4DK4 Lab 2

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Experiment Results and Analysis

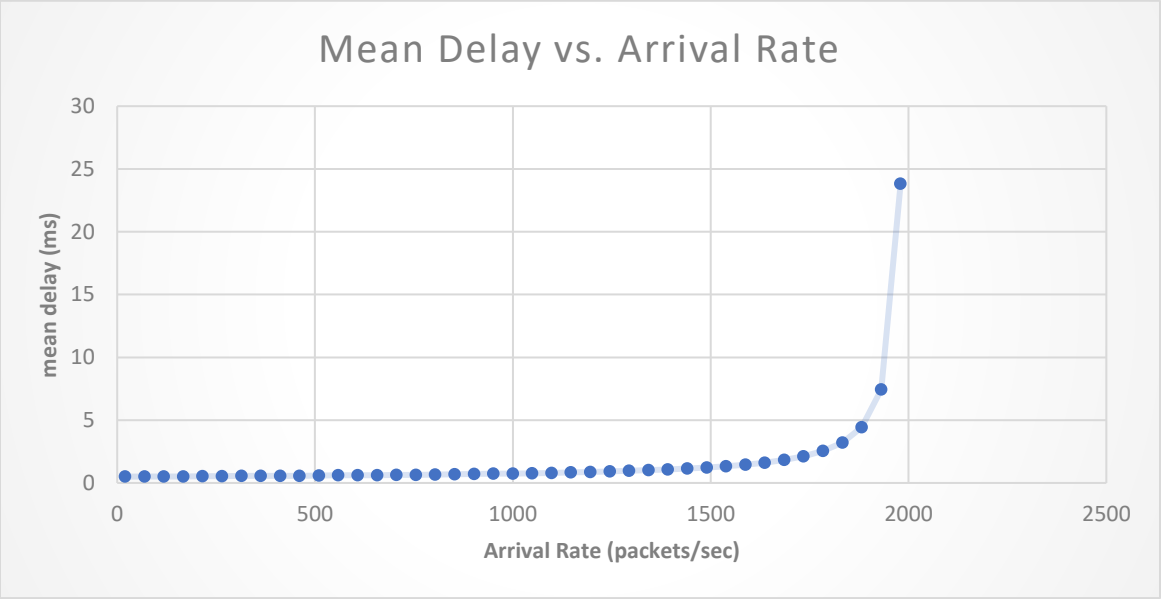
Section 2

Plot mean delay vs. ARRIVAL RATE

I've generated two plots. One plot that maintains the following condition, and one that violates it.

$$0 < \texttt{ARRIVAL\_RATE} \times \texttt{SERVICE\_TIME} < 1$$

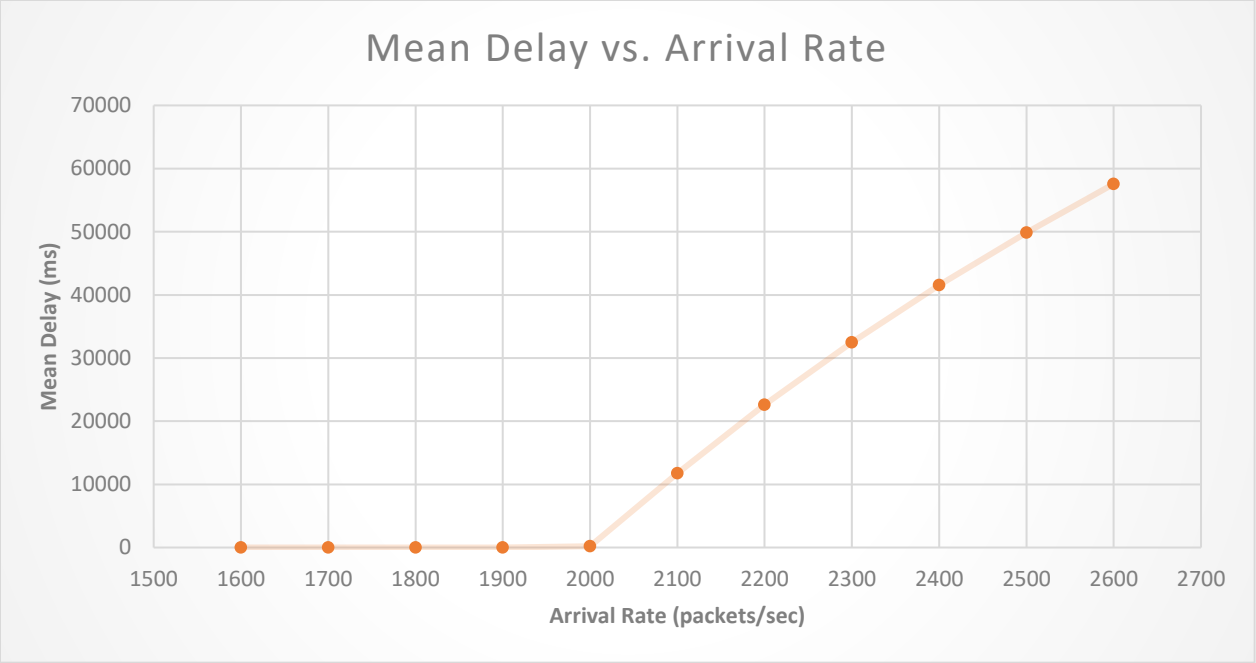
In the new simulation methodology, SERVICE_TIME = `PACKET_LENGTH / LINK_BIT_RATE`



Data is in the appendix at mean delay vs. ARRIVAL RATE Data.

As we can see, when the constraint is satisfied, the results are the same as in Lab 1. The mean delay increases slightly at low values and explodes to infinity as the constraint boundary is reached.

When the constraint is violated and server utilization reaches 100%, we see the same behaviour in Lab 1. The mean delay continues to explode to infinity as the arrival rate increases.

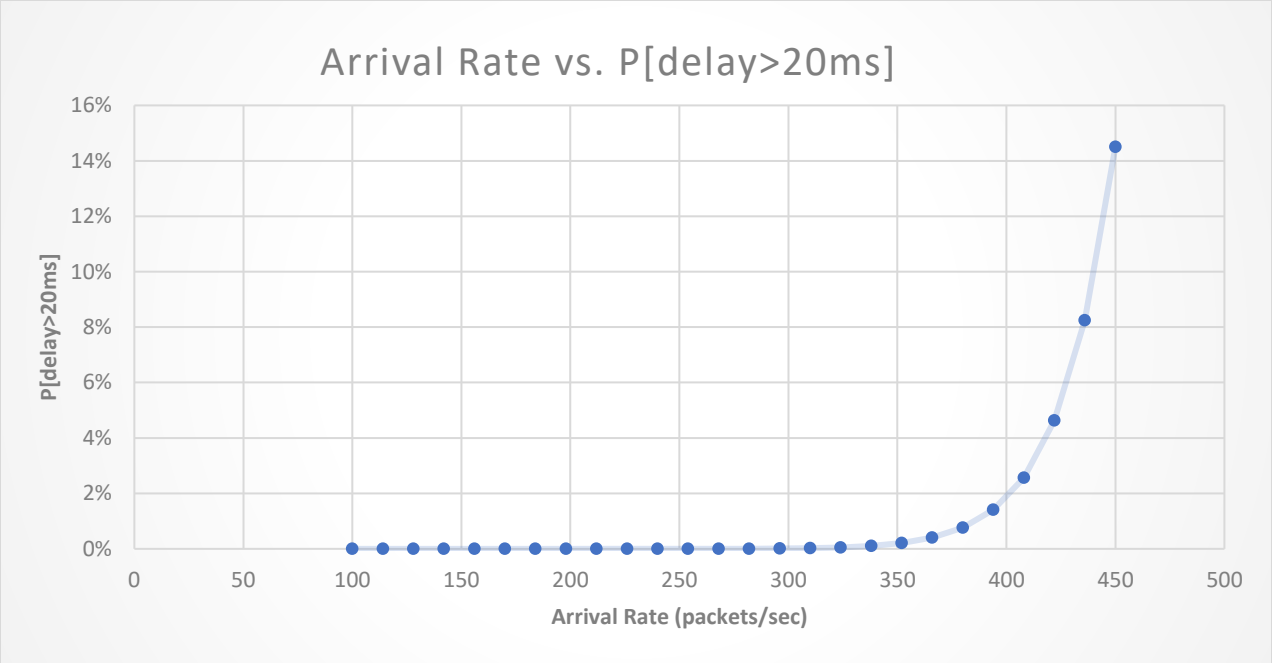


Data is in the appendix at [mean delay vs. ARRIVAL RATE Data].

Section 3

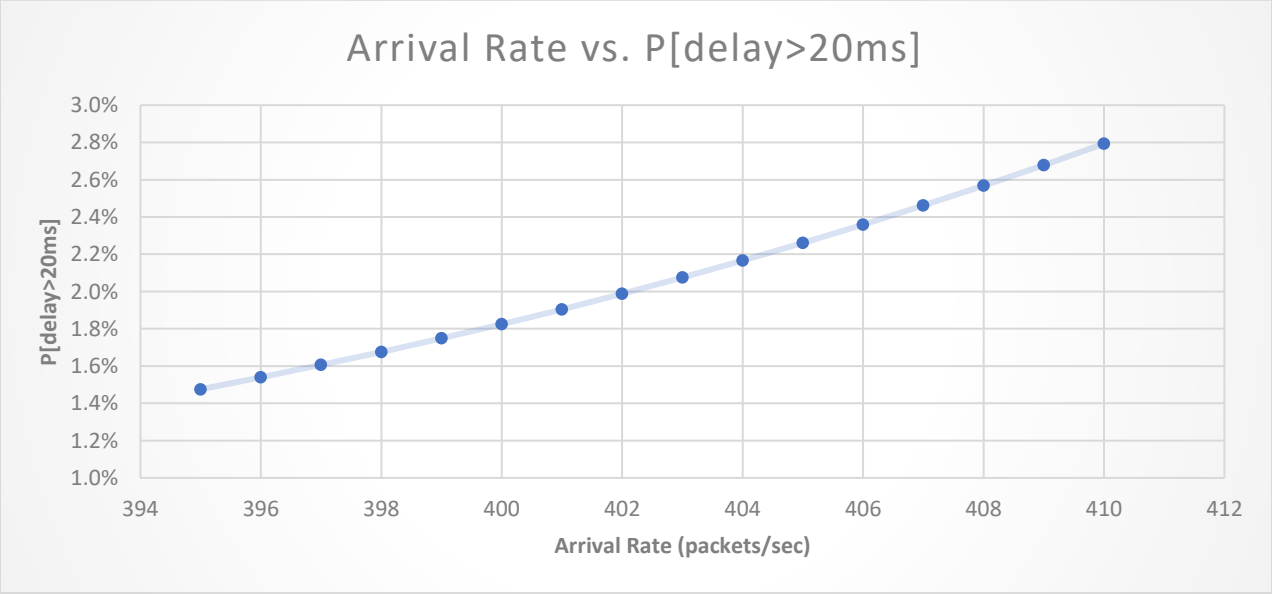
To detect the maximum value of λ such that the probability that a packet's delay exceeds 20 msec is less than 2%, I performed a check on each transmission of whether the delay for that packet was greater than 20 ms. If this was true, I would increment an internal counter. If a large number of packets are transmitted, the ratio of packets with delay greater than 20ns / all transmitted packets will approximate the probability that a packet will experience a delay greater than 20ns.

To find the λ such that this probability is 2%, I first tried a wide range of arrival rates, to find the region closest to 20ns.



Data is in the appendix at Arrival Rate vs. P[delay>20ms]

We can see that 2% is crossed near λ = 400. To figure out exactly where it is crossed, I will sample each value between 395 and 410.

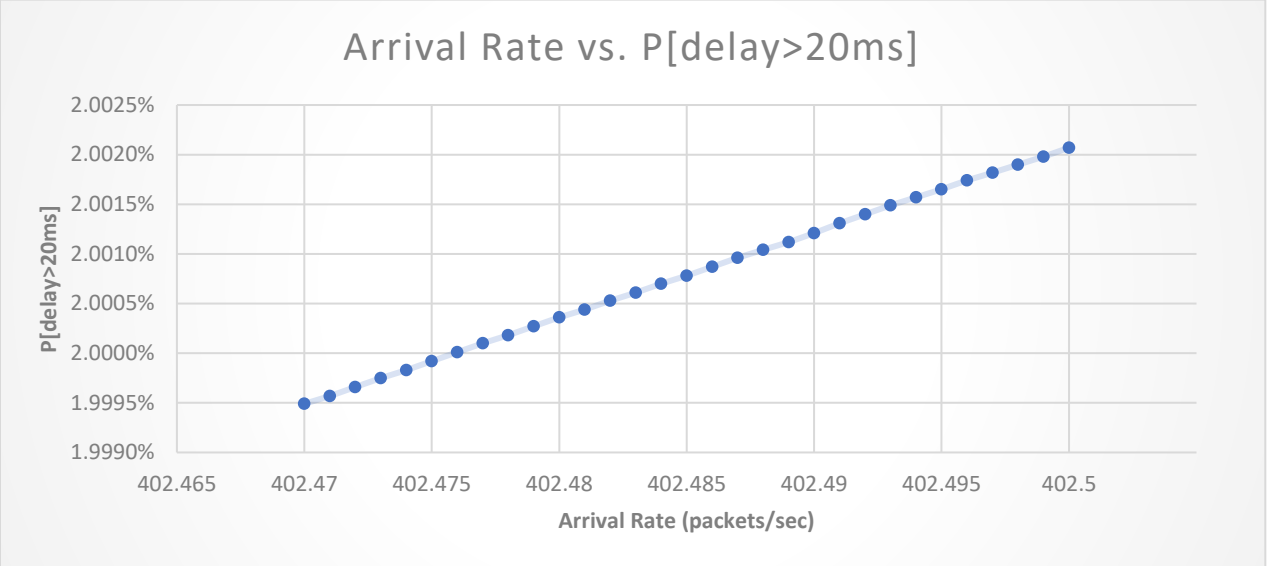


Here we can see that the λ = 402 value is just below 2.0%. The exact value measured was 1.98784%.

I wanted to increase the precision of my run. I collected 40 data points between 401.5 and 402.5. I found the boundary of the 2% mark at these data points:

402.475	0.019981
402.5	0.020002

To achieve a final level of precision, I now collect 30 data points between `402.470` and 402.5, but with a run length of 250M packets.



Data in the appendix at Arrival Rate vs. P[delay>20ms] high-precision

The data with this high level of precision shows that the max λ is just before 402.476.

I perform a linear approximation, based on these two data points:

402.475	0.0199992
402.476	0.0200001

$$y - y_1 = \frac{y_1 - y_2}{x_1 - x_2} \cdot (x - x_1)$$

$$(y - y_1) \cdot \frac{x_1 - x_2}{y_1 - y_2} = (x - x_1)$$

$$x = (y - y_1) \cdot \frac{x_1 - x_2}{y_1 - y_2} + x_1$$

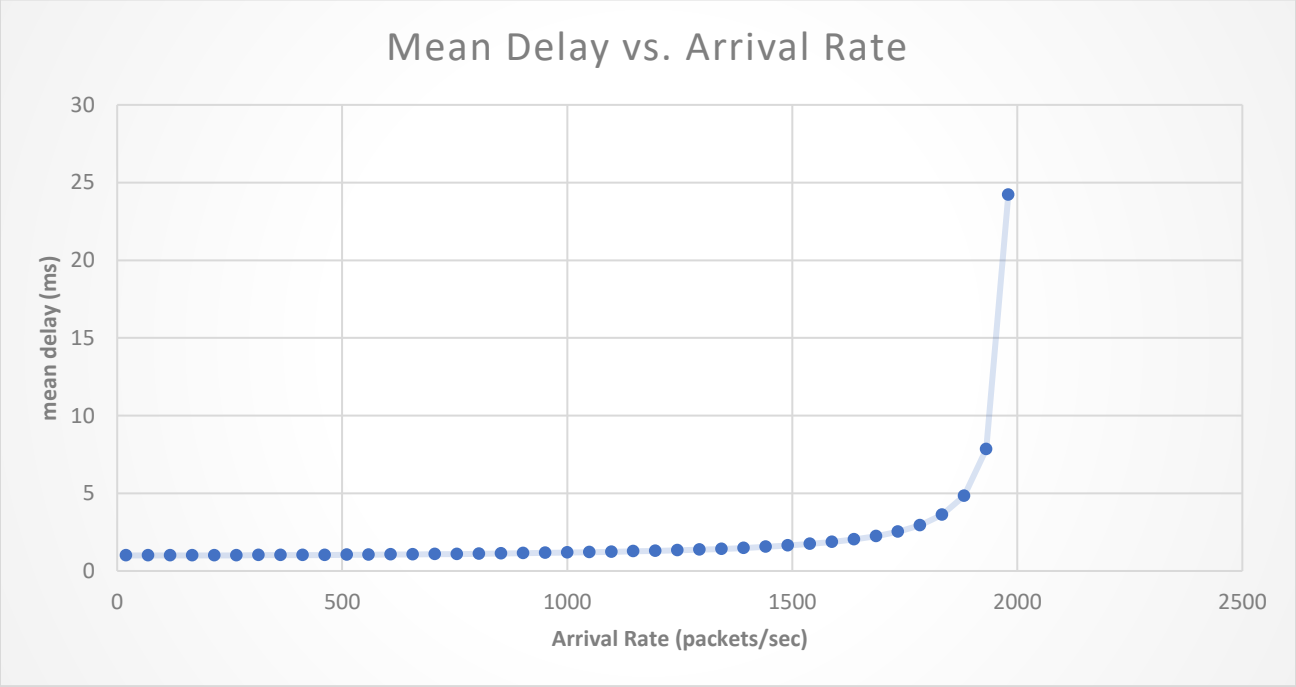
$$x = (0.02 - 0.0200001) \cdot \frac{402.476 - 402.475}{0.0200001 - 0.0199992} + 402.476$$

$$x = \ 402.475888889$$

Therefore, the maximum value of λ such that the probability that a packet's delay exceeds 20 msec is less than 2% is 402.475888889 packets/sec.

Section 4

To test an M/D/2 system, I modified the code to have two `Server_Ptr`'s, link1 and link2. The simulation will only buffer an arriving packet if both links are busy. I set the link bit rate to 500kbps and observed the following results.



Data is in the appendix at M/D/2 mean delay vs. ARRIVAL RATE Data.

Comparing these results to the **system in Section 2**, The **horizontal asymptote** has changed from 0.5ms to 1ms. This is because the delay experienced by a packet arriving to an empty system has doubled; because the length of packet has stayed the same, but the link rate is halved.

The **vertical asymptote** has remained at the same arrival rate. This is because the **mean** SERVICE_TIME is:

$$\text{SERVICE\_TIME} = \frac{packet\ length}{number\ of\ servers \times link\ rate}$$

So, this relationship has not changed:

$$0 < \text{ARRIVAL\_RATE} \times \text{SERVICE\_TIME} < 1$$

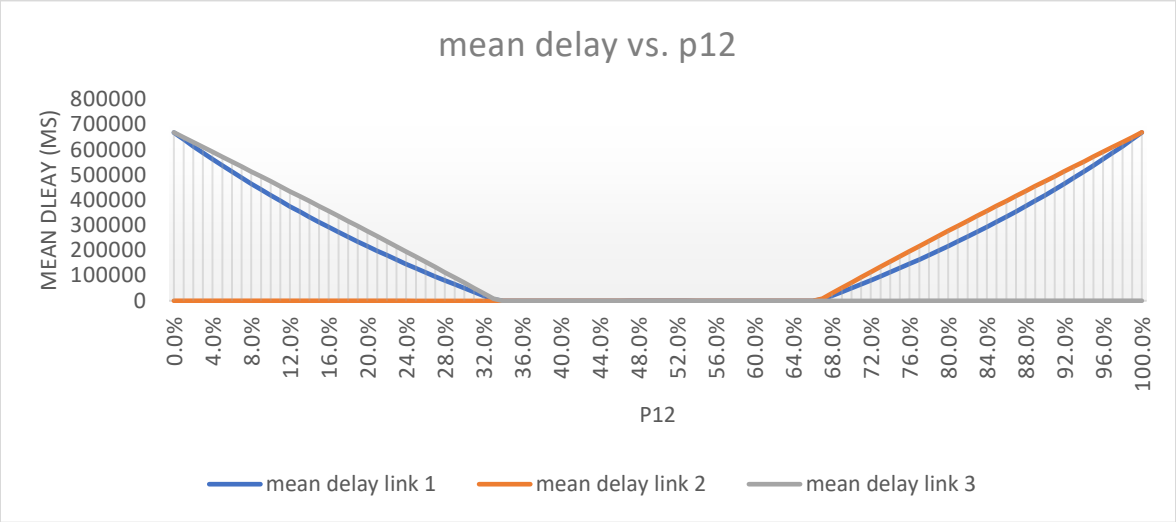
The link rate has halved, but the number of servers has doubled, so the vertical asymptote is unchanged.

This means that a system with a slower link rate, can increase its maximum stable throughput, by increasing the number of servers.

Section 5

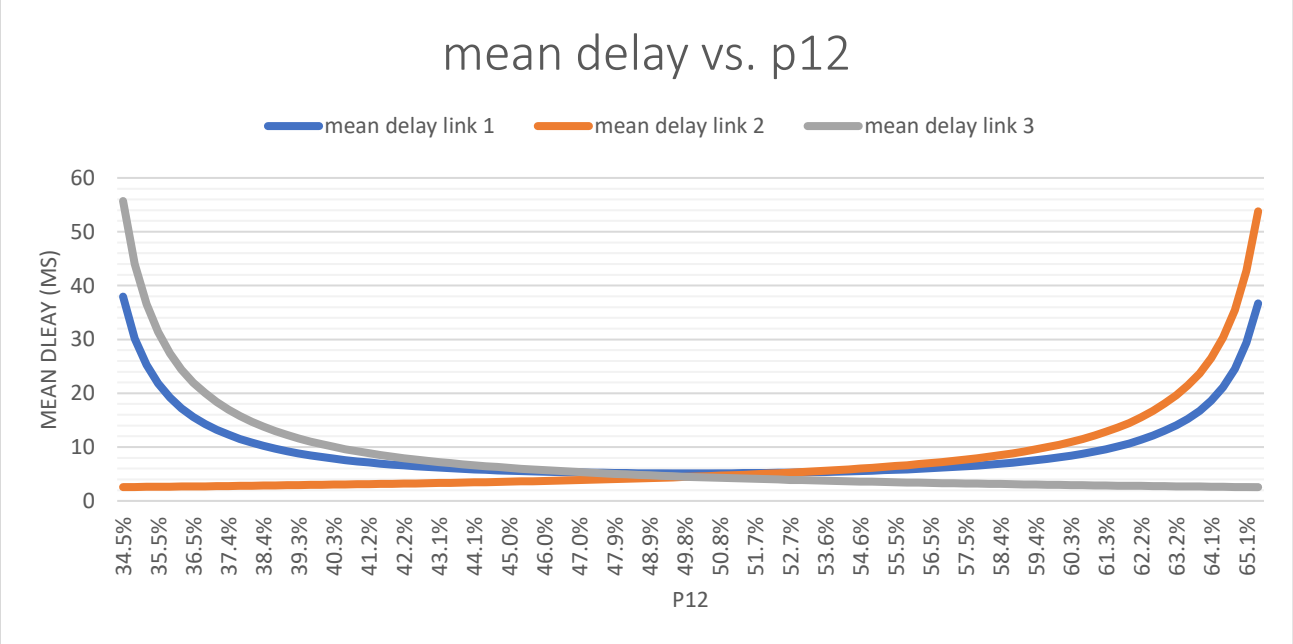
To simulate three switches, I defined a new struct of type Switch, that would hold a reference to the server and buffer. When a transmission occurs on Link 1, I model a new arrival on Link 2 or Link 3, depending on the p12.

I calculated 100 data points in the range on p12 = [0,1]



Data is in the appendix at mean delay vs. p12

This data reveals that outside the range [0.33,0.66] the delay for **link 1** explodes to infinity. We can see that in the range [0,0.33], the delay for **link 3** explodes to infinity, and in the range [0.66,1], the delay for **link 2** explodes to infinity. I collected 100 datapoints within the range [0.33,0.66], to explore the non-asymptotic behaviour.



Data is in the appendix at mean delay vs. p12 (load-balanced)

General Analysis

The maximum stable arrival rate for Link 2 and 3 is at 1000 packets/sec.

$$arrival\ rate\ \max = \frac{1}{\text{SERVICE\_TIME}} = \frac{number\ of\ servers\ \times link\ rate}{packet\ length}$$

$$\frac{link\ rate}{number\ of\ servers\ \times packet\ length} = \frac{1\ \times 10^6}{1000} = 1000\frac{packets}{sec}$$

When the p12 is near 0.5, the traffic contributed by link 1 will be an additional 375 packets/sec.

The superposition of multiple independent Poisson processes is a Poisson process with a rate equal to the sum of the sub-process rates.

This puts the arrival rate of Link 2 and Link 3 at:

$$500\ \frac{packets}{sec} + 375\ \frac{packets}{sec} = 875\ \frac{packets}{sec}$$

A general formula can be expressed as:

$$\lambda_n = 500\ \frac{packets}{sec} + 750 * p_{1n}\ \frac{packets}{sec}$$

Using this arrival rate, we can calculate the expected mean delay for an M/D/1 system given p12=0.5.

$$T = \frac{1}{2\mu} \cdot \frac{2-\rho}{1-\rho}$$

$$\rho = \frac{\lambda}{\mu} = \frac{875}{1000} = 0.875$$

$$\therefore T = \frac{1}{2(1000)} \cdot \frac{2-0.875}{1-0.875} = \frac{1.125}{2000 \cdot 0.125} = 4.5ms$$

I will perform a separate analysis of the effects of p12 on mean delay for packets originating at each switch.

Switch 1

Packets that originate at switch 1 see a minimum mean delay when **p12 = 0.5**. This balance puts the least amount of strain on the system, and the benefit is shared with packets originating at switch 1.

The value of mean delay when p12 = 0.5 is 5.15ms. This is because packets originating at switch 1 will experience 4.5ms of delay from Link 2 or Link 3, plus 0.65ms contributed by Link 1.

The mean delay in Link 1 is:

$$T = \frac{1}{2\mu} \cdot \frac{2-\rho}{1-\rho}$$

$$\rho = \frac{\lambda}{\mu} = \frac{750}{2000} = 0.375$$

$$\therefore T = \frac{1}{2(2000)} \cdot \frac{2-0.375}{1-0.375} = \frac{1.625}{4000 \cdot 0.625} = 0.65ms$$

$$T(packet\ 1, p = 0.5) = 4.5ms + 0.65ms = 5.15ms$$

The theoretical value of $5.15ms$ is 99.5% accurate against the experimental results ($5.12ms$). This discrepancy can likely be attributed to the law of large numbers.

When the p12 is outside the range p12 = [0.33,0.66], the mean delay explodes to infinity. This is because the departure rate from Link 1 plus the arrival rate of Link 2 or Link 3 will be near or greater than 1000 packets/sec. This results in Link 2 or Link 3 becoming unstable, and their mean delay explodes to infinity. Any packets from Link 1 that travel to an unstable link, will experience a very large unstable delay.

The mean delay for packets originating at switch 1 will be unstable outside this range, but it will be **less** than the mean delay experienced by the unstable link. This is because **some packets from Link 1 go to the stable switch.** This is only true when p12 does not equal 1 or 0 exactly.

Switch 2

When the p12 is $\gg$ than 0.5, Link 2 becomes unstable.

$$\lambda_2 < 1000$$

$$\lambda_2 = 500\ \frac{packets}{sec} + 750 * p_{12}\ \frac{packets}{sec}$$

$$500\ \frac{packets}{sec} + 750 * p_{12}\ \frac{packets}{sec} < 1000$$

$$750 * p_{12}\ \frac{packets}{sec} < 500$$

$$p_{12} < \frac{500}{750}$$

$$p_{12} < \overline{0.66}$$

When this condition is violated, Link 2 becomes unstable.

When p12=0.5, the system is load balanced, and the mean delay for link 2 is 4.5ms. See General Analysis.

When p12 approaches 0, Link 2 mean delay approaches 1.5ms.

$$\lambda_2 = 500\ \frac{packets}{sec}$$

$$T = \frac{1}{2(1000)} \cdot \frac{2-0.5}{1-0.5} = \frac{1.5}{2000 \cdot 0.5} = 1.5ms$$

This is because some of the packets from link 1 will travel through the stable link.

Switch 3

When the p12 is ≪ than 0.5, Link 3 becomes unstable.

$$\lambda_3 < 1000$$

$$\lambda_3 = 500\ \frac{packets}{sec} + 750 * p_{13}\ \frac{packets}{sec}$$

$$500\ \frac{packets}{sec} + 750 * (1-p_{12})\ \frac{packets}{sec} < 1000$$

$$750 * (1-p_{12})\ \frac{packets}{sec} < 500$$

$$(1-p_{12}) < \frac{500}{750}$$

$$p_{12} < 1 - \frac{500}{750}$$

$$p_{12} < \overline{0.33}$$

When this condition is violated, Link 3 becomes unstable.

When p12=0.5, the system is load balanced, and the mean delay for link 3 is 4.5ms. See General Analysis.

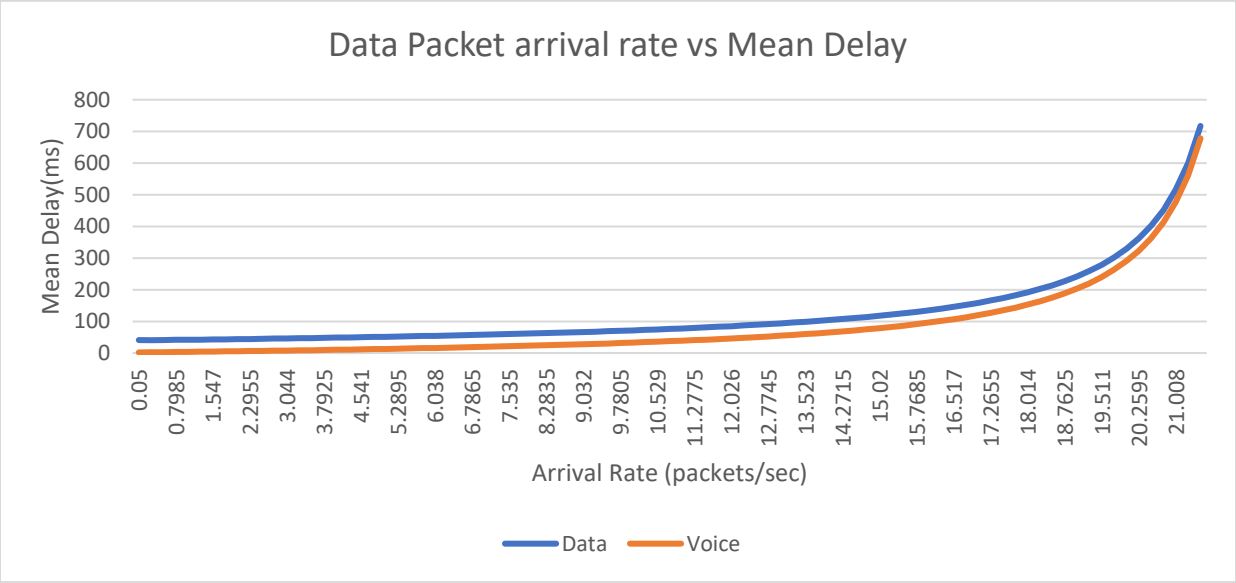
When p12 approaches 0, Link 3 mean delay approaches 1.5ms.

$$\lambda_3 = 500\ \frac{packets}{sec}$$

$$T = \frac{1}{2(1000)} \cdot \frac{2-0.5}{1-0.5} = \frac{1.5}{2000 \cdot 0.5} = 1.5ms$$

Section 6

I plot the mean delay for voice and data packets, for data packet arrival rates between [0.005, 21.008] packets/sec.



Data is in the appendix at Data Packet arrival rate vs Mean Delay Full range

The mean delay for voice packets has an **x-axis intercept** near 1.776 ms. This is the service time of a voice packet.

The mean delay for data packets has an **x-axis intercept** near 40.16 ms. This is because, if there are a very small number of data packets, the average data packet will only experience 40ms of service time, **or** 40ms of service time plus 1.776ms of waiting time.

The probability that a voice packet is in service, is:

$$\frac{1.776ms}{20ms} = 8.88\%$$

With this, we can calculate **the x-axis intercept** data packet mean delay.

$$T = 41.776 \cdot 8.88\% + 40 \cdot (1 - 8.88\%) = 40.158ms$$

When I run the simulation over 1 billion packets, with a data arrival rate of 0.005, I get the following results:

$$T = 40.11ms$$

With such a small arrival rate, only ~100000 data packets are processed. This data is accurate to a tenth of a millisecond of the theoretical value

The **vertical asymptote** for both voice and data packets is approximately:

$$\lambda = 22.96 \frac{packets}{sec}$$

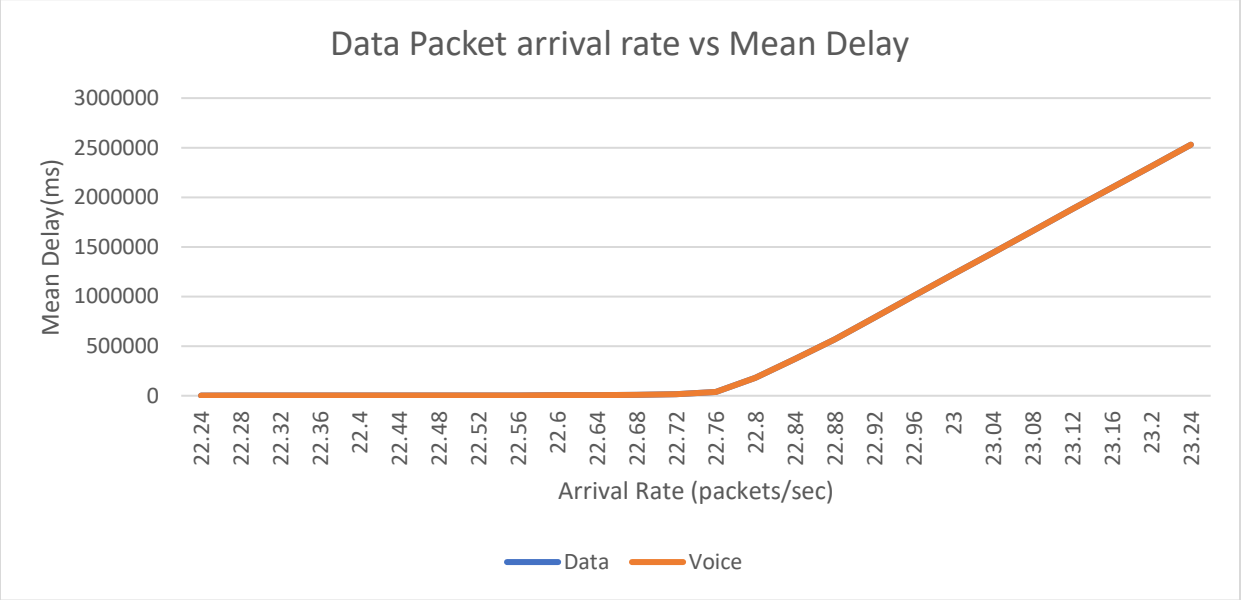
This can be derived by considering the arrival rate of voice packets, and the service time of data packets. Given the service time of a data packet is 40ms, and the inter-arrival time of a voice packet is 20ms, we can conclude that **two** voice packets will arrive while a data packet is processing. For the system to be stable, the arrival rate for data packets needs to allow for the two voice packets to be processed after the data packet has been processed, before a new data packet arrives.

This can be calculated as:

$$Inter\ Arrival\ Time\ (ms) = 1.776 \cdot 2 + 40$$

$$\lambda = \frac{1}{Inter\ Arrival\ Time\ (ms) \cdot \frac{1}{1000}} = 22.96\ \frac{packets}{sec}$$

I collected mean delay data for arrival rates between [22.24,23.24].



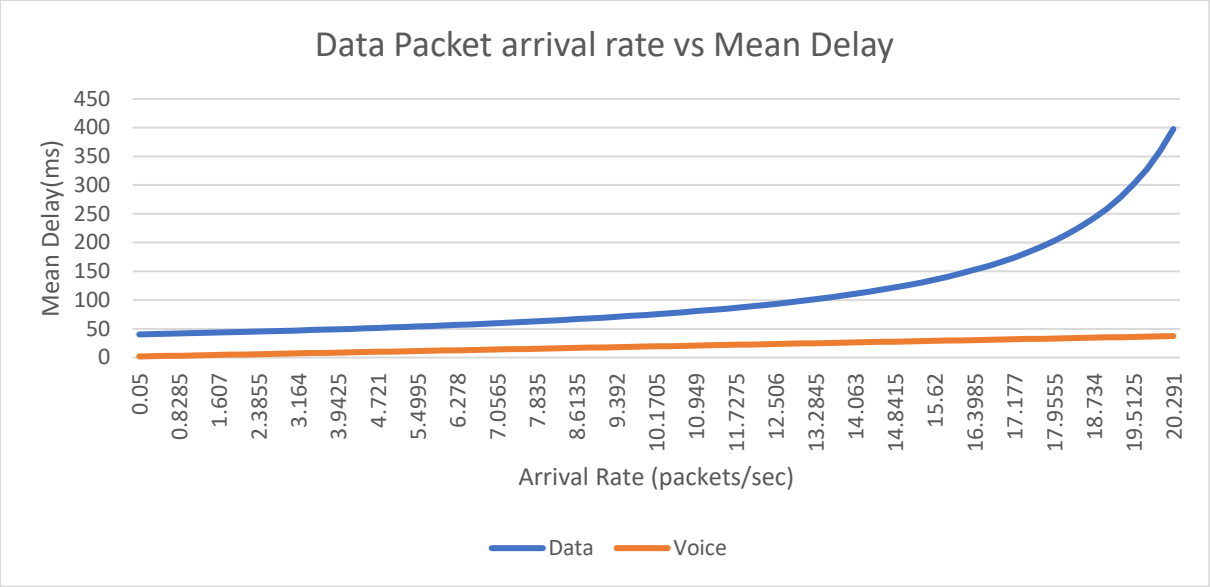
Data is in the appendix at Data Packet arrival rate vs Mean Delay vertical asymptote

We can see that the mean delay explodes to infinity around 22.76 packets/sec. This is approximately equal to the theoretical value of 22.96 packets/sec. The discrepancy likely results from the probability of the data packet arriving while a voice packet is being processed. In that case, the inter-arrival time would need to allow for **three** voice packets to be processed, decreasing the theoretical value of $\lambda_{Unstable}$.

Section 7

To ensure that voice packets are given non-preemptive priority, I buffer the streams of voice and data packets separately. Data packets will not be processed until the voice packets have all been processed.

I've plotted the mean delay of data and voice packets against the data packet arrival rate in the range [0.05,20.291].



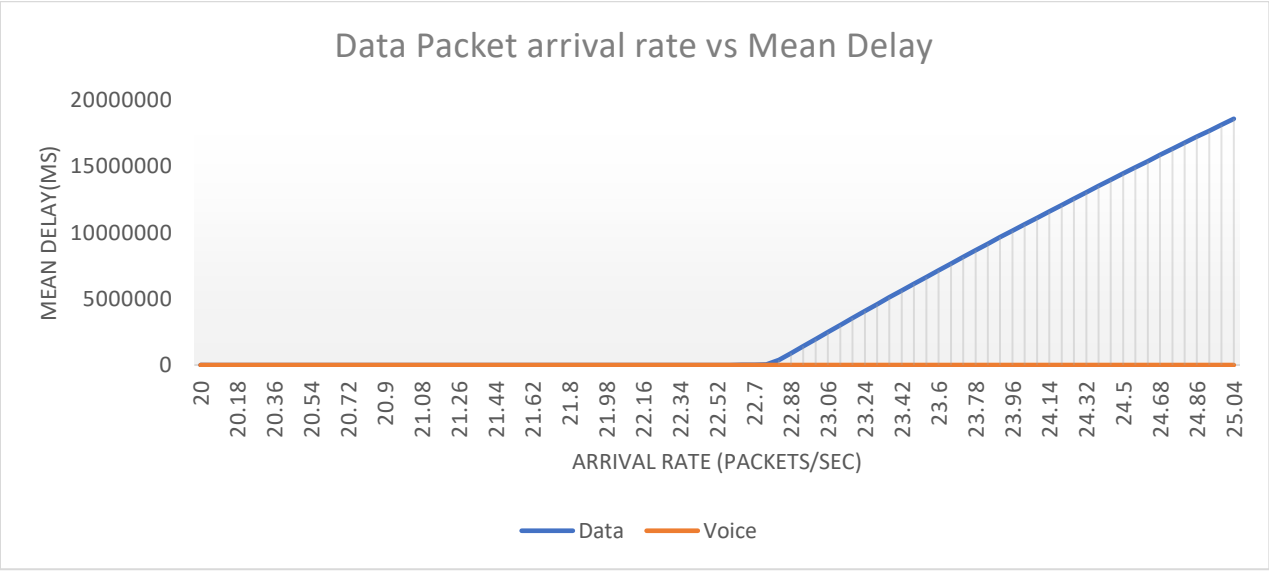
Data is in the appendix at Data Packet arrival rate vs Mean Delay

We can see that the **x-axis intercept** is the same as in Section 6.

The mean delay for voice packets has an **x-axis intercept** near 1.776 ms. This is the service time of a voice packet.

The mean delay for data packets has an **x-axis intercept** near 40.16 ms.

The non-preemptive priority affects the behavior as the data packet arrival rate increases. We see that in this mode of operation, the data packets mean delay grows much faster than the voice packets. In fact, the voice packets have a **horizontal asymptote** at 41.776ms. We see that the data packets explode to infinity, while the voice packets do not, in a plot of the asymptotic behavior for larger data packet arrival rates.



Data is in the appendix at Data Packet arrival rate vs Mean Delay Asymptotic

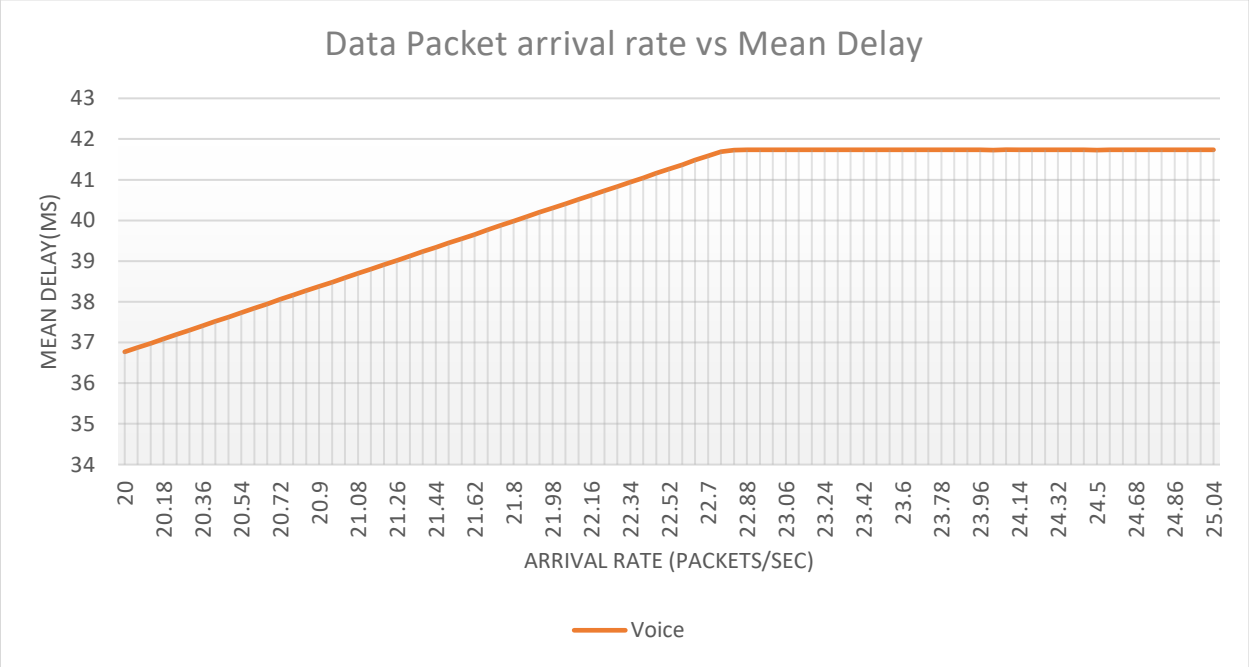
The derivation for the data packet vertical asymptote remains the same as in Section 6. The data packet inter-arrival time will still need to allow for 2-3 voice packets to complete before a new data packet arrives. This places the vertical asymptote around:

$$\lambda = 22.96 \frac{packets}{sec}$$

The voice packets do not have a vertical asymptote. They trend to a horizontal asymptote.

The data confirms the theoretical asymptote, showing that the voice packet mean delay trends towards a horizontal asymptote of 41.776ms. This is because when the voice packets are given non-preemptive priority, the maximum possible delay they can experience is their service time + a single data packet service time.

$$T = 1.776ms + 40ms = 41.776ms$$



Data is in the appendix at Data Packet arrival rate vs Mean Delay Asymptotic

Modifications to code

For-loops were used to allow a range of arrival rates, seeds, and p12 values to be generated: to collect a fine range of data.

Data was exported en-masse to a .csv file, where the data was manipulated in excel to create the plots.

The code was modified throughout the lab to enable:

- Counters were used to detect probability of packets with mean delays greater than 20ms.
- Multiple link pointers were used to emulate M/D/2

- A *Switch* struct was used to emulate multiple switches. The struct would point to a link and a buffer and had an integer identifier. The struct was used to accumulate the delays of packets originating at that switch.
- A *rand()* call was used to emulate a uniform distribution. The result of this was directly compared against the p12 value (i.e. rand < p12), in order to decide which link would receive a packet form Link 1.
- Two new arrival functions were added to define voice and data packets. These arrival functions would feed into the same shared link/buffer.
- Two buffers were used to emulate non-preemptive priorities. The voice/data arrival functions would feed into their respective buffer, and the voice buffer was given priority when scheduling the next transmission if both buffers had data.

Appendix

mean delay vs. ARRIVAL RATE Data.

Student number is 400137271. If seed not specified, this was used as the seed.

arrival rate	mean delay	random seed
20	0.5	400137271
20	0.5	4728394
20	0.5	12950156
20	0.5	1255
20	0.5	1627
20	0.5	136127
20	0.5	3845648
20	0.5	8834
20	0.5	348734
20	0.5	98
69	0.51	400137271
69	0.51	4728394
69	0.51	12950156
69	0.51	1255
69	0.51	1627
69	0.51	136127
69	0.51	3845648
69	0.51	8834
69	0.51	348734
69	0.51	98
118	0.52	400137271
118	0.52	4728394
118	0.52	12950156
118	0.52	1255
118	0.52	1627

118	0.52	136127
118	0.52	3845648
118	0.52	8834
118	0.52	348734
118	0.52	98
167	0.52	400137271
167	0.52	4728394
167	0.52	12950156
167	0.52	1255
167	0.52	1627
167	0.52	136127
167	0.52	3845648
167	0.52	8834
167	0.52	348734
167	0.52	98
216	0.53	400137271
216	0.53	4728394
216	0.53	12950156
216	0.53	1255
216	0.53	1627
216	0.53	136127
216	0.53	3845648
216	0.53	8834
216	0.53	348734
216	0.53	98
265	0.54	400137271
265	0.54	4728394
265	0.54	12950156
265	0.54	1255
265	0.54	1627
265	0.54	136127
265	0.54	3845648
265	0.54	8834
265	0.54	348734
265	0.54	98
314	0.55	400137271
314	0.55	4728394
314	0.55	12950156
314	0.55	1255
314	0.55	1627
314	0.55	136127
314	0.55	3845648
314	0.55	8834

314	0.55	348734
314	0.55	98
363	0.56	400137271
363	0.56	4728394
363	0.56	12950156
363	0.56	1255
363	0.56	1627
363	0.56	136127
363	0.56	3845648
363	0.56	8834
363	0.56	348734
363	0.56	98
412	0.57	400137271
412	0.57	4728394
412	0.56	12950156
412	0.57	1255
412	0.56	1627
412	0.56	136127
412	0.56	3845648
412	0.56	8834
412	0.56	348734
412	0.56	98
461	0.58	400137271
461	0.58	4728394
461	0.57	12950156
461	0.58	1255
461	0.57	1627
461	0.57	136127
461	0.57	3845648
461	0.57	8834
461	0.58	348734
461	0.57	98
510	0.59	400137271
510	0.59	4728394
510	0.59	12950156
510	0.59	1255
510	0.59	1627
510	0.59	136127
510	0.59	3845648
510	0.59	8834
510	0.59	348734
510	0.59	98
559	0.6	400137271

559	0.6	4728394
559	0.6	12950156
559	0.6	1255
559	0.6	1627
559	0.6	136127
559	0.6	3845648
559	0.6	8834
559	0.6	348734
559	0.6	98
608	0.61	400137271
608	0.61	4728394
608	0.61	12950156
608	0.61	1255
608	0.61	1627
608	0.61	136127
608	0.61	3845648
608	0.61	8834
608	0.61	348734
608	0.61	98
657	0.62	400137271
657	0.62	4728394
657	0.62	12950156
657	0.62	1255
657	0.62	1627
657	0.62	136127
657	0.62	3845648
657	0.62	8834
657	0.62	348734
657	0.62	98
706	0.64	400137271
706	0.64	4728394
706	0.64	12950156
706	0.64	1255
706	0.64	1627
706	0.64	136127
706	0.64	3845648
706	0.64	8834
706	0.64	348734
706	0.64	98
755	0.65	400137271
755	0.65	4728394
755	0.65	12950156
755	0.65	1255

755	0.65	1627
755	0.65	136127
755	0.65	3845648
755	0.65	8834
755	0.65	348734
755	0.65	98
804	0.67	400137271
804	0.67	4728394
804	0.67	12950156
804	0.67	1255
804	0.67	1627
804	0.67	136127
804	0.67	3845648
804	0.67	8834
804	0.67	348734
804	0.67	98
853	0.69	400137271
853	0.69	4728394
853	0.68	12950156
853	0.69	1255
853	0.69	1627
853	0.69	136127
853	0.69	3845648
853	0.69	8834
853	0.69	348734
853	0.69	98
902	0.71	400137271
902	0.71	4728394
902	0.7	12950156
902	0.71	1255
902	0.71	1627
902	0.7	136127
902	0.7	3845648
902	0.7	8834
902	0.7	348734
902	0.71	98
951	0.73	400137271
951	0.73	4728394
951	0.73	12950156
951	0.73	1255
951	0.73	1627
951	0.73	136127
951	0.73	3845648

951	0.73	8834
951	0.73	348734
951	0.73	98
1000	0.75	400137271
1000	0.75	4728394
1000	0.75	12950156
1000	0.75	1255
1000	0.75	1627
1000	0.75	136127
1000	0.75	3845648
1000	0.75	8834
1000	0.75	348734
1000	0.75	98
1049	0.78	400137271
1049	0.78	4728394
1049	0.77	12950156
1049	0.78	1255
1049	0.78	1627
1049	0.77	136127
1049	0.77	3845648
1049	0.77	8834
1049	0.77	348734
1049	0.78	98
1098	0.8	400137271
1098	0.81	4728394
1098	0.8	12950156
1098	0.81	1255
1098	0.8	1627
1098	0.8	136127
1098	0.8	3845648
1098	0.8	8834
1098	0.8	348734
1098	0.8	98
1147	0.84	400137271
1147	0.84	4728394
1147	0.83	12950156
1147	0.84	1255
1147	0.84	1627
1147	0.83	136127
1147	0.83	3845648
1147	0.83	8834
1147	0.84	348734
1147	0.84	98

1196	0.87	400137271
1196	0.87	4728394
1196	0.87	12950156
1196	0.87	1255
1196	0.87	1627
1196	0.87	136127
1196	0.87	3845648
1196	0.87	8834
1196	0.87	348734
1196	0.87	98
1245	0.91	400137271
1245	0.91	4728394
1245	0.91	12950156
1245	0.92	1255
1245	0.91	1627
1245	0.91	136127
1245	0.91	3845648
1245	0.91	8834
1245	0.91	348734
1245	0.91	98
1294	0.96	400137271
1294	0.96	4728394
1294	0.95	12950156
1294	0.96	1255
1294	0.96	1627
1294	0.95	136127
1294	0.96	3845648
1294	0.95	8834
1294	0.96	348734
1294	0.96	98
1343	1.01	400137271
1343	1.01	4728394
1343	1.01	12950156
1343	1.01	1255
1343	1.01	1627
1343	1.01	136127
1343	1.01	3845648
1343	1.01	8834
1343	1.01	348734
1343	1.01	98
1392	1.07	400137271
1392	1.08	4728394
1392	1.07	12950156

1392	1.08	1255
1392	1.07	1627
1392	1.07	136127
1392	1.07	3845648
1392	1.07	8834
1392	1.07	348734
1392	1.07	98
1441	1.14	400137271
1441	1.15	4728394
1441	1.14	12950156
1441	1.15	1255
1441	1.15	1627
1441	1.14	136127
1441	1.14	3845648
1441	1.14	8834
1441	1.14	348734
1441	1.14	98
1490	1.23	400137271
1490	1.24	4728394
1490	1.22	12950156
1490	1.24	1255
1490	1.23	1627
1490	1.22	136127
1490	1.23	3845648
1490	1.22	8834
1490	1.23	348734
1490	1.22	98
1539	1.33	400137271
1539	1.34	4728394
1539	1.33	12950156
1539	1.34	1255
1539	1.34	1627
1539	1.33	136127
1539	1.33	3845648
1539	1.32	8834
1539	1.33	348734
1539	1.32	98
1588	1.46	400137271
1588	1.47	4728394
1588	1.45	12950156
1588	1.48	1255
1588	1.47	1627
1588	1.45	136127

1588	1.46	3845648
1588	1.45	8834
1588	1.46	348734
1588	1.45	98
1637	1.62	400137271
1637	1.63	4728394
1637	1.61	12950156
1637	1.64	1255
1637	1.63	1627
1637	1.61	136127
1637	1.62	3845648
1637	1.6	8834
1637	1.62	348734
1637	1.61	98
1686	1.83	400137271
1686	1.84	4728394
1686	1.83	12950156
1686	1.86	1255
1686	1.85	1627
1686	1.82	136127
1686	1.84	3845648
1686	1.81	8834
1686	1.83	348734
1686	1.81	98
1735	2.12	400137271
1735	2.13	4728394
1735	2.12	12950156
1735	2.16	1255
1735	2.15	1627
1735	2.1	136127
1735	2.13	3845648
1735	2.09	8834
1735	2.12	348734
1735	2.09	98
1784	2.54	400137271
1784	2.56	4728394
1784	2.54	12950156
1784	2.59	1255
1784	2.59	1627
1784	2.51	136127
1784	2.55	3845648
1784	2.49	8834
1784	2.56	348734

1784	2.5	98
1833	3.2	400137271
1833	3.26	4728394
1833	3.2	12950156
1833	3.28	1255
1833	3.29	1627
1833	3.15	136127
1833	3.22	3845648
1833	3.13	8834
1833	3.27	348734
1833	3.13	98
1882	4.41	400137271
1882	4.62	4728394
1882	4.37	12950156
1882	4.58	1255
1882	4.56	1627
1882	4.27	136127
1882	4.5	3845648
1882	4.26	8834
1882	4.56	348734
1882	4.22	98
1931	7.48	400137271
1931	8.24	4728394
1931	7.17	12950156
1931	7.83	1255
1931	7.75	1627
1931	6.9	136127
1931	7.69	3845648
1931	7.01	8834
1931	7.61	348734
1931	6.7	98
1980	26.31	400137271
1980	27.28	4728394
1980	20.01	12950156
1980	26.23	1255
1980	28.24	1627
1980	19.94	136127
1980	25.11	3845648
1980	22.94	8834
1980	22.66	348734
1980	19.49	98
1600	1.5	400137271
1600	1.5	4728394

1600	1.49	12950156
1600	1.51	1255
1600	1.5	1627
1600	1.49	136127
1600	1.5	3845648
1600	1.48	8834
1600	1.49	348734
1600	1.48	98
1700	1.91	400137271
1700	1.92	4728394
1700	1.9	12950156
1700	1.94	1255
1700	1.93	1627
1700	1.89	136127
1700	1.91	3845648
1700	1.88	8834
1700	1.91	348734
1700	1.88	98
1800	2.72	400137271
1800	2.74	4728394
1800	2.72	12950156
1800	2.78	1255
1800	2.79	1627
1800	2.69	136127
1800	2.73	3845648
1800	2.67	8834
1800	2.75	348734
1800	2.67	98
1900	5.16	400137271
1900	5.49	4728394
1900	5.09	12950156
1900	5.38	1255
1900	5.36	1627
1900	4.94	136127
1900	5.28	3845648
1900	4.96	8834
1900	5.35	348734
1900	4.86	98
2000	280.24	400137271
2000	191.51	4728394
2000	89.15	12950156
2000	319.74	1255
2000	424.37	1627

2000	93.66	136127
2000	169.23	3845648
2000	101.73	8834
2000	197.09	348734
2000	89.37	98
2100	11864.33	400137271
2100	12053.5	4728394
2100	11439.46	12950156
2100	12144.33	1255
2100	12151.13	1627
2100	11294.18	136127
2100	11916.27	3845648
2100	11554.23	8834
2100	11804.47	348734
2100	11409.47	98
2200	22688.4	400137271
2200	22868.51	4728394
2200	22282.04	12950156
2200	22955.94	1255
2200	22962.43	1627
2200	22144.27	136127
2200	22736.28	3845648
2200	22392.68	8834
2200	22618.16	348734
2200	22253.37	98
2300	32571.24	400137271
2300	32743.4	4728394
2300	32182.52	12950156
2300	32827.41	1255
2300	32833.62	1627
2300	32050.88	136127
2300	32615.73	3845648
2300	32288.66	8834
2300	32503.84	348734
2300	32155.05	98
2400	41630.51	400137271
2400	41795.62	4728394
2400	41258.26	12950156
2400	41876.26	1255
2400	41882.21	1627
2400	41132.08	136127
2400	41672.18	3845648
2400	41359.98	8834

2400	41565.71	348734
2400	41231.81	98
2500	49965.24	400137271
2500	50123.67	4728394
2500	49607.94	12950156
2500	50201.2	1255
2500	50206.91	1627
2500	49486.81	136127
2500	50004.3	3845648
2500	49705.59	8834
2500	49902.84	348734
2500	49582.43	98
2600	57658.9	400137271
2600	57811.09	4728394
2600	57315.33	12950156
2600	57885.76	1255
2600	57891.25	1627
2600	57198.86	136127
2600	57695.49	3845648
2600	57409.23	8834
2600	57598.68	348734
2600	57290.69	98

Arrival Rate vs. P[delay>20ms]

arrival rate	mean delay	seed	greater than 20ms	total served	P[greater than 20ms]
100	2.25	400137271	0	20000000	0
114	2.3	400137271	0	20000000	0
128	2.34	400137271	0	20000000	0
142	2.4	400137271	0	20000000	0
156	2.45	400137271	0	20000000	0
170	2.52	400137271	0	20000000	0
184	2.58	400137271	0	20000000	0
198	2.66	400137271	1	20000000	0
212	2.74	400137271	5	20000000	0.0000002
226	2.83	400137271	29	20000000	0.0000015
240	2.92	400137271	83	20000000	0.0000042
254	3.03	400137271	194	20000000	0.0000097
268	3.16	400137271	453	20000000	0.0000227
282	3.3	400137271	1041	20000000	0.000052
296	3.45	400137271	2209	20000000	0.0001105
310	3.63	400137271	4710	20000000	0.0002355

324	3.84	400137271	10108	20000000	0.0005054
338	4.09	400137271	20555	20000000	0.0010278
352	4.38	400137271	41036	20000000	0.0020518
366	4.74	400137271	79991	20000000	0.0039996
380	5.17	400137271	152387	20000000	0.0076194
394	5.72	400137271	282797	20000000	0.0141399
408	6.44	400137271	513581	20000000	0.025679
422	7.42	400137271	925770	20000000	0.0462885
436	8.83	400137271	1650039	20000000	0.082502
450	11.02	400137271	2901690	20000000	0.1450845

Arrival Rate vs. P[delay>20ms] high-precision

arrival rate	mean delay	seed	greater than 20ms	total served	P[greater than 20ms]
402.47	6.13	400137271	4998714	250000000	0.0199949
402.471	6.13	400137271	4998925	250000000	0.0199957
402.472	6.13	400137271	4999146	250000000	0.0199966
402.473	6.13	400137271	4999377	250000000	0.0199975
402.474	6.13	400137271	4999585	250000000	0.0199983
402.475	6.13	400137271	4999799	250000000	0.0199992
402.476	6.13	400137271	5000016	250000000	0.0200001
402.477	6.13	400137271	5000250	250000000	0.020001
402.478	6.13	400137271	5000451	250000000	0.0200018
402.479	6.13	400137271	5000683	250000000	0.0200027
402.48	6.13	400137271	5000904	250000000	0.0200036
402.481	6.13	400137271	5001111	250000000	0.0200044
402.482	6.13	400137271	5001320	250000000	0.0200053
402.483	6.13	400137271	5001523	250000000	0.0200061
402.484	6.13	400137271	5001742	250000000	0.020007
402.485	6.13	400137271	5001943	250000000	0.0200078
402.486	6.13	400137271	5002187	250000000	0.0200087
402.487	6.13	400137271	5002410	250000000	0.0200096
402.488	6.13	400137271	5002611	250000000	0.0200104
402.489	6.13	400137271	5002811	250000000	0.0200112
402.49	6.13	400137271	5003026	250000000	0.0200121
402.491	6.13	400137271	5003269	250000000	0.0200131
402.492	6.13	400137271	5003502	250000000	0.020014
402.493	6.13	400137271	5003720	250000000	0.0200149
402.494	6.13	400137271	5003936	250000000	0.0200157
402.495	6.13	400137271	5004132	250000000	0.0200165
402.496	6.13	400137271	5004338	250000000	0.0200174
402.497	6.13	400137271	5004547	250000000	0.0200182

402.498	6.13	400137271	5004752	250000000	0.020019
402.499	6.13	400137271	5004955	250000000	0.0200198
402.5	6.13	400137271	5005178	250000000	0.0200207

M/D/2 mean delay vs. ARRIVAL RATE Data.

arrival rate	mean delay	seed
20	1	400137271
20	1	4728394
20	1	12950156
20	1	1255
20	1	1627
20	1	136127
20	1	3845648
20	1	8834
20	1	348734
20	1	98
69	1	400137271
69	1	4728394
69	1	12950156
69	1	1255
69	1	1627
69	1	136127
69	1	3845648
69	1	8834
69	1	348734
69	1	98
118	1	400137271
118	1	4728394
118	1	12950156
118	1	1255
118	1	1627
118	1	136127
118	1	3845648
118	1	8834
118	1	348734
118	1	98
167	1	400137271
167	1	4728394
167	1	12950156
167	1	1255
167	1	1627
167	1	136127

167	1	3845648
167	1	8834
167	1	348734
167	1	98
216	1.01	400137271
216	1.01	4728394
216	1.01	12950156
216	1.01	1255
216	1.01	1627
216	1.01	136127
216	1.01	3845648
216	1.01	8834
216	1.01	348734
216	1.01	98
265	1.01	400137271
265	1.01	4728394
265	1.01	12950156
265	1.01	1255
265	1.01	1627
265	1.01	136127
265	1.01	3845648
265	1.01	8834
265	1.01	348734
265	1.01	98
314	1.02	400137271
314	1.02	4728394
314	1.01	12950156
314	1.02	1255
314	1.01	1627
314	1.01	136127
314	1.01	3845648
314	1.02	8834
314	1.02	348734
314	1.01	98
363	1.02	400137271
363	1.02	4728394
363	1.02	12950156
363	1.02	1255
363	1.02	1627
363	1.02	136127
363	1.02	3845648
363	1.02	8834
363	1.02	348734

363	1.02	98
412	1.03	400137271
412	1.03	4728394
412	1.03	12950156
412	1.03	1255
412	1.03	1627
412	1.03	136127
412	1.03	3845648
412	1.03	8834
412	1.03	348734
412	1.03	98
461	1.03	400137271
461	1.03	4728394
461	1.03	12950156
461	1.03	1255
461	1.03	1627
461	1.03	136127
461	1.03	3845648
461	1.03	8834
461	1.03	348734
461	1.03	98
510	1.04	400137271
510	1.04	4728394
510	1.04	12950156
510	1.04	1255
510	1.04	1627
510	1.04	136127
510	1.04	3845648
510	1.04	8834
510	1.04	348734
510	1.04	98
559	1.05	400137271
559	1.05	4728394
559	1.05	12950156
559	1.05	1255
559	1.05	1627
559	1.05	136127
559	1.05	3845648
559	1.05	8834
559	1.05	348734
559	1.05	98
608	1.06	400137271
608	1.06	4728394

608	1.06	12950156
608	1.06	1255
608	1.06	1627
608	1.06	136127
608	1.06	3845648
608	1.06	8834
608	1.06	348734
608	1.06	98
657	1.07	400137271
657	1.07	4728394
657	1.07	12950156
657	1.07	1255
657	1.07	1627
657	1.07	136127
657	1.07	3845648
657	1.07	8834
657	1.07	348734
657	1.07	98
706	1.08	400137271
706	1.08	4728394
706	1.08	12950156
706	1.08	1255
706	1.08	1627
706	1.08	136127
706	1.08	3845648
706	1.08	8834
706	1.08	348734
706	1.08	98
755	1.09	400137271
755	1.09	4728394
755	1.09	12950156
755	1.09	1255
755	1.09	1627
755	1.09	136127
755	1.09	3845648
755	1.09	8834
755	1.09	348734
755	1.09	98
804	1.1	400137271
804	1.11	4728394
804	1.1	12950156
804	1.1	1255
804	1.1	1627

804	1.1	136127
804	1.1	3845648
804	1.1	8834
804	1.1	348734
804	1.1	98
853	1.12	400137271
853	1.12	4728394
853	1.12	12950156
853	1.12	1255
853	1.12	1627
853	1.12	136127
853	1.12	3845648
853	1.12	8834
853	1.12	348734
853	1.12	98
902	1.14	400137271
902	1.14	4728394
902	1.14	12950156
902	1.14	1255
902	1.14	1627
902	1.14	136127
902	1.14	3845648
902	1.14	8834
902	1.14	348734
902	1.14	98
951	1.16	400137271
951	1.16	4728394
951	1.15	12950156
951	1.16	1255
951	1.16	1627
951	1.15	136127
951	1.15	3845648
951	1.16	8834
951	1.15	348734
951	1.16	98
1000	1.18	400137271
1000	1.18	4728394
1000	1.18	12950156
1000	1.18	1255
1000	1.18	1627
1000	1.18	136127
1000	1.18	3845648
1000	1.18	8834

1000	1.18	348734
1000	1.18	98
1049	1.2	400137271
1049	1.2	4728394
1049	1.2	12950156
1049	1.2	1255
1049	1.2	1627
1049	1.2	136127
1049	1.2	3845648
1049	1.2	8834
1049	1.2	348734
1049	1.2	98
1098	1.23	400137271
1098	1.23	4728394
1098	1.23	12950156
1098	1.23	1255
1098	1.23	1627
1098	1.22	136127
1098	1.23	3845648
1098	1.23	8834
1098	1.23	348734
1098	1.23	98
1147	1.26	400137271
1147	1.26	4728394
1147	1.26	12950156
1147	1.26	1255
1147	1.26	1627
1147	1.25	136127
1147	1.26	3845648
1147	1.25	8834
1147	1.26	348734
1147	1.26	98
1196	1.29	400137271
1196	1.29	4728394
1196	1.29	12950156
1196	1.29	1255
1196	1.29	1627
1196	1.29	136127
1196	1.29	3845648
1196	1.29	8834
1196	1.29	348734
1196	1.29	98
1245	1.33	400137271

1245	1.33	4728394
1245	1.33	12950156
1245	1.33	1255
1245	1.33	1627
1245	1.33	136127
1245	1.33	3845648
1245	1.33	8834
1245	1.33	348734
1245	1.33	98
1294	1.37	400137271
1294	1.38	4728394
1294	1.37	12950156
1294	1.38	1255
1294	1.37	1627
1294	1.37	136127
1294	1.37	3845648
1294	1.37	8834
1294	1.37	348734
1294	1.37	98
1343	1.42	400137271
1343	1.43	4728394
1343	1.42	12950156
1343	1.43	1255
1343	1.42	1627
1343	1.42	136127
1343	1.42	3845648
1343	1.42	8834
1343	1.42	348734
1343	1.42	98
1392	1.48	400137271
1392	1.49	4728394
1392	1.48	12950156
1392	1.49	1255
1392	1.48	1627
1392	1.48	136127
1392	1.48	3845648
1392	1.48	8834
1392	1.48	348734
1392	1.48	98
1441	1.55	400137271
1441	1.56	4728394
1441	1.55	12950156
1441	1.56	1255

1441	1.55	1627
1441	1.55	136127
1441	1.55	3845648
1441	1.55	8834
1441	1.55	348734
1441	1.55	98
1490	1.64	400137271
1490	1.64	4728394
1490	1.63	12950156
1490	1.64	1255
1490	1.64	1627
1490	1.63	136127
1490	1.64	3845648
1490	1.63	8834
1490	1.63	348734
1490	1.63	98
1539	1.74	400137271
1539	1.75	4728394
1539	1.73	12950156
1539	1.75	1255
1539	1.74	1627
1539	1.73	136127
1539	1.74	3845648
1539	1.73	8834
1539	1.73	348734
1539	1.73	98
1588	1.86	400137271
1588	1.87	4728394
1588	1.86	12950156
1588	1.88	1255
1588	1.87	1627
1588	1.86	136127
1588	1.87	3845648
1588	1.85	8834
1588	1.86	348734
1588	1.85	98
1637	2.02	400137271
1637	2.03	4728394
1637	2.02	12950156
1637	2.05	1255
1637	2.04	1627
1637	2.01	136127
1637	2.03	3845648

1637	2.01	8834
1637	2.02	348734
1637	2.01	98
1686	2.23	400137271
1686	2.24	4728394
1686	2.23	12950156
1686	2.26	1255
1686	2.25	1627
1686	2.22	136127
1686	2.24	3845648
1686	2.21	8834
1686	2.23	348734
1686	2.21	98
1735	2.52	400137271
1735	2.53	4728394
1735	2.52	12950156
1735	2.56	1255
1735	2.55	1627
1735	2.5	136127
1735	2.53	3845648
1735	2.49	8834
1735	2.52	348734
1735	2.49	98
1784	2.94	400137271
1784	2.95	4728394
1784	2.93	12950156
1784	2.99	1255
1784	2.99	1627
1784	2.91	136127
1784	2.95	3845648
1784	2.89	8834
1784	2.95	348734
1784	2.9	98
1833	3.6	400137271
1833	3.66	4728394
1833	3.59	12950156
1833	3.68	1255
1833	3.68	1627
1833	3.55	136127
1833	3.62	3845648
1833	3.52	8834
1833	3.66	348734
1833	3.52	98

1882	4.81	400137271
1882	5.01	4728394
1882	4.77	12950156
1882	4.97	1255
1882	4.95	1627
1882	4.67	136127
1882	4.9	3845648
1882	4.66	8834
1882	4.95	348734
1882	4.61	98
1931	7.87	400137271
1931	8.63	4728394
1931	7.56	12950156
1931	8.22	1255
1931	8.14	1627
1931	7.29	136127
1931	8.08	3845648
1931	7.4	8834
1931	8	348734
1931	7.1	98
1980	26.7	400137271
1980	27.66	4728394
1980	20.4	12950156
1980	26.63	1255
1980	28.63	1627
1980	20.34	136127
1980	25.51	3845648
1980	23.33	8834
1980	23.04	348734
1980	19.89	98

mean delay vs. p12

p12	mean delay link 1	mean delay link 2	mean delay link 3	seed
0	668161.71	1.5	668728.73	400137271
0.01	640657.38	1.52	649291.24	400137271
0.02	613843.1	1.53	629917.49	400137271
0.03	587630.29	1.55	610493.41	400137271
0.04	562085.18	1.56	591187.62	400137271
0.05	537024.02	1.58	571757.76	400137271
0.06	512363.21	1.6	552265.05	400137271
0.07	488438.81	1.62	532925.49	400137271
0.08	464888.11	1.64	513472.34	400137271

0.09	441816.44	1.66	493951.91	400137271
0.1	419093.71	1.68	474273.04	400137271
0.11	396726.92	1.7	454454.94	400137271
0.12	374837.69	1.72	434595.19	400137271
0.13	353787.69	1.74	415143.14	400137271
0.14	332987.07	1.77	395476.63	400137271
0.15	312607.24	1.79	375772.17	400137271
0.16	292602.71	1.82	355972.85	400137271
0.17	272873.09	1.84	336004.59	400137271
0.18	253687.06	1.87	316111.41	400137271
0.19	234969.48	1.9	296290.12	400137271
0.2	216459.51	1.93	276233.98	400137271
0.21	198233.38	1.96	256030.14	400137271
0.22	180589.8	1.99	236025.44	400137271
0.23	163241.06	2.03	215901.81	400137271
0.24	145864.93	2.06	195287.51	400137271
0.25	129172.6	2.1	175036.2	400137271
0.26	112726.19	2.14	154592.7	400137271
0.27	96475.27	2.18	133948.46	400137271
0.28	80470.28	2.22	113105.83	400137271
0.29	64962	2.27	92429.43	400137271
0.3	49733.8	2.31	71639.11	400137271
0.31	34614.22	2.37	50478.22	400137271
0.32	19954.82	2.42	29461.21	400137271
0.33	5403.46	2.48	8075.93	400137271
0.34	70.23	2.53	104.25	400137271
0.35	27.83	2.6	40.47	400137271
0.36	17.98	2.67	25.62	400137271
0.37	13.52	2.74	18.83	400137271
0.38	10.91	2.82	14.84	400137271
0.39	9.24	2.9	12.24	400137271
0.4	8.11	2.99	10.45	400137271
0.41	7.29	3.09	9.12	400137271
0.42	6.69	3.19	8.11	400137271
0.43	6.23	3.31	7.32	400137271
0.44	5.89	3.43	6.68	400137271
0.45	5.63	3.57	6.15	400137271
0.46	5.43	3.72	5.71	400137271
0.47	5.29	3.88	5.33	400137271
0.48	5.19	4.06	5	400137271
0.49	5.14	4.27	4.71	400137271
0.5	5.12	4.49	4.46	400137271
0.51	5.14	4.75	4.24	400137271

0.52	5.2	5.03	4.04	400137271
0.53	5.3	5.37	3.86	400137271
0.54	5.45	5.75	3.7	400137271
0.55	5.65	6.2	3.55	400137271
0.56	5.91	6.72	3.41	400137271
0.57	6.25	7.36	3.29	400137271
0.58	6.7	8.14	3.18	400137271
0.59	7.29	9.12	3.08	400137271
0.6	8.09	10.43	2.98	400137271
0.61	9.22	12.22	2.89	400137271
0.62	10.86	14.77	2.8	400137271
0.63	13.42	18.69	2.73	400137271
0.64	17.75	25.24	2.65	400137271
0.65	27.82	40.43	2.59	400137271
0.66	65.95	97.68	2.53	400137271
0.67	5705.82	8534.74	2.47	400137271
0.68	20201.1	29851.18	2.41	400137271
0.69	34928.51	50980.65	2.36	400137271
0.7	50106.64	72241.87	2.31	400137271
0.71	65489.84	93255.9	2.26	400137271
0.72	81060.3	114033.74	2.21	400137271
0.73	97140.22	134990.05	2.17	400137271
0.74	113335.22	155599.38	2.13	400137271
0.75	129909.55	176207.79	2.09	400137271
0.76	146751.06	196623.9	2.06	400137271
0.77	163833.75	216882.69	2.02	400137271
0.78	181509	237375.5	1.99	400137271
0.79	199144.64	257318.11	1.95	400137271
0.8	217329.47	277465.07	1.92	400137271
0.81	235811.67	297489.59	1.89	400137271
0.82	254589.42	317337.47	1.87	400137271
0.83	273570.98	336961.43	1.84	400137271
0.84	293203.07	356808.88	1.81	400137271
0.85	312978.05	376348.6	1.79	400137271
0.86	333433.75	396121	1.76	400137271
0.87	354175.6	415728	1.74	400137271
0.88	375392.66	435371.59	1.72	400137271
0.89	397223.88	455113.25	1.7	400137271
0.9	419477.33	474796.23	1.68	400137271
0.91	441932.26	494204.87	1.66	400137271
0.92	465045.83	513759.77	1.64	400137271
0.93	488767.38	533373.12	1.62	400137271
0.94	512715.67	552775.74	1.6	400137271

0.95	537276.49	572176.18	1.58	400137271
0.96	562364.34	591624.9	1.56	400137271
0.97	587634.69	610718.87	1.55	400137271
0.98	613915.27	630133.77	1.53	400137271
0.99	640643.12	649454.76	1.52	400137271
1	668285.16	669009.68	1.5	400137271

mean delay vs. p12 (load-balanced)

p12	mean delay link 1	mean delay link 2	mean delay link 3	seed
0.32	19954.82	2.42	29461.21	400137271
0.3231818	15251.41	2.44	22606.5	400137271
0.3263636	10696.47	2.46	15916.66	400137271
0.3295455	6063.24	2.47	9057.12	400137271
0.3327273	1599.27	2.49	2396.45	400137271
0.3359091	158.31	2.51	236.42	400137271
0.3390909	81.34	2.53	120.96	400137271
0.3422727	51.47	2.55	76.02	400137271
0.3454545	37.95	2.57	55.71	400137271
0.3486364	30.17	2.59	43.99	400137271
0.3518182	25.25	2.61	36.59	400137271
0.355	21.81	2.63	31.4	400137271
0.3581818	19.19	2.65	27.44	400137271
0.3613636	17.19	2.68	24.41	400137271
0.3645455	15.58	2.7	21.98	400137271
0.3677273	14.31	2.72	20.04	400137271
0.3709091	13.23	2.75	18.39	400137271
0.3740909	12.3	2.77	16.97	400137271
0.3772727	11.5	2.79	15.74	400137271
0.3804545	10.83	2.82	14.71	400137271
0.3836364	10.23	2.85	13.78	400137271
0.3868182	9.71	2.87	12.98	400137271
0.39	9.24	2.9	12.24	400137271
0.3931818	8.84	2.93	11.61	400137271
0.3963636	8.47	2.96	11.03	400137271
0.3995455	8.15	2.99	10.52	400137271
0.4027273	7.86	3.02	10.05	400137271
0.4059091	7.59	3.05	9.61	400137271
0.4090909	7.35	3.08	9.22	400137271
0.4122727	7.14	3.11	8.87	400137271
0.4154545	6.94	3.14	8.53	400137271
0.4186364	6.76	3.18	8.23	400137271

0.4218182	6.6	3.21	7.95	400137271
0.425	6.45	3.25	7.7	400137271
0.4281818	6.31	3.29	7.45	400137271
0.4313636	6.18	3.32	7.22	400137271
0.4345455	6.07	3.36	7.02	400137271
0.4377273	5.96	3.4	6.82	400137271
0.4409091	5.86	3.44	6.63	400137271
0.4440909	5.78	3.49	6.45	400137271
0.4472727	5.69	3.53	6.29	400137271
0.4504545	5.62	3.57	6.13	400137271
0.4536364	5.55	3.62	5.98	400137271
0.4568182	5.49	3.67	5.84	400137271
0.46	5.43	3.72	5.71	400137271
0.4631818	5.38	3.77	5.58	400137271
0.4663636	5.33	3.82	5.46	400137271
0.4695455	5.29	3.87	5.34	400137271
0.4727273	5.26	3.93	5.23	400137271
0.4759091	5.22	3.99	5.12	400137271
0.4790909	5.2	4.05	5.03	400137271
0.4822727	5.17	4.11	4.93	400137271
0.4854545	5.15	4.17	4.84	400137271
0.4886364	5.14	4.24	4.75	400137271
0.4918182	5.13	4.3	4.67	400137271
0.495	5.12	4.37	4.58	400137271
0.4981818	5.12	4.45	4.5	400137271
0.5013636	5.12	4.53	4.43	400137271
0.5045455	5.12	4.6	4.35	400137271
0.5077273	5.13	4.69	4.28	400137271
0.5109091	5.14	4.77	4.22	400137271
0.5140909	5.16	4.86	4.15	400137271
0.5172727	5.17	4.95	4.09	400137271
0.5204545	5.2	5.05	4.03	400137271
0.5236364	5.23	5.15	3.97	400137271
0.5268182	5.26	5.26	3.91	400137271
0.53	5.3	5.37	3.86	400137271
0.5331818	5.34	5.48	3.8	400137271
0.5363636	5.39	5.6	3.75	400137271
0.5395455	5.44	5.73	3.7	400137271
0.5427273	5.49	5.86	3.66	400137271
0.5459091	5.56	6	3.61	400137271
0.5490909	5.63	6.15	3.56	400137271
0.5522727	5.7	6.31	3.52	400137271
0.5554545	5.78	6.47	3.47	400137271

0.5586364	5.87	6.64	3.43	400137271
0.5618182	5.97	6.83	3.39	400137271
0.565	6.07	7.02	3.35	400137271
0.5681818	6.18	7.23	3.31	400137271
0.5713636	6.3	7.45	3.28	400137271
0.5745455	6.44	7.69	3.24	400137271
0.5777273	6.58	7.94	3.2	400137271
0.5809091	6.74	8.22	3.17	400137271
0.5840909	6.92	8.51	3.14	400137271
0.5872727	7.11	8.83	3.1	400137271
0.5904545	7.32	9.18	3.07	400137271
0.5936364	7.55	9.56	3.04	400137271
0.5968182	7.81	9.98	3.01	400137271
0.6	8.09	10.43	2.98	400137271
0.6031818	8.41	10.94	2.95	400137271
0.6063636	8.76	11.5	2.92	400137271
0.6095455	9.16	12.13	2.89	400137271
0.6127273	9.61	12.83	2.86	400137271
0.6159091	10.11	13.6	2.84	400137271
0.6190909	10.68	14.49	2.81	400137271
0.6222727	11.35	15.51	2.79	400137271
0.6254545	12.12	16.7	2.76	400137271
0.6286364	13.01	18.06	2.74	400137271
0.6318182	14.03	19.61	2.71	400137271
0.635	15.26	21.47	2.69	400137271
0.6381818	16.73	23.69	2.67	400137271
0.6413636	18.62	26.54	2.65	400137271
0.6445455	21.11	30.32	2.62	400137271
0.6477273	24.5	35.42	2.6	400137271
0.6509091	29.36	42.74	2.58	400137271
0.6540909	36.7	53.79	2.56	400137271
0.6572727	48.1	70.91	2.54	400137271
0.6604545	70.4	104.34	2.52	400137271
0.6636364	130.39	194.17	2.5	400137271
0.6668182	1291.77	1936.72	2.48	400137271
0.67	5705.82	8534.74	2.47	400137271

Data Packet arrival rate vs Mean Delay Full range

Arrival rate	Mean delay [data]	Mean delay [voice]
0.05	40.7327	1.864181

0.2995	40.50066	2.297845
0.549	41.099	2.745209
0.7985	41.44011	3.196676
1.048	41.88919	3.658913
1.2975	42.34411	4.134243
1.547	42.85037	4.62809
1.7965	43.36072	5.122599
2.046	43.88308	5.631928
2.2955	44.4274	6.159958
2.545	45.00507	6.697373
2.7945	45.55204	7.247712
3.044	46.10776	7.813387
3.2935	46.72435	8.396643
3.543	47.38514	8.998732
3.7925	47.98694	9.601912
4.042	48.64919	10.24051
4.2915	49.28625	10.87671
4.541	49.9719	11.54541
4.7905	50.66466	12.22553
5.04	51.38105	12.93174
5.2895	52.1027	13.6554
5.539	52.86503	14.40402
5.7885	53.64686	15.16521
6.038	54.43911	15.9516
6.2875	55.28194	16.76909
6.537	56.12455	17.59925
6.7865	56.99766	18.45878
7.036	57.87608	19.34668
7.2855	58.80933	20.26632
7.535	59.80421	21.23852
7.7845	60.80746	22.23096
8.034	61.87991	23.27993
8.2835	62.95303	24.33817
8.533	64.05315	25.43645
8.7825	65.19143	26.56511
9.032	66.37747	27.73871
9.2815	67.60109	28.95635
9.531	68.87841	30.22851
9.7805	70.19667	31.54522
10.03	71.56354	32.89725
10.2795	73.01657	34.3489
10.529	74.49671	35.82218
10.7785	76.04519	37.36147

11.028	77.65652	38.96375
11.2775	79.32411	40.62499
11.527	81.047	42.33832
11.7765	82.86675	44.14699
12.026	84.84893	46.10582
12.2755	86.88807	48.12441
12.525	89.07331	50.29654
12.7745	91.30534	52.51246
13.024	93.64068	54.84133
13.2735	96.0649	57.26801
13.523	98.63258	59.82428
13.7725	101.3631	62.55317
14.022	104.2451	65.41983
14.2715	107.3069	68.46801
14.521	110.5022	71.68201
14.7705	113.8924	75.07155
15.02	117.5949	78.75163
15.2695	121.4738	82.62564
15.519	125.651	86.80433
15.7685	130.0728	91.23349
16.018	134.9228	96.069
16.2675	140.1577	101.2899
16.517	145.8917	106.9921
16.7665	151.8843	112.9862
17.016	158.5478	119.6267
17.2655	165.7482	126.8039
17.515	173.7215	134.7574
17.7645	182.3626	143.3899
18.014	191.8288	152.8509
18.2635	202.2981	163.3056
18.513	214.0321	175.0391
18.7625	227.1897	188.2055
19.012	242.0992	203.1243
19.2615	259.1557	220.1882
19.511	278.8043	239.8437
19.7605	301.8744	262.9347
20.01	329.029	290.0959
20.2595	362.0744	323.0659
20.509	401.4003	362.405
20.7585	451.4494	412.443
21.008	515.8243	476.7873
21.2575	600.0443	561.0288
21.507	717.1804	678.0675

Data Packet arrival rate vs Mean Delay vertical asymptote

Arrival rate	Mean delay [data]	Mean delay [voice]
22.24	1641.061	1601.597
22.28	1763.854	1724.505
22.32	1905.964	1866.749
22.36	2074.446	2035.386
22.4	2278.884	2239.989
22.44	2524.43	2485.771
22.48	2834.467	2795.985
22.52	3251.071	3212.596
22.56	3911.841	3873.214
22.6	5053.782	5015.205
22.64	6644.333	6606.219
22.68	10023.66	9983.479
22.72	16299.35	16258.84
22.76	38744.23	38704.19
22.8	179294.5	179287.6
22.84	370638.9	370684.3
22.88	568127	568217.5
22.92	787108.6	787231.5
22.96	1005854	1006016
23	1224358	1224561
23.04	1442670	1442852
23.08	1660735	1660923
23.12	1878551	1878762
23.16	2096126	2096369
23.2	2313484	2313727
23.24	2530536	2530868

Data Packet arrival rate vs Mean Delay

Arrival rate	Mean delay [data]	Mean delay [voice]
0.05	40.22127	1.862921
0.3095	40.5878	2.307491
0.569	41.10865	2.751885
0.8285	41.67689	3.199248
1.088	42.2133	3.645397
1.3475	42.78902	4.093015

1.607	43.35046	4.540916
1.8665	43.9396	4.988741
2.126	44.5377	5.435957
2.3855	45.18275	5.886633
2.645	45.83224	6.342205
2.9045	46.48257	6.791548
3.164	47.15016	7.242786
3.4235	47.81516	7.687157
3.683	48.53618	8.140988
3.9425	49.25139	8.588658
4.202	49.99506	9.037552
4.4615	50.76396	9.487488
4.721	51.56205	9.943816
4.9805	52.3781	10.39396
5.24	53.21113	10.84884
5.4995	54.05779	11.29788
5.759	54.93885	11.74635
6.0185	55.8327	12.1998
6.278	56.7907	12.6516
6.5375	57.74395	13.10395
6.797	58.73969	13.55283
7.0565	59.78226	14.00312
7.316	60.84462	14.45216
7.5755	61.9517	14.90834
7.835	63.08559	15.35853
8.0945	64.28481	15.8141
8.354	65.50245	16.26582
8.6135	66.76797	16.72388
8.873	68.08312	17.17316
9.1325	69.47069	17.63235
9.392	70.87757	18.08664
9.6515	72.36868	18.53947
9.911	73.90846	18.99789
10.1705	75.5022	19.44495
10.43	77.16554	19.90112
10.6895	78.88078	20.35474
10.949	80.66817	20.80665
11.2085	82.53862	21.25422
11.468	84.50164	21.70607
11.7275	86.57199	22.16565
11.987	88.7536	22.61629
12.2465	91.02449	23.07417
12.506	93.40929	23.52815

12.7655	95.88142	23.97926
13.025	98.54583	24.43262
13.2845	101.3632	24.89329
13.544	104.3376	25.3551
13.8035	107.471	25.81022
14.063	110.759	26.26588
14.3225	114.2656	26.72777
14.582	117.9617	27.1824
14.8415	121.8908	27.63648
15.101	126.1269	28.096
15.3605	130.6181	28.55227
15.62	135.4852	29.00801
15.8795	140.7015	29.46295
16.139	146.326	29.92198
16.3985	152.4612	30.3831
16.658	159.0663	30.84052
16.9175	166.1983	31.30068
17.177	174.0576	31.76272
17.4365	182.6434	32.21671
17.696	192.099	32.67785
17.9555	202.6566	33.13944
18.215	214.4391	33.59843
18.4745	227.6341	34.05914
18.734	242.4782	34.52226
18.9935	259.3248	34.98481
19.253	278.6987	35.44358
19.5125	301.3219	35.90926
19.772	327.7509	36.36584
20.0315	359.0974	36.82368
20.291	397.5224	37.28713

Data Packet arrival rate vs Mean Delay Asymptotic

Arrival rate	Mean delay [data]	Mean delay [voice]
20	355.0168	36.76998
20.06	362.8694	36.876
20.12	371.2554	36.98132
20.18	380.0636	37.09109
20.24	389.1701	37.19601
20.3	398.9616	37.30156
20.36	409.0312	37.41055

20.42	419.5548	37.52235
20.48	430.6005	37.62494
20.54	442.488	37.7325
20.6	454.8238	37.8445
20.66	467.9681	37.94827
20.72	482.1991	38.05966
20.78	496.879	38.16203
20.84	512.2815	38.27173
20.9	528.7409	38.37802
20.96	546.252	38.48303
21.02	565.0806	38.58972
21.08	585.8023	38.69705
21.14	607.6971	38.80238
21.2	632.7069	38.91273
21.26	658.3016	39.01788
21.32	686.6131	39.12598
21.38	716.5545	39.23366
21.44	749.0892	39.33856
21.5	784.6242	39.44613
21.56	823.6617	39.54752
21.62	866.5412	39.65467
21.68	914.7796	39.76615
21.74	967.8533	39.87742
21.8	1027.095	39.9817
21.86	1093.615	40.09052
21.92	1168.808	40.20132
21.98	1255.238	40.30369
22.04	1353.767	40.40733
22.1	1468.854	40.51507
22.16	1603.193	40.62175
22.22	1765.036	40.72839
22.28	1961.383	40.83199
22.34	2209.165	40.94371
22.4	2529.29	41.04405
22.46	2976.727	41.16173
22.52	3646.7	41.26352
22.58	4911.143	41.36713
22.64	7178.64	41.48534
22.7	13069.18	41.58535
22.76	41756.96	41.68597
22.82	389394.6	41.73129
22.88	890082.7	41.73363
22.94	1426823	41.73685

23	1960763	41.73408
23.06	2491924	41.73608
23.12	3020331	41.73195
23.18	3546000	41.73341
23.24	4068958	41.73625
23.3	4589219	41.73403
23.36	5106809	41.73733
23.42	5621748	41.73216
23.48	6134054	41.73274
23.54	6643749	41.73547
23.6	7150852	41.73641
23.66	7655382	41.73733
23.72	8157362	41.73267
23.78	8656807	41.73202
23.84	9153740	41.73675
23.9	9648176	41.73328
23.96	10140135	41.73618
24.02	10629639	41.73174
24.08	11116702	41.73875
24.14	11601345	41.73612
24.2	12083583	41.73427
24.26	12563436	41.73399
24.32	13040924	41.73729
24.38	13516059	41.73581
24.44	13988861	41.7378
24.5	14459349	41.73176
24.56	14927538	41.73851
24.62	15393445	41.73747
24.68	15857085	41.73394
24.74	16318476	41.73559
24.8	16777637	41.73661
24.86	17234579	41.73514
24.92	17689321	41.73265
24.98	18141880	41.7377
25.04	18592269	41.73649