	51.80	52.90	54.60	55.92
62	36.82	39.21	40.36	43.39	44.90	46.56	49.07	51.27	52.72	53.83	55.55	56.88
63	37.59	40.00	41.16	44.23	45.75	47.43	49.96	52.18	53.64	54.77	56.49	57.84
64	38.35	40.80	41.97	45.06	46.60	48.30	50.85	53.10	54.57	55.70	57.44	58.80
65	39.12	41.59	42.78	45.90	47.45	49.16	51.74	54.01	55.49	56.63	58.39	59.76
66	39.89	42.39	43.58	46.74	48.30	50.03	52.64	54.92	56.42	57.57	59.34	60.72
67	40.66	43.18	44.39	47.58	49.16	50.90	53.53	55.83	57.34	58.50	60.29	61.68
68	41.44	43.98	45.20	48.42	50.01	51.77	54.42	56.75	58.27	59.44	61.24	62.64
69	42.21	44.78	46.02	49.26	50.87	52.65	55.32	57.66	59.20	60.37	62.19	63.60
70	42.99	45.58	46.83	50.10	51.73	53.52	56.21	58.57	60.12	61.31	63.14	64.56
71	43.77	46.39	47.64	50.95	52.59	54.39	57.11	59.49	61.05	62.25	64.09	65.52
72	44.55	47.19	48.46	51.79	53.45	55.27	58.01	60.41	61.98	63.18	65.04	66.48
73	45.33	48.00	49.28	52.64	54.31	56.14	58.90	61.32	62.91	64.12	65.99	67.44
74	46.11	48.81	50.10	53.49	55.17	57.02	59.80	62.24	63.84	65.06	66.94	68.40
75	46.90	49.61	50.92	54.34	56.03	57.90	60.70	63.16	64.76	66.00	67.89	69.37
76	47.68	50.42	51.74	55.19	56.89	58.78	61.60	64.07	65.69	66.94	68.85	70.33
77	48.47	51.23	52.56	56.04	57.76	59.65	62.50	64.99	66.63	67.88	69.80	71.29
78	49.26	52.05	53.38	56.89	58.62	60.53	63.40	65.91	67.56	68.82	70.75	72.25
79	50.05	52.86	54.21	57.74	59.49	61.41	64.30	66.83	68.49	69.76	71.70	73.22
80	50.84	53.68	55.03	58.60	60.36	62.30	65.21	67.75	69.42	70.70	72.66	74.18
81	51.63	54.49	55.86	59.45	61.22	63.18	66.11	68.67	70.35	71.64	73.61	75.14
82	52.43	55.31	56.69	60.30	62.09	64.06	67.01	69.59	71.28	72.58	74.57	76.11
83	53.22	56.13	57.52	61.16	62.96	64.94	67.92	70.52	72.22	73.52	75.52	77.07
84	54.02	56.95	58.35	62.02	63.83	65.83	68.82	71.44	73.15	74.46	76.47	78.04
85	54.81	57.77	59.18	62.88	64.70	66.71	69.73	72.36	74.08	75.40	77.43	79.00
86	55.61	58.59	60.01	63.73	65.57	67.60	70.63	73.28	75.02	76.35	78.38	79.97
87	56.41	59.41	60.84	64.59	66.45	68.48	71.54	74.21	75.95	77.29	79.34	80.93
88	57.21	60.23	61.67	65.45	67.32	69.37	72.45	75.13	76.89	78.23	80.30	81.90
89	58.02	61.06	62.51	66.32	68.19	70.26	73.35	76.06	77.82	79.18	81.25	82.86
90	58.82	61.88	63.34	67.18	69.07	71.15	74.26	76.98	78.76	80.12	82.21	83.83

91	59.62	62.71	64.18	68.04	69.94	72.04	75.17	77.91	79.69	81.06	83.16	84.79
92	60.43	63.54	65.02	68.90	70.82	72.92	76.08	78.83	80.63	82.01	84.12	85.76
93	61.23	64.36	65.86	69.77	71.70	73.81	76.99	79.76	81.57	82.95	85.08	86.73
94	62.04	65.19	66.70	70.63	72.57	74.71	77.90	80.69	82.50	83.90	86.03	87.69
95	62.85	66.02	67.54	71.50	73.45	75.60	78.81	81.61	83.44	84.84	86.99	88.66
96	63.66	66.85	68.38	72.36	74.33	76.49	79.72	82.54	84.38	85.79	87.95	89.62
97	64.47	67.69	69.22	73.23	75.21	77.38	80.63	83.47	85.32	86.74	88.91	90.59
98	65.28	68.52	70.06	74.10	76.09	78.27	81.54	84.39	86.26	87.68	89.87	91.56
99	66.09	69.35	70.90	74.97	76.97	79.17	82.46	85.32	87.20	88.63	90.82	92.53
100	66.91	70.19	71.75	75.84	77.85	80.06	83.37	86.25	88.13	89.58	91.78	93.49

N is the number of servers. The numerical column headings indicate blocking probability B in %. Table generated by Dan Dexter