Written by:

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Imports

In [ ]:

```
import re
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import display
import datetime
```

Parsing Information

We parse all raw data to obtain information that aid in the analysis.

Concurrent Session Parsing

In [ ]:

```
def parse_concurrent_session_data(file):
  df = pd.read_csv(file)
  # Note space in front of "frequency"...exact string: ' frequency of occurence'
  df = df.rename(columns={'# of concurrent sessions': 'num_sessions', ' frequency of occurence': 'fr
  return df

df = parse_concurrent_session_data("Case1_Data/case1-concurrent-sessions-histogram.txt")
display(df)
```

	num_sessions	frequency
0	1	0
1	2	1
2	3	1
3	4	1
4	5	1
...	...	...
995	996	0
996	997	0
997	998	0
998	999	0
999	1000	0

1000 rows × 2 columns

Perfmon Parsing

In [ ]:

```
def parse_perfmon(file):
  df = pd.read_csv(file, sep=',')
  df = df.rename(columns={
    r'Time': 'time',
  r'\PhysicalDisk(_Total)\% Disk Time': 'physicaldisk_total_disk_time',
    r'\Memory\Available Bytes': 'memory_available_bytes',
```

```
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    r'\Memory\Cache Faults/sec': 'memory_cache_faults_sec',
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    r'\Memory\Page Reads/sec': 'memory_page_reads_sec',
    r'\Memory\Page Writes/sec': 'memory_page_writes_sec',
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    r'\Memory\Pages Output/sec': 'memory_pages_output_sec',
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    r'\Paging File(_Total)\% Usage': 'paging_file_total_usage',
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    r'\Processor(0)\% Interrupt Time': 'processor_0_interrupt_time',
    r'\Processor(0)\% Privileged Time': 'processor_0_privileged_time',
    r'\Processor(0)\% Processor Time': 'processor_0_processor_time',
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    r'\System\Exception Dispatches/sec': 'system_exception_dispatches_sec',
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    r'\\isp-01\Process(server#12)\Handle Count': 'isp_01_process_server_12_handle_count',
    r'\\isp-01\Process(server#12)\Thread Count': 'isp_01_process_server_12_thread_count',
    r'\\isp-01\Process(server#13)\Page Faults/sec': 'isp_01_process_server_13_page_faults_sec',
    r'\\isp-01\Process(server#13)\Working Set Peak': 'isp_01_process_server_13_working_set_peak',
    r'\\isp-01\Process(server#13)\Page File Bytes Peak': 'isp_01_process_server_13_page_file_bytes_p
    r'\\isp-01\Process(server#13)\% Privileged Time': 'isp_01_process_server_13_privileged_time',
    r'\\isp-01\Process(server#13)\% User Time': 'isp_01_process_server_13_user_time',
    r'\\isp-01\Process(server#13)\Handle Count': 'isp_01_process_server_13_handle_count',
    r'\\isp-01\Process(server#13)\Thread Count': 'isp_01_process_server_13_thread_count',
    r'\\isp-01\Process(server#14)\Page Faults/sec': 'isp_01_process_server_14_page_faults_sec',
    r'\\isp-01\Process(server#14)\Working Set Peak': 'isp_01_process_server_14_working_set_peak',
    r'\\isp-01\Process(server#14)\Page File Bytes Peak': 'isp_01_process_server_14_page_file_bytes_p
    r'\\isp-01\Process(server#14)\% Privileged Time': 'isp_01_process_server_14_privileged_time',
    r'\\isp-01\Process(server#14)\% User Time': 'isp_01_process_server_14_user_time',
    r'\\isp-01\Process(server#14)\Handle Count': 'isp_01_process_server_14_handle_count',
    r'\\isp-01\Process(server#14)\Thread Count': 'isp_01_process_server_14_thread_count',
    r'\\isp-01\Process(server#15)\Page Faults/sec': 'isp_01_process_server_15_page_faults_sec',
    r'\\isp-01\Process(server#15)\Working Set Peak': 'isp_01_process_server_15_working_set_peak',
    r'\\isp-01\Process(server#15)\Page File Bytes Peak': 'isp_01_process_server_15_page_file_bytes_p
    r'\\isp-01\Process(server#15)\% Privileged Time': 'isp_01_process_server_15_privileged_time',
    r'\\isp-01\Process(server#15)\% User Time': 'isp_01_process_server_15_user_time',
    r'\\isp-01\Process(server#15)\Handle Count': 'isp_01_process_server_15_handle_count',
    r'\\isp-01\Process(server#15)\Thread Count': 'isp_01_process_server_15_thread_count',
  })
  df = df.fillna(0)
  return df

df = parse_perfmon("./Case1_Data/case1-perfmon-data.csv")
display(df)
```

	time	physicaldisk_total_disk_time	memory_available_bytes	memory_cache_bytes	memory_cache_faults_sec
0	1049697973	9.0219	157610000	31879200	18.9550
1	1049698033	3.4969	155288000	32534500	5.9608
2	1049698094	3.6862	154452000	33058800	3.6221
3	1049698154	4.0838	153801000	33472500	5.3757
4	1049698214	3.1999	153260000	33816600	3.9351
...	...	...	...	...	...
179	1049708796	3.8311	143446000	41533400	2.7811
180	1049708856	4.6612	143028000	41926700	3.1551
181	1049708917	3.9123	143233000	41746400	3.6666
182	1049708977	3.6274	142905000	42057700	3.7376
183	1049709037	4.4243	142569000	42393600	3.8699

184 rows × 248 columns

Perfmon Data

In [ ]:

```
perfmon_df_case1 = parse_perfmon("./Case1_Data/case1-perfmon-data.csv")
perfmon_df_case2 = parse_perfmon("./Case2_Data/case2-perfmon-data.csv")
```

Processing HTTP data

HTTPPerf Details Parsing

In [ ]:
```python
def parse_httperf_details(file):
  httperf_details = pd.read_csv(file)
  httperf_details = httperf_details.rename(columns={
    '#Time of request completion (in ms after experiment start)': 'request_completion_time_ms',
    ' Session ID': 'session_id',
    ' Time taken to open connection with server (ms)': 'open_connection_ms',
    ' Time taken to receive first byte of reply (ms)': 'recieve_first_byte_ms',
    ' Time taken to receive last byte of reply (ms)': 'recieve_last_byte_ms',
    ' number of concurrent sessions in the system': 'num_sessions',
    ' size of response (bytes) ': 'response_bytes'
  })
  return httperf_details

httperf_details_case1 = parse_httperf_details("Case1_Data/case1-httperf-detailed-output.csv")
display(httperf_details_case1)
httperf_details_case2 = parse_httperf_details("Case2_Data/case2-httperf-detailed-output.txt")
display(httperf_details_case2)
```

	request_completion_time_ms	session_id	open_connection_ms	recieve_first_byte_ms	recieve_last_byte_ms	nun
0	3.972507e+03	0	738.1	548.5	6.5	
1	5.808276e+03	1	22.3	151.4	6.4	
2	6.166294e+03	2	24.3	286.1	24.9	
3	6.269296e+03	3	35.1	175.3	22.1	
4	6.898326e+03	4	32.3	113.5	6.2	
...	...	...	...	...	...	
89587	1.113908e+07	9930	-1.0	248.4	20.3	
89588	1.113888e+07	9048	-1.0	874.9	0.0	
89589	1.113901e+07	7266	-1.0	979.9	0.0	
89590	1.113905e+07	7648	-1.0	949.3	0.0	
89591	1.113928e+07	9705	-1.0	888.6	0.0	

89592 rows × 7 columns

	request_completion_time_ms	session_id	open_connection_ms	recieve_first_byte_ms	recieve_last_byte_ms	nun
0	4.000229e+03	0	841.7	626.7	6.7	
1	5.981286e+03	1	30.6	151.4	6.5	
2	6.368299e+03	2	23.6	146.5	7.6	
3	6.478311e+03	3	23.8	160.9	6.4	
4	7.157337e+03	4	24.6	145.5	6.3	
...	...	...	...	...	...	
90394	1.211387e+07	9951	-1.0	106.2	22.4	
90395	1.211427e+07	9244	-1.0	68.4	0.0	
90396	1.211453e+07	7886	-1.0	92.7	0.0	
90397	1.211437e+07	9836	-1.0	253.1	0.0	
90398	1.211467e+07	9212	-1.0	69.3	0.0	

90399 rows × 7 columns

HTTPerf Summary Parsing

In [ ]:
```python
# Case 1
num_requests_case1 = 89602
num_replies_case1 = 89592
duration_case1 = 11136.199 # seconds
```

```
mean_connection_time_case1 = 368514.5 # milliseconds
mean_replies_per_conn_case1 = 9.248
mean_response_time_case1 = 1398.6 # milliseconds
mean_reply_time_case1 = 84.7 # milliseconds

# Case 2
num_requests_case2 = 90400
num_replies_case2 = 90399
duration_case2 = 12110.736 # seconds
mean_connection_time_case2 = 375877.2 # milliseconds
mean_replies_per_conn_case2 = 9.253
mean_response_time_case2 = 1958.1 # milliseconds
mean_reply_time_case2 = 54.9 # milliseconds
```

4. Analyzing *perfmon* Data

Question 4 - Part A (4.a)

What is the difference between "system" and "user" CPU utilization as reported by perfmon?

"System" utilization refers to CPU utilization that is running low-level operations like Kernel operations, while "user" utilization refers to operation that are ran by user processes. In Perfmon, "% Processor Time" refers to any time the processor spent running (i.e. system time + user time), while "% Privileged Time" is the system time (running on the kernel) and "% User Time" is the time spent running user processes.

Question 4 - Part B (4.b)

Since you are interested in bottleneck identification and model parameter calculation, compute the following: (do this for both Current DB and Big DB)

1) The duration of the performance test (4.b.1)

In [ ]:

```
# Get test duration of perfmon data in seconds
def get_perfmon_test_duration(perfmon_df):
  time_col = perfmon_df['time']
  min_time = time_col.min()
  max_time = time_col.max()
  return max_time - min_time

case1_duration = int(get_perfmon_test_duration(perfmon_df_case1))
case2_duration = int(get_perfmon_test_duration(perfmon_df_case2))

print(f"The test duration of the Current DB is: {case1_duration} seconds ({datetime.timedelta(seconc
print(f"The test duration of the Big DB is: {case2_duration} seconds ({datetime.timedelta(seconds=ca
```

```
The test duration of the Current DB is: 11064 seconds (3:04:24).
The test duration of the Big DB is: 12026 seconds (3:20:26).
```

2) The frequency of the sampling performance data (seconds) (4.b.2)

In [ ]:

```
def get_perfmon_test_frequency(perfmon_df):
  time_col = perfmon_df['time']
  time_diff = time_col.diff()
  return time_diff.mean()

case1_frequency = get_perfmon_test_frequency(perfmon_df_case1)
case2_frequency = get_perfmon_test_frequency(perfmon_df_case2)
print("The average test frequency of the Current DB is one request per {:.2f} seconds.".format(case1
print("The average test frequency of the Big DB is one request per {:.2f} seconds.".format(case2_fre
```

```
The average test frequency of the Current DB is one request per 60.46 seconds.
The average test frequency of the Big DB is one request per 60.43 seconds.
```

3) The mean utilization of the CPUs and the disks in the system (4.b.3)

In [ ]:

```
def get_perfmon_cpu_utilization(perfmon_df):
  db_processor_col = perfmon_df['processor_0_processor_time']
  web_app_col = perfmon_df[['isp_01_processor_0_processor_time', 'isp_01_processor_1_processor_time'
  processor_time_df = pd.DataFrame({'% DB Processor Utilization': db_processor_col, '% Web App Proce
  display(processor_time_df.mean())
  return processor_time_df.mean()

def get_perfmon_disk_utilization(perfmon_df):
  db_disk_col_name = 'physicaldisk_total_disk_time'
  web_app_disk_col_name = 'isp_01_physicaldisk_total_disk_time'
  percent_disk_time = perfmon_df[[db_disk_col_name, web_app_disk_col_name]]
  percent_disk_time = percent_disk_time.rename(columns={db_disk_col_name: '% DB Disk Utilization', w
  display(percent_disk_time.mean())
  return percent_disk_time.mean()

print("--------- Current DB ---------")
case1_cpu_utilization = get_perfmon_cpu_utilization(perfmon_df_case1)
case1_disk_utilization = get_perfmon_disk_utilization(perfmon_df_case1)

print("--------- Big DB ---------")
case2_cpu_utilization = get_perfmon_cpu_utilization(perfmon_df_case2)
case2_disk_utilization = get_perfmon_disk_utilization(perfmon_df_case2)
```

```
--------- Current DB ---------
% DB Processor Utilization         31.167545
% Web App Processor Utilization    76.706262
dtype: float64
% DB Disk Utilization         4.553785
% Web App Disk Utilization    6.755602
dtype: float64
--------- Big DB ---------
% DB Processor Utilization         83.193071
% Web App Processor Utilization    70.734618
dtype: float64
% DB Disk Utilization         4.978980
% Web App Disk Utilization    6.678767
dtype: float64
```

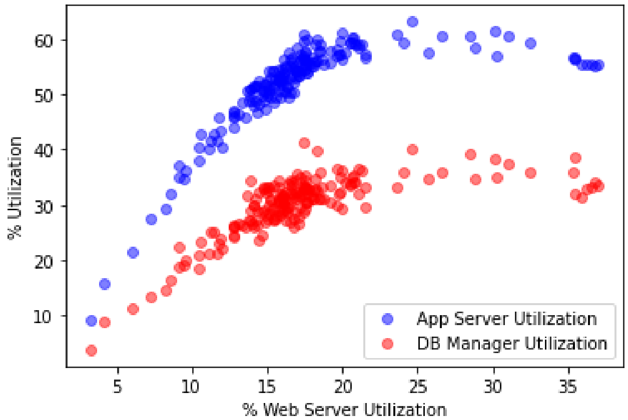
4) The mean CPU utilization caused by the Web server process, app server process, and the database management system process (4.b.4)

In [ ]:

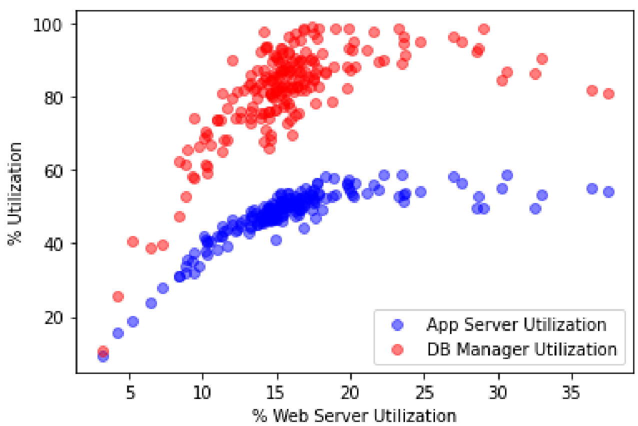
```
def get_perfmon_cpu_process_utilization(perfmon_df):
  num_cores = 2

  df = pd.DataFrame()
  db_privileged_time_name = 'process_db2syscs_privileged_time'
  db_user_time_name = 'process_db2syscs_user_time'
  df['% DB Utilization'] = perfmon_df[db_privileged_time_name] + perfmon_df[db_user_time_name]
  df['% Web Server Utilization'] = (perfmon_df['isp_01_process_whttpg_privileged_time'] + perfmon_df

  app_df = pd.DataFrame()
  for i in range(16):
    app_df[f'use_time_{i}'] = perfmon_df[f'isp_01_process_server_{i}_privileged_time'] + perfmon_df[

  # Sum can be over 100% for 1 CPU because there are 2 CPUs (100% of both CPUs is 200%)
  df['% App Server Utilization'] = app_df.sum(axis=1) / num_cores

  display(df.mean())

  plt.scatter(x=df['% Web Server Utilization'], y=df['% App Server Utilization'], color="b", alpha=(
  plt.scatter(x=df['% Web Server Utilization'], y=df['% DB Utilization'], color="r", alpha=0.5, labe
  plt.xlabel("% Web Server Utilization")
  plt.ylabel("% Utilization")
  plt.legend(loc="lower right")
  plt.show()

  return df

print("Note: Percent utilization rates are reported as percentage of 2 CPU cores. \
```

```
The database manager has only one CPU core so results are unchanged, but the web server and app serv
The raw data shows double the utilization but it has been corrected here.")

print("--------- Current DB ---------")
cpu_process_utilization_df_case1 = get_perfmon_cpu_process_utilization(perfmon_df_case1)

print("--------- Big DB ---------")
cpu_process_utilization_df_case2 = get_perfmon_cpu_process_utilization(perfmon_df_case2)
```

```
Note: Percent utilization rates are reported as percentage of 2 CPU cores. The database manager has
only one CPU core so results are unchanged, but the web server and app server run on a CPU with 2 co
res. The raw data shows double the utilization but it has been corrected here.
--------- Current DB ---------
% DB Utilization            30.121618
% Web Server Utilization    17.382567
% App Server Utilization    52.177833
dtype: float64
```




```
--------- Big DB ---------
% DB Utilization            81.916143
% Web Server Utilization    15.961232
% App Server Utilization    48.222740
dtype: float64
```



Question 4 - Part C (4.c)

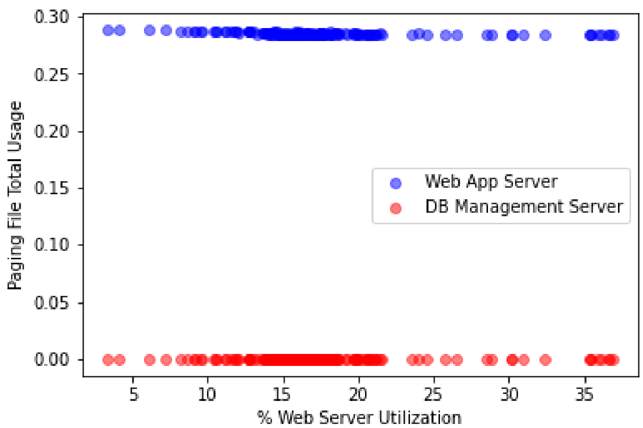
Bookzilla test engineers have told you that there is very little virtual memory activity in their systems and that you need not worry about this factor during performance evaluation. Based on the perfmon data, do you agree with this assessment? Provide concrete reasons for your view.

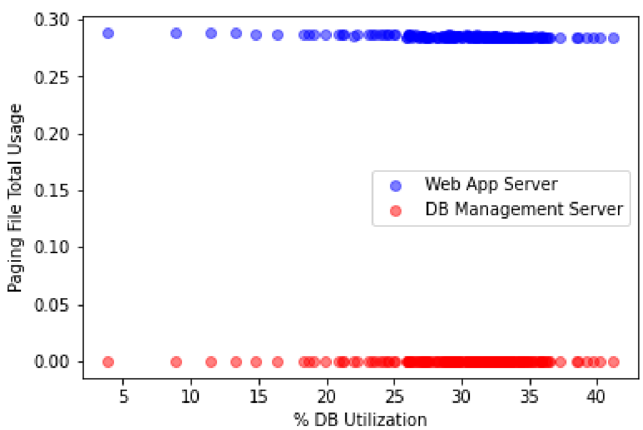
This assessment is inaccurate based on the perfmon metric "\Paging File(_Total)\% Usage" that measures how much the Paging File is being used. Paging File is a Windows tool that helps with paging when the number of applications open on a computer exceed the amount of physical RAM being used thus requiring paging and using virtual memory (and disk space) to hold all of the application's RAM. For the current DB, the paging file is not in use on the database server, but on the big DB, the paging file is used up to 6% of the time. Given that paging is a slow process the test engineers should be more concerned about this number, especially if it grows any further.

See the plots below for the data source:

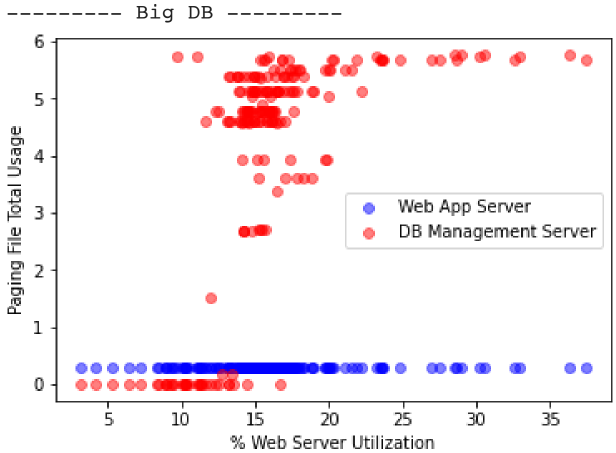
```
In [ ]:
def get_perfmon_memory_analysis(perfmon_df, process_utilization_df, x_label):
    plt.scatter(x=process_utilization_df[x_label], y=perfmon_df['isp_01_paging_file_total_usage'], c
    plt.scatter(x=process_utilization_df[x_label], y=perfmon_df['paging_file_total_usage'], color='r
    plt.xlabel(x_label)
    plt.ylabel('Paging File Total Usage')
    plt.legend(loc="center right")
    plt.show()

print("--------- Current DB ---------")
get_perfmon_memory_analysis(perfmon_df_case1, cpu_process_utilization_df_case1, '% Web Server Utiliz
get_perfmon_memory_analysis(perfmon_df_case1, cpu_process_utilization_df_case1, '% DB Utilization')

print("--------- Big DB ---------")
get_perfmon_memory_analysis(perfmon_df_case2, cpu_process_utilization_df_case2, '% Web Server Utiliz
get_perfmon_memory_analysis(perfmon_df_case2, cpu_process_utilization_df_case2, '% DB Utilization')
```

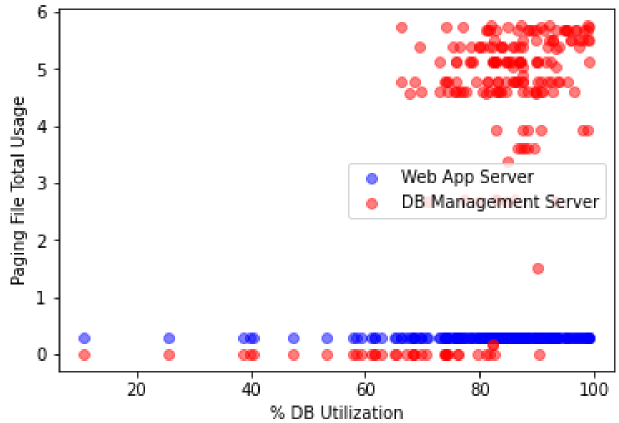
```
--------- Current DB ---------
```






```
--------- Big DB ---------
```





Question 4 - Part D (4.d)

Do you agree with the thread/process concurrency information provided by Bookzilla for the Web, application, and database servers? Provide a justification based on the perfmon data.

Most of the given information about threads and process concurrency is correct. According to the perfmon column "\Process(db2syscs)\Thread Count", there are indeed 33 threads and there are 16 processes labelled "\isp-01\Process(server#0)" through "\isp-01\Process(server#15)", each of them with only one thread.

However, there are not 1000 threads when observing the column "isp_01_process_whttpg_thread_count". Instead there are 1008 threads. One possible explanation is that those 1008 threads are divided within some number of thread pools or other potential components within the web server. Alternatively, there may be other processes running in the background on the server.

The work is shown below to justify this data:

In [ ]:

```
def get_perfmon_threads(perfmon_df):
  thread_df = perfmon_df[['process_db2syscs_thread_count', 'isp_01_process_whttpg_thread_count']].co

  app_df = pd.DataFrame()
  for i in range(16):
    app_df[f'thread_count_{i}'] = perfmon_df[f'isp_01_process_server_{i}_thread_count']

  thread_df['total_app_server_thread_count'] = app_df.sum(axis=1)

  display(thread_df.mean())

print("--------- Current DB ---------")
get_perfmon_threads(perfmon_df_case1)

print("--------- Big DB ---------")
get_perfmon_threads(perfmon_df_case2)
```

```
--------- Current DB ---------
process_db2syscs_thread_count          33.0
isp_01_process_whttpg_thread_count   1008.0
total_app_server_thread_count          16.0
dtype: float64
--------- Big DB ---------
process_db2syscs_thread_count          33.0
isp_01_process_whttpg_thread_count   1008.0
total_app_server_thread_count          16.0
dtype: float64
```

Question 4 - Part E (4.e)

You will observe a slight discrepancy between what you computed in 4.b.4 and 4.b.3. For example, although the database management system process was the only process using the DB machine, its CPU utilization (computed in

4.b.4) is less than that of the CPU utilization of the DB machine computed in 4.b.3. Provide possible explanations for such mismatches.

One reason for the total CPU utilization reported by the processes is slightly less than the CPU utilization reported by the processor is because the processor is busy performing tasks that do not count towards any individual process' time. For example, switching between two different processes requires time to save the current context and load the new context. Event interruptions from a process not actively being operated on can also incur further switching costs. Another explanation is that there are other activities that are either classified as other processes or miscellanious tasks. Tasks like the performance monitor itself and the underlying Windows OS would also count for processor consumption but not appear as utilization for any individual processes of interest.

These mismatches are fairly minor, though it is a good reminder that a small amount of overhead needs to be considered for these systems so that they can perform their OS tasks as well.

4f.

Based on your analysis in a), which resource is likely to be the bottleneck in Bookzilla's current 1,000 books setup? Will the bottleneck shift with their planned expansion to 100,000 books?

In the current system, the app server is the current bottleneck because it has the highest utilization of 52.18% and thus it will be exhausted first when more users arrive. However with the expansion to 100,000 books, the bottleneck shifts over to the database management system with the highest utilization of 81.92% in the performance tests.

5. Analyzing httperf data

Question 5 - Part A (5.a)

Let us now focus on application-level metrics such as throughput and response time. Compute the following for both Current DB and Big DB:

1) The per-request mean response time is the sum of the time to establish a connection with the server, wait till the first byte of the response, and ultimately obtain the last byte of the response. (5.a.1)

This data can be retrieved from the http-details.

In [ ]:

```
def get_mean_response_time(df):
    total_sessions = len(df.index)
    total_connection_time = df['open_connection_ms'].sum()
    total_first_byte_time = df['recieve_first_byte_ms'].sum()
    total_last_byte_time = df['recieve_last_byte_ms'].sum()
    per_request_mean_response_time = (
        total_connection_time +
        total_first_byte_time +
        total_last_byte_time
        ) / total_sessions
    return per_request_mean_response_time

mean_response_time_case1 = get_mean_response_time(httperf_details_case1)
print("The per-request mean response time for Current DB is:", mean_response_time_case1, "ms.")
mean_response_time_case2 = get_mean_response_time(httperf_details_case2)
print("The per-request mean response time for Big DB is:", mean_response_time_case2, "ms.")
```

```
The per-request mean response time for Current DB is: 1489.7259230734885 ms.
The per-request mean response time for Big DB is: 2018.9039845573514 ms.
```

2) The throughput in request completions/second. (5.a.2)

This is the total number of requests divided by the maximum completion time of all requests. The number of requests is readily available in the http summary data.

The formula we use to calculate throughput is: $X = \frac{C_k}{T}$ where

$X = thoughput$

$C_k = number\ of\ completions$

$T = period\ in\ time$

In [ ]:
```
def compute_throughput(num_completions, time_period):
    return num_completions / time_period

throughput_case1 = compute_throughput(num_replies_case1, duration_case1)
throughput_case2 = compute_throughput(num_replies_case2, duration_case2)
print("The throughput for Current DB is:", throughput_case1, "request completions per second. ")
print("The throughput for Big DB is:", throughput_case2, "request completions per second. ")
```

```
The throughput for Current DB is: 8.045114854718383 request completions per second.
The throughput for Big DB is: 7.4643688046705 request completions per second.
```

3) The mean think time between successive requests from a customer (5.a.3)

The average connection time per session, average number of replies per session, and the average reply and transfer time. All metrics are available in the http summary with the exception of average number of requests per session. This metrics is the quotient of replies and sessions.

In [ ]:
```
def compute_think_time(
  mean_replies,
  mean_reply_response_time,
  mean_reply_transfer_time,
  mean_connection_time
):
  mean_response_time = mean_reply_response_time + mean_reply_transfer_time
  mean_total_response_time = mean_replies * mean_response_time
  mean_total_think_time = mean_connection_time - mean_total_response_time
  mean_think_time = mean_total_think_time / mean_replies
  return mean_think_time

mean_think_time_case1 = compute_think_time(
  mean_replies_per_conn_case1,
  mean_response_time_case1,
  mean_reply_time_case1,
  mean_connection_time_case1
)
print("The mean think time between successive requests for Current DB is: ", mean_think_time_case1,

mean_think_time_case2 = compute_think_time(
  mean_replies_per_conn_case2,
  mean_response_time_case2,
  mean_reply_time_case2,
  mean_connection_time_case2
)
print("The mean think time between successive requests for Big DB is: ", mean_think_time_case2, "ms.
```

```
The mean think time between successive requests for Current DB is:  38273.59527069814 ms.
The mean think time between successive requests for Big DB is:  38548.3942214299 ms.
```

4) The mean number of concurrent customer sessions in the system. (5.a.4)

This is a product of throughput in customer sessions and average time per session.

The formula we use to calculate concurrent customer sessions is: $N = X(R + Z)$ where

$N = concurrent\ customer\ session$

$X = throughput$

$R = average\ response\ time$

$Z = average\ think\ time$

In [ ]:

```
def compute_concurrent_users(throughput, mean_response_time, think_time):
  return throughput * ((mean_response_time + think_time) / 1000)

mean_sessions_case1 = compute_concurrent_users(
  throughput_case1,
  mean_response_time_case1 + mean_reply_time_case1,
  mean_think_time_case1
)
print("The mean number number of concurrent customer sessions for Current DB is:", mean_sessions_cas

mean_sessions_case2 = compute_concurrent_users(
  throughput_case2,
  mean_response_time_case2 + mean_reply_time_case2,
  mean_think_time_case2
)
print("The mean number number of concurrent customer sessions for Big DB is:", mean_sessions_case2)
```

```
The mean number number of concurrent customer sessions for Current DB is: 320.5819072371451
The mean number number of concurrent customer sessions for Big DB is: 303.21906906591323
```

Question 5 - Part B (5.b)

Bookzilla's test engineers have told you that the network was lightly utilized and that it can be ignored as a factor in your study. Is there any data available to back up this claim?

The network provides a dedicated 100 Mbps connection between machines. Thus, a network usage that is lower than this bandwidth would support the claim that the network is not heavily utilized. With the average number of requests per second, and the average number of bytes transferred per second, an estimate of the average utilized bandwidth can be produced.

In [ ]:

```
def compute_mean_MB_transferred_per_second(df, throughput):
    total_bytes = df['response_bytes'].sum()
    total_requests = len(df.index)
    bytes_per_request = (total_bytes / total_requests) * throughput
    megabytes_per_request = bytes_per_request / pow(2, 20)
    megabits_per_request = megabytes_per_request * 8
    return megabits_per_request

print("The mean number of Mbps for Current DB is: ", compute_mean_MB_transferred_per_second(httperf_
print("The mean number of Mbps for Big DB is: ", compute_mean_MB_transferred_per_second(httperf_deta
```

```
The mean number of Mbps for Current DB is:  0.4097806787738495
The mean number of Mbps for Big DB is:  0.389173698775304
```

From the results of 5.b, it can be seen that the average network usage is below 1% of the network bandwidth, which is in agreement with their claim that the network will not be the source of the bottleneck.

Question 5 - Part C

Discuss the implications of supporting a larger catalog of books on the experience of an end-user of Bookzilla.

With respect to the 4 metrics discussed in 5.a, the effect of a larger catalog will be discussed with respect to each metrics individually.

1) per-request mean response time - this would see an increase proportional to the increase in catalog size as the response likely contains the catalog.

2) Throughput in requests/second - this would decrease as the number of per-request mean response time is increasing, allowing for fewer completed requests per second.

3) Mean think time between successive requests - larger catalogs imply a greater think time as there is more for the customer to look at

4) Mean number of concurrent sessions - this would increase as customer think time increases

Overall, the customers would likely notice similar, or slightly worse, performance with a bigger catalogue. Although the size of requests would increase, and the throughput limit of requests/second would decrease, an increase think time despite more concurrent sessions, would keep the load similar to what it is now. However, more concurrent sessions increases likelyhood of more concurrent requests, with more likelyhood of reaching 100% utlization on a bottleneck resource.

6. Computing resource demands for use in a performance model

Do the computations asked for both Current DB and Big DB.

You will need metrics marked in bold to parameterize the performance model used in Section B.

Question 6 - Part A

a) As discussed in class, the mean resource demands placed by a customer request on various system resources such as CPUs and disks are essential for building performance models. Apply the utilization law to compute the mean demands placed by request on the following resources:

The formula we use to calculate concurrent customer sessions is: $D = \frac{U}{X}$ where

$D = demand$

$U = utilization$

$X = throughput$

In [ ]:

```
def compute_demand(utilization_index, utilization, throughput):
  return (utilization[utilization_index] / throughput) / 100

# Web / App Machine CPUs (6.a.1)
webapp_cpu_demand_case1 = compute_demand(1, case1_cpu_utilization, throughput_case1)
print("The Web/App machine's CPU in the Current DB test is:", webapp_cpu_demand_case1, "seconds/requ
webapp_cpu_demand_case2 = compute_demand(1, case2_cpu_utilization, throughput_case2)
print("The Web/App machine's CPU in the Big DB test is:", webapp_cpu_demand_case2, "seconds/request'

# DB Machine CPU (6.a.2)
db_cpu_demand_case1 = compute_demand(0, case1_cpu_utilization, throughput_case1)
print("The DB machine's CPU in the Current DB test is:", db_cpu_demand_case1, "seconds/request")
db_cpu_demand_case2 = compute_demand(0, case2_cpu_utilization, throughput_case2)
print("The DB machine's CPU in the Big DB test is:", db_cpu_demand_case2, "seconds/request")

# Web/App machine disk (6.a.3)
webapp_disk_demand_case1 = compute_demand(1, case1_disk_utilization, throughput_case1)
print("The Web/App machine's disk in the Current DB test is:", webapp_disk_demand_case1, "seconds/re
webapp_disk_demand_case2 = compute_demand(1, case2_disk_utilization, throughput_case2)
print("The Web/App machine's disk in the Big DB test is:", webapp_disk_demand_case2, "seconds/reques

# DB Machine CPU (6.a.4)
db_disk_demand_case1 = compute_demand(0, case1_disk_utilization, throughput_case1)
print("The DB machine's CPU in the Current DB test is:", db_disk_demand_case1, "seconds/request")
db_disk_demand_case2 = compute_demand(0, case2_disk_utilization, throughput_case2)
print("The DB machine's CPU in the Big DB test is:", db_disk_demand_case2, "seconds/request")
```

```
The Web/App machine's CPU in the Current DB test is: 0.0953451421660366 seconds/request
The Web/App machine's CPU in the Big DB test is: 0.09476302598518573 seconds/request
The DB machine's CPU in the Current DB test is: 0.03874095662778252 seconds/request
The DB machine's CPU in the Big DB test is: 0.1114535906210122 seconds/request
The Web/App machine's disk in the Current DB test is: 0.00839714752670397 seconds/request
The Web/App machine's disk in the Big DB test is: 0.00894753149900773 seconds/request
The DB machine's CPU in the Current DB test is: 0.005660311143247636 seconds/request
The DB machine's CPU in the Big DB test is: 0.006670329575468755 seconds/request
```

Question 6 - Part B (6.b)

In [ ]:

```
# Mean per-request demand from the web server (6.b.1)
web_cpu_demand_case1 = compute_demand('% Web Server Utilization', cpu_process_utilization_df_case1.r
print("The Web's demand in the Current DB test is:", web_cpu_demand_case1, "seconds/request")
web_cpu_demand_case2 = compute_demand('% Web Server Utilization', cpu_process_utilization_df_case2.r
print("The Web's demand in the Big DB test is:", web_cpu_demand_case2, "seconds/request")

# Mean per-request demand from the app server (6.b.2)
app_cpu_demand_case1 = compute_demand('% App Server Utilization', cpu_process_utilization_df_case1.r
print("The app's demand in the Current DB test is:", app_cpu_demand_case1, "seconds/request")
app_cpu_demand_case2 = compute_demand('% App Server Utilization', cpu_process_utilization_df_case2.r
print("The app's demand in the Big DB test is:", app_cpu_demand_case2, "seconds/request")

# Mean per-request demand from the DB server (6.b.3)
db_cpu_demand_case1 = compute_demand('% DB Utilization', cpu_process_utilization_df_case1.mean(), th
print("The db's demand in the Current DB test is:", db_cpu_demand_case1, "seconds/request")
db_cpu_demand_case2 = compute_demand('% DB Utilization', cpu_process_utilization_df_case2.mean(), th
print("The db's demand in the Big DB test is:", db_cpu_demand_case2, "seconds/request")
```

```
The Web's demand in the Current DB test is: 0.021606362233464252 seconds/request
The Web's demand in the Big DB test is: 0.02138323101078951 seconds/request
The app's demand in the Current DB test is: 0.06485654176865824 seconds/request
The app's demand in the Big DB test is: 0.06460390912065699 seconds/request
The db's demand in the Current DB test is: 0.037440880138783925 seconds/request
The db's demand in the Big DB test is: 0.10974289339608274 seconds/request
```

Question 6 - Part C

You will observe a slight mismatch between the total demand you calculated for a resource in6.a and the sum of the demands placed on that resource by processes using that resource (6.b).Explain the reason for this mismatch.

The demand values from 6a is higher than than the demand values from 6b. This is because 6a takes into account the whole system while 6b only considers each individual resource. During the performance test, the CPU also has to perform activities, already mentioned in Part 4e such as context switching.

Question 6 - Part D

Compare the resource demands you computed for the Current DB and Big DB scenarios. Discuss reasons for any significant differences that you observe. Discuss whether these demands provide us any insights on the kind of additional resources needed to satisfy the planned expansion of Bookzilla.

As seen and discussed in 4.b.4/4.f, between the current DB test and the big DB is that the bottleneck in the current DB test is the Web/App server, whereas the bottleneck in the big DB test is the DB server. The reason for this difference is the size of the database between the tests; more records results in longer service time and higher demand time.

We can see that with the big DB test, demand time for the database server more than doubles due to the number of records. From utilization and demand time, we can see the database is the bottleneck and also has higher demand time. In expanding Bookzilla, we recommend they expand database server count as the CPU is the bottleneck and disk utilization is low. This can be done by expanding vertically through adding more cores to the machine. After improving the database service, the Web/App server will become the bottleneck as its CPU utilization is close to that of the database. This can also be done with a vertical expansion or placing the service behind a load balancer.