In [47]:
```
%matplotlib inline
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import os,sys
```

In [48]:
```
closed = pd.read_csv("ClosedAverage.csv", \
            names=['time', 'resp', 'proxy', 'router', 'originA', 'originB'])
print("closed has", len(closed.index), "rows")
closed[:5]
```

closed has 9957 rows

Out[48]:

	time	resp	proxy	router	originA	originB
0	10.036511	0.166524	0.637821	0.155142	0.924056	0.749871
1	20.075607	0.178683	0.614420	0.137205	0.981474	0.679607
2	30.141002	0.255604	0.620062	0.136784	0.980300	0.691470
3	40.216904	0.236859	0.595849	0.130627	0.986105	0.630321
4	50.229666	0.205837	0.577142	0.127432	0.989218	0.612193

In [49]:
```
closed[9900:9905]
```

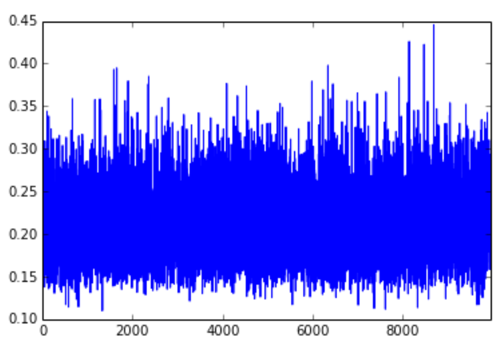
Out[49]:

	time	resp	proxy	router	originA	originB
9900	99439.909293	0.213893	0.568720	0.131192	0.984616	0.656018
9901	99449.946263	0.264462	0.568718	0.131192	0.984618	0.656012
9902	99459.954034	0.243375	0.568715	0.131192	0.984619	0.656008
9903	99469.982108	0.191640	0.568709	0.131190	0.984621	0.655995
9904	99479.994366	0.205872	0.568708	0.131188	0.984623	0.655983

Now, lets plot the response time and the utilization for one component

In [50]:
```
closed['resp'].plot()
```

Out[50]: <matplotlib.axes.AxesSubplot at 0x7f8a991d2160>



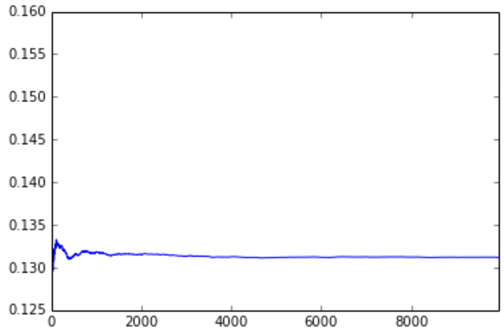
In [51]:

```
print("Router Utilization")
closed['router'].plot()
```

```
Router Utilization
```

Out[51]:

```
<matplotlib.axes.AxesSubplot at 0x7f8a993ba9e8>
```



It's clear there's a transient for the first ~40,000 seconds (recall that we're looking at the data divided into 10 second averages)

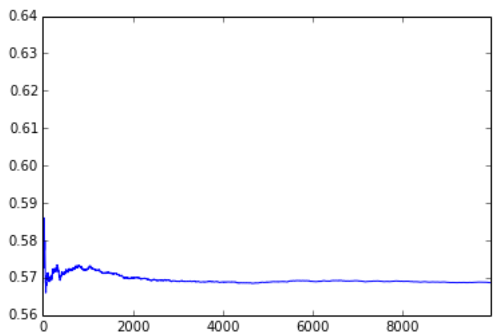
In [52]:

```
print("Proxy Utilization")
closed['proxy'].plot()
```

```
Proxy Utilization
```

Out[52]:

```
<matplotlib.axes.AxesSubplot at 0x7f8a98f8f2e8>
```



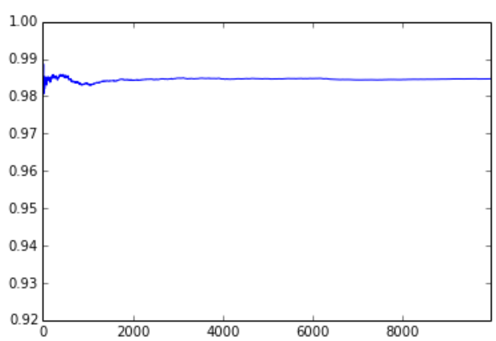
In [53]:

```
print("OriginA Utilization")
closed['originA'].plot()
```

```
OriginA Utilization
```

Out[53]:

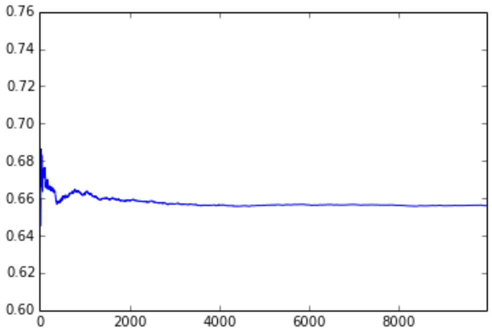
```
<matplotlib.axes.AxesSubplot at 0x7f8a98f5eeb8>
```



In [54]:
```
print("OriginB Utilization")
closed['originB'].plot()
```

```
OriginB Utilization
```

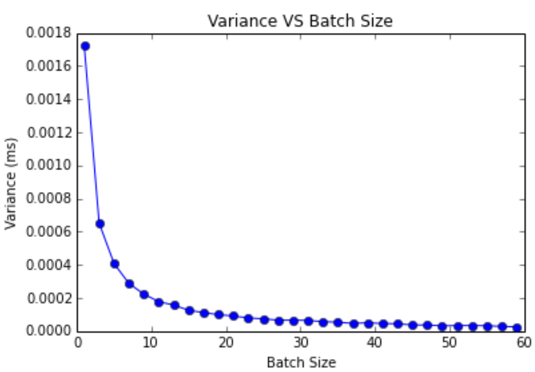
Out[54]: <matplotlib.axes.AxesSubplot at 0x7f8a98faa5c0>

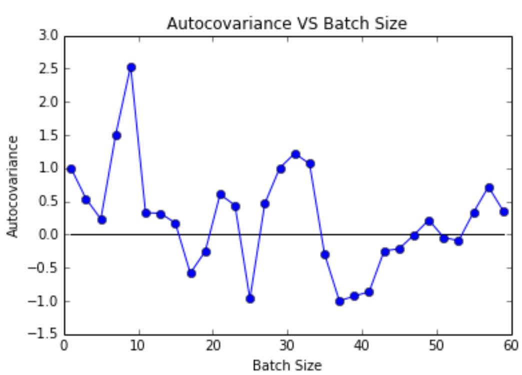


In [55]:

```
# Problem 1 parts 1&2

# Run for long time
# N observations
# Divide up into batches
# m batches size n each so m = N/n
# Compute batch mean (xi)
# Compute var of batch means as function of batch size (X is overall mean)
# Var(x) = (1/(m-1))(xi-X)2
# Plot variance versus size n
# When n starts decreasing, have transient

#closedAll = pd.read_csv("OmnetClosed.csv", \
#            names=['time', 'resp', 'proxy', 'router', 'originA', 'originB'])

#total_rows = len(closedAll.index)
#print("Total observations = ", total_rows)
import numpy as np
from numpy import mean
import statistics

def autocovariance(Xi):
    NN = np.size(Xi)
    k = 5
    Xs = np.average(Xi)
    autoCov = 0
    for i in np.arange(0, NN-k):
        autoCov += ((Xi[i+k])-Xs)*(Xi[i]-Xs)
    return (1/(NN-1))*autoCov

total_rows = len(closed.index)
print("Total observations = ", total_rows)
# variance1 = []
autocov = []
variance2 = []
overall_mean = mean(closed['resp'])

batch_sizes = [x for x in range(1,61,2)]

for n in batch_sizes:
    m = int(total_rows/n)

    batch_means = []

    for ii in range(0,total_rows,n):
        #print(i)
        m_temp = mean(closed['resp'][ii:n+ii])
        batch_means.append(m_temp)

    autocov.append(autocovariance(batch_means))
    variance2.append(statistics.variance(batch_means))

#Plot variance vs batch size (n)
# line0, = plt.plot(batch_sizes, variance1, 'bo-')
line0, = plt.plot(batch_sizes, variance2, 'o-')
plt.xlabel('Batch Size')
plt.ylabel('Variance (ms)')
plt.title("Variance VS Batch Size")
plt.show()

line0, = plt.plot(batch_sizes, [0 for x in autocov], 'k-')
line1, = plt.plot(batch_sizes, [x/autocov[0] for x in autocov], 'bo-')
plt.xlabel('Batch Size')
plt.ylabel('Autocovariance')
plt.title("Autocovariance VS Batch Size")
plt.show()

#print([x/autocov[0] for x in autocov])


print("The transient period appears to stop around 46000 seconds")
print("This can be seen visually in the utilization plots as they level out around this time ")
print("Futhermore the autocovariance of the batch of means drops to less than 1% of the original value at this time
print("The batch size is thus 46 (the size which gets to the end of the transient period)")
```

```
Total observations =  9957
```






```
The transient period appears to stop around 46000 seconds
This can be seen visually in the utilization plots as they level out around this time
Futhermore the autocovariance of the batch of means drops to less than 1% of the original value at this time
The batch size is thus 46 (the size which gets to the end of the transient period)
```

In [56]:

```
import scipy
def mean_confidence_interval(data, confidence=0.95):
    a = 1.0*np.array(data)
    n = len(a)
    m, se = np.mean(a), scipy.stats.sem(a)
    h = se * sp.stats.t._ppf((1+confidence)/2., n-1)
    # return [m, [m-h, m+h]]
    return [m, h]
```

In [57]:

```
#Problem 1 part 3
batch_size = 46

proxy_stats = []
router_stats = []
originA_stats = []
originB_stats = []

for ii in range(0, total_rows, batch_size):
    proxy_stats.append(mean(closed['proxy'][ii:n+ii]))
    router_stats.append(mean(closed['router'][ii:n+ii]))
    originA_stats.append(mean(closed['originA'][ii:n+ii]))
    originB_stats.append(mean(closed['originB'][ii:n+ii]))

proxy_util = mean_confidence_interval(proxy_stats)
router_util = mean_confidence_interval(router_stats)
originA_util = mean_confidence_interval(originA_stats)
originB_util = mean_confidence_interval(originB_stats)

print("Proxy mean utilization (%) = ", proxy_util[0], "Proxy 95% confidence +- =", proxy_util[1])
print("Router mean utilization (%) = ", router_util[0], "Router 95% confidence +- =", router_util[1])
print("OriginA mean utilization (%) = ", originA_util[0], "OriginA 95% confidence +- =", originA_util[1])
print("OriginB mean utilization (%) = ", originB_util[0], "OriginB 95% confidence +- =", originB_util[1])
```

```
Proxy mean utilization (%) =  0.569529193517 Proxy 95% confidence +- = 0.00017563621038
Router mean utilization (%) =  0.131328225775 Router 95% confidence +- = 3.26638020721e-05
OriginA mean utilization (%) =  0.984502657113 OriginA 95% confidence +- = 4.91803572912e-05
OriginB mean utilization (%) =  0.657499219121 OriginB 95% confidence +- = 0.000353074808017
```

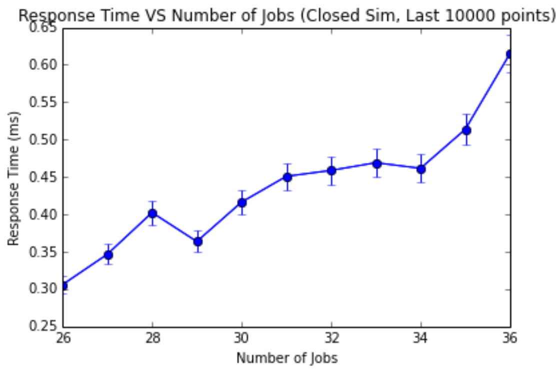
In [58]:

```
#Problem 2
#Report last 5 measurements:
#49999.897656465426,0.039093270671,0.577865,0.133549,0.999779,0.667094
#49999.929923779502,0.461592592368,0.577865,0.133549,0.999778,0.667094
#49999.949150078496,0.068900355486,0.577866,0.133549,0.999781,0.667096
#49999.976601088507,0.005503812923,0.577865,0.133549,0.999781,0.667095
#49999.994374383683,0.349631026105,0.577865,0.133549,0.99978,0.667095

import scipy as sp
import scipy.stats
import matplotlib.pyplot as plt

print("Last 5 measurements: ")
print('time', 'resp', 'proxy', 'router', 'originA', 'originB')
print('''49999.897656465426,0.039093270671,0.577865,0.133549,0.999779,0.667094
49999.929923779502,0.461592592368,0.577865,0.133549,0.999778,0.667094
49999.949150078496,0.068900355486,0.577866,0.133549,0.999781,0.667096
49999.976601088507,0.005503812923,0.577865,0.133549,0.999781,0.667095
49999.994374383683,0.349631026105,0.577865,0.133549,0.99978,0.667095''')

#Using R (or some other tool), make a plot of the response time as a function of the number of jobs in the system.
#I'm averaging the last 10000 response times
avg_response = []
response_confint = []
for ii in range(26,37):
    file = "OmnetClosed" + str(ii) + ".csv"
    TehCSV = pd.read_csv(file, \
            names=['time', 'resp', 'proxy', 'router', 'originA', 'originB'])
    last_N = TehCSV['resp'][-10000:]
    #res[0]=mean, 1=confint
    res = mean_confidence_interval(last_N)
    avg_response.append(res[0])
    response_confint.append(res[1])

#print("Avg response = ", avg_response)
#print("Confint = ", response_confint)
```

```
Last 5 measurements:
time resp proxy router originA originB
49999.897656465426,0.039093270671,0.577865,0.133549,0.999779,0.667094
49999.929923779502,0.461592592368,0.577865,0.133549,0.999778,0.667094
49999.949150078496,0.068900355486,0.577866,0.133549,0.999781,0.667096
49999.976601088507,0.005503812923,0.577865,0.133549,0.999781,0.667095
49999.994374383683,0.349631026105,0.577865,0.133549,0.99978,0.667095
```

In [59]:

```
x = []
for jj in range(26,37):
    x.append(jj)
line0, = plt.plot(x, avg_response, 'bo-')
plt.errorbar(x, avg_response,
  yerr=response_confint, fmt='bo-')

#title and axis labels
plt.xlabel('Number of Jobs')
plt.ylabel('Response Time (ms)')
plt.title("Response Time VS Number of Jobs (Closed Sim, Last 10000 points)")
plt.show()
print("95% confidence intervals or last 10000 points shown on plot")
```




```
95% confidence intervals or last 10000 points shown on plot
```

In [60]:

```
#Problem 3
print("15 ms interarrivaltime gets very close to 1, here are the last 5 measurements:")
print('''49999.885753074046,0.014867338833,0.833873,0.183423,0.999982,0.99984
49999.90796650579,0.024744846576,0.833873,0.183422,0.999981,0.99984
49999.931279015363,60.418726752998,0.833873,0.183422,0.99998,0.999839
49999.934273498183,0.03122815644,0.833873,0.183422,0.99998,0.999839
49999.98892562328,0.006565631384,0.833872,0.183422,0.999983,0.99984
''')
```

```
15 ms interarrivaltime gets very close to 1, here are the last 5 measurements:
49999.885753074046,0.014867338833,0.833873,0.183423,0.999982,0.99984
49999.90796650579,0.024744846576,0.833873,0.183422,0.999981,0.99984
49999.931279015363,60.418726752998,0.833873,0.183422,0.99998,0.999839
49999.934273498183,0.03122815644,0.833873,0.183422,0.99998,0.999839
49999.98892562328,0.006565631384,0.833872,0.183422,0.999983,0.99984
```

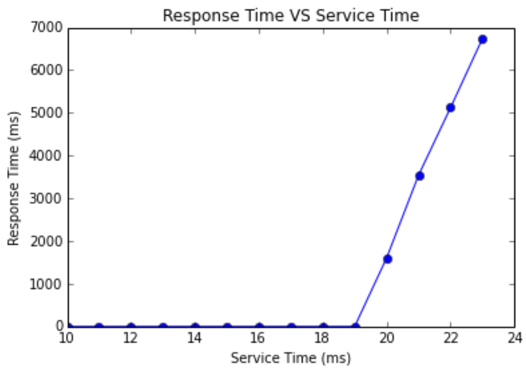
In [61]:

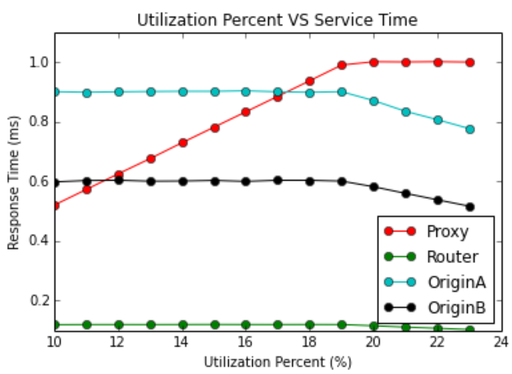
```
#Problem 4

avg_response_4 = []
proxy = []
router = []
originA = []
originB = []
for ii in range(0,14):
    if ii<14:
        file = "OmnetOpen" + str(ii+10) + "_" + str(ii*2+70) + ".csv"
        print(file)
        TehCSV = pd.read_csv(file, \
                names=['time', 'resp', 'proxy', 'router', 'originA', 'originB'])
        avg_response_4.append(mean(TehCSV['resp'][-10000:]))
        proxy.append(mean(TehCSV['proxy'][-10000:]))
        router.append(mean(TehCSV['router'][-10000:]))
        originA.append(mean(TehCSV['originA'][-10000:]))
        originB.append(mean(TehCSV['originB'][-10000:]))
```

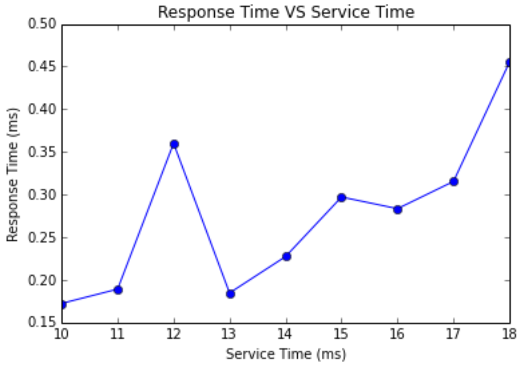
```
OmnetOpen10_70.csv
OmnetOpen11_72.csv
OmnetOpen12_74.csv
OmnetOpen13_76.csv
OmnetOpen14_78.csv
OmnetOpen15_80.csv
OmnetOpen16_82.csv
OmnetOpen17_84.csv
OmnetOpen18_86.csv
OmnetOpen19_88.csv
OmnetOpen20_90.csv
OmnetOpen21_92.csv
OmnetOpen22_94.csv
OmnetOpen23_96.csv
```

In [62]:

```
x = []
for jj in range(0,14):
    if ii<24:
        x.append(jj+10)

#print(len(x), len(proxy))
#print(x)
#print(avg_response_4)

line0, = plt.plot(x, avg_response_4, 'bo-')
plt.xlabel('Service Time (ms)')
plt.ylabel('Response Time (ms)')
plt.title("Response Time VS Service Time")
plt.show()

line1, = plt.plot(x, proxy, 'ro-')
line2, = plt.plot(x, router, 'go-')
line3, = plt.plot(x, originA, 'co-')
line4, = plt.plot(x, originB, 'ko-')
plt.legend([line1, line2, line3, line4],
  ['Proxy', 'Router', 'OriginA', 'OriginB'], loc=4)
plt.xlabel('Utilization Percent (%)')
plt.ylabel('Response Time (ms)')
plt.title("Utilization Percent VS Service Time")
plt.show()

line0, = plt.plot(x[0:9], avg_response_4[0:9], 'bo-')
plt.xlabel('Service Time (ms)')
plt.ylabel('Response Time (ms)')
plt.title("Response Time VS Service Time")
plt.show()

print("I used the open simulation as it was unclear which to use")
print("10ms service time with 70% hit rate is the best configuration")
print("Looking at the above plots the proxy utilization climbs as the service time increases")
print("At around 19 ms service time the response time spikes as the proxy reaches 100% utilization")
```








```
I used the open simulation as it was unclear which to use
10ms service time with 70% hit rate is the best configuration
Looking at the above plots the proxy utilization climbs as the service time increases
At around 19 ms service time the response time spikes as the proxy reaches 100% utilization
```

In [ ]: