In [6]:

```
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime
import numpy as np
import statistics
import os
import logging
from pathlib import Path
import sqlite3
%autosave 20
```

```
Autosaving every 20 seconds
```

In [8]:

```
gpu_data=pd.read_csv("./Documents/gpu.csv")
app_data=pd.read_csv("./Documents/application-checkpoints.csv")
task_data=pd.read_csv("./Documents/task-x-y.csv")
```

In [9]:

```
gpu_data.head(5)
```

Out[9]:

	timestamp	hostname	gpuSerial	gpuUUID	pc
0	2018-11-08T08:27:10.314Z	8b6a0eebc87b4cb2b0539e81075191b900001C	323217055910	GPU-1d1602dc-f615-a7c7-ab53-fb4a7a479534	
1	2018-11-08T08:27:10.192Z	d8241877cd994572b46c861e5d144c85000000	323617020295	GPU-04a2dea7-f4f1-12d0-b94d-996446746e6f	
2	2018-11-08T08:27:10.842Z	db871cd77a544e13bc791a64a0c8ed50000006	323217056562	GPU-f4597939-a0b4-e78a-2436-12dbab9a350f	
3	2018-11-08T08:27:10.424Z	b9a1fa7ae2f74eb68f25f607980f97d7000010	325217085931	GPU-ad773c69-c386-a4be-b214-1ea4fc6045df	
4	2018-11-08T08:27:10.937Z	db871cd77a544e13bc791a64a0c8ed50000003	323217056464	GPU-2d4eed64-4ca8-f12c-24bc-28f036493ea2	

In [10]:

```
app_data.head(5)
```

Out[10]:

	timestamp	hostname	eventName	eventType	
0	2018-11-08T07:41:55.921Z	0d56a730076643d585f77e00d2d8521a00000N	Tiling	STOP	1024- 7e02 5fd0- abd61f74
1	2018-11-08T07:42:29.842Z	0d56a730076643d585f77e00d2d8521a00000N	Saving Config	START	1024- 7e02 5fd0- abd61f74
2	2018-11-08T07:42:29.845Z	0d56a730076643d585f77e00d2d8521a00000N	Saving Config	STOP	1024- 7e02 5fd0- abd61f74
3	2018-11-08T07:42:29.845Z	0d56a730076643d585f77e00d2d8521a00000N	Render	START	1024- 7e02 5fd0- abd61f74
4	2018-11-08T07:43:13.957Z	0d56a730076643d585f77e00d2d8521a00000N	TotalRender	STOP	1024- 7e02 5fd0- abd61f74

In [17]:

```
app_data.pivot_table('timestamp', ['hostname','eventName','jobId','taskId'], 'eventType')
```

...

In [11]:

```
task_data.head(5)
```

Out[11]:

	taskId	jobId	x	y	level
0	00004e77-304c-4fbd-88a1-1346ef947567	1024-lvl12-7e026be3-5fd0-48ee-b7d1-abd61f747705	116	178	12
1	0002afb5-d05e-4da9-bd53-7b6dc19ea6d4	1024-lvl12-7e026be3-5fd0-48ee-b7d1-abd61f747705	142	190	12
2	0003c380-4db9-49fb-8e1c-6f8ae466ad85	1024-lvl12-7e026be3-5fd0-48ee-b7d1-abd61f747705	142	86	12
3	000993b6-fc88-489d-a4ca-0a44fd800bd3	1024-lvl12-7e026be3-5fd0-48ee-b7d1-abd61f747705	235	11	12
4	000b158b-0ba3-4dca-bf5b-1b3bd5c28207	1024-lvl12-7e026be3-5fd0-48ee-b7d1-abd61f747705	171	53	12

In [12]:

```
gpu_data.columns
```

Out[12]:

```
Index(['timestamp', 'hostname', 'gpuSerial', 'gpuUUID', 'powerDrawWatt',
       'gpuTempC', 'gpuUtilPerc', 'gpuMemUtilPerc'],
      dtype='object')
```

In [13]:

```
app_data.columns
```

Out[13]:

```
Index(['timestamp', 'hostname', 'eventName', 'eventType', 'jobId', 'taskI
d'], dtype='object')
```

In [14]:

```
task_data.columns
```

Out[14]:

```
Index(['taskId', 'jobId', 'x', 'y', 'level'], dtype='object')
```

In [29]:

```
# merging the datasets to form a final dataset

TIMESTAMP_FORMAT = '%Y-%m-%dT%H:%M:%S.%fZ'

def timestamp_conversion(df):

    df = df.apply(lambda x: (datetime.strptime(x, TIMESTAMP_FORMAT)))
    return(df)


def clean_gpu(gpu_df):

    gpu_df['timestamp'] = timestamp_conversion(gpu_df['timestamp'])
    return(gpu_df)

def merge_check_task(checkpoints_df, tasks_df):


    # Use left join on taskId and jobId

    check_task_df = checkpoints_df.merge(tasks_df,on=['taskId', 'jobId'], how='left')
    return (check_task_df)


def clean_check_task(check_task_df):

    # Fix date format

    check_task_df['timestamp'] = timestamp_conv(check_task_df['timestamp'])

    return(check_task_df)


def merge_check_task_gpu(gpu_df, check_task_df):


    # Record start and stop times for events and drop old timestamps

    check_task_df_start = check_task_df[
    check_task_df['eventType'] == 'START']
    check_task_df_stop = check_task_df[
    check_task_df['eventType'] == 'STOP']

    check_task_df_start.rename(index=str, columns={"timestamp": "start_time"}, inplace = Tr
    check_task_df_stop.rename(index=str, columns={"timestamp": "stop_time"}, inplace = True

    check_task_df_stop.drop('eventType', axis = 1, inplace = True)
    check_task_df_start.drop('eventType', axis = 1, inplace = True)

    # Make each field record start and stop combined

    check_task_df = pd.merge( check_task_df_start, check_task_df_stop,on=['hostname', 'even

    # Remove any timestamps that occur out of the gpu dataset

    check_task_df = check_task_df[
            (check_task_df['start_time'] >= gpu_df['timestamp'][0]) &
            (check_task_df['stop_time']
            <= gpu_df['timestamp'][len(gpu_df)-1])]
    # Use sqllite to only combine with gpu if timestamp is between times

    # connection to sql
    conn = sqlite3.connect(':memory:')

    # move dataframes to sql
    check_task_df.to_sql('CheckTask', conn, index=False)
    gpu_df.to_sql('Gpu', conn, index=False)

    # SQL query
    query = '''
    SELECT *
    FROM Gpu
    LEFT JOIN CheckTask ON gpu.hostname = CheckTask.hostname
    WHERE gpu.timestamp >= CheckTask.start_time
        AND gpu.timestamp <= CheckTask.stop_time
    '''
    # get new df
    merged_df = pd.read_sql_query(query, conn)

    # drop duplicate hostname row (index 8)
    merged_df = merged_df.loc[:,~merged_df.columns.duplicated()]

    # group for averages (average stats for every task)

    functions = {
        'powerDrawWatt': 'mean', 'gpuTempC': 'mean',
        'gpuUtilPerc': 'mean', 'gpuMemUtilPerc': 'mean',
        'start_time': 'first', 'stop_time': 'first',
        'gpuUUID' : 'first'}

    merged_df = merged_df.groupby(
        ['hostname', 'eventName', 'x', 'y', 'level'],
        as_index=False, sort=False
    ).agg(functions)

    return(merged_df)


gpu_df = pd.read_csv("./Documents/gpu.csv")
checkpoints_df = pd.read_csv("./Documents/application-checkpoints.csv")
tasks_df =pd.read_csv("./Documents/task-x-y.csv")

# Cleaning and merging process
gpu_df = clean_gpu(gpu_df)
check_task_df = merge_check_task(checkpoints_df, tasks_df)
check_task_df = clean_check_task(check_task_df)
final_df = merge_check_task_gpu(gpu_df, check_task_df)
final_df.head(5)
```

```
77e00d2d8521a00000Q     Render    156   186   12    96.807273   37.590909   70.318182   37.863636


bf7bd0f41ecaa700000J  Uploading   200   23    12    42.440000   41.000000    0.000000    0.000000
```

hostname	eventName	x	y	level	powerDrawWatt	gpuTempC	gpuUtilPerc	gpuMemUtilPerc
3bf7bd0f41ecaa700000J	Tiling	200	23	12	42.440000	41.000000	0.000000	0.000000
25f607980f97d700000H	TotalRender	160	14	12	91.566957	38.695652	71.000000	39.913043

In [170]:

```
TIMESTAMP_FORMAT = '%Y-%m-%d %H:%M:%S'
```

In [171]:

```
final_df['start']=pd.to_datetime(final_df['start_time'],format=TIMESTAMP_FORMAT, errors='ig
final_df['stop']=pd.to_datetime(final_df['stop_time'],format=TIMESTAMP_FORMAT, errors='igno
```

In [172]:

```
final_df.head(5)
```

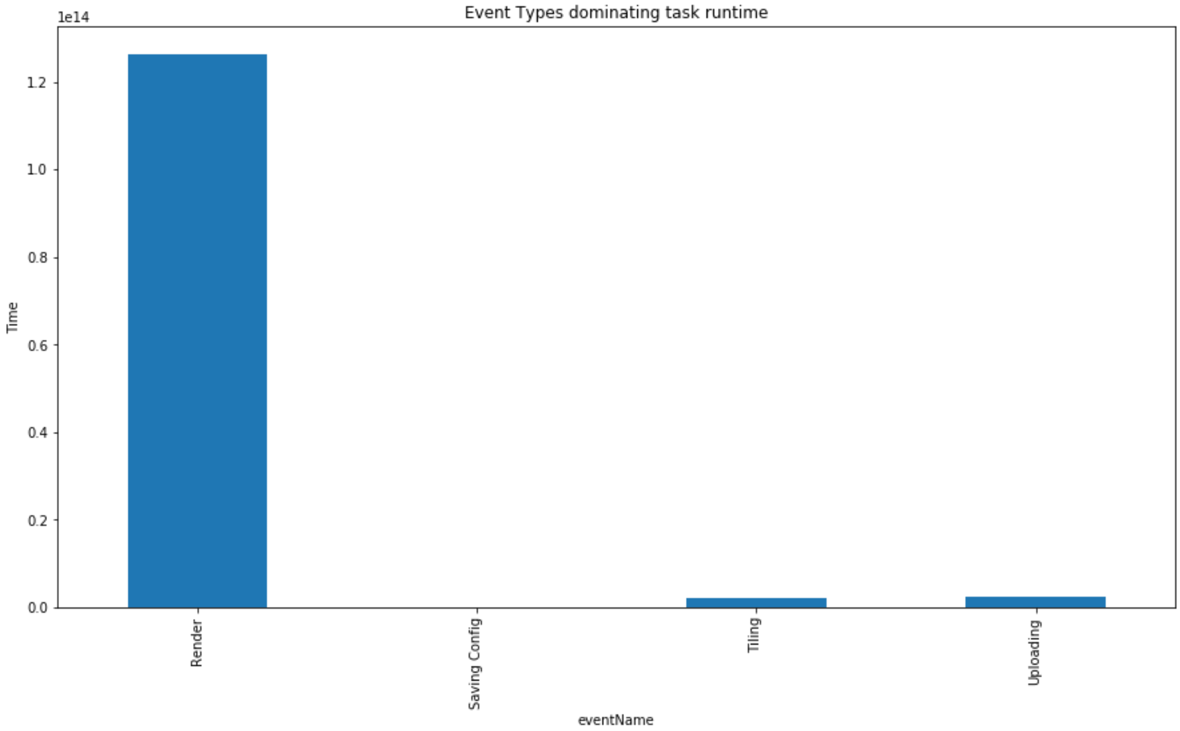
Out[172]:

x	y	level	powerDrawWatt	gpuTempC	gpuUtilPerc	gpuMemUtilPerc	start_time	stop_
156	186	12	96.807273	37.590909	70.318182	37.863636	2018-11-08 08:27:10.606	2018-1 08:27:54
156	186	12	96.807273	37.590909	70.318182	37.863636	2018-11-08 08:27:10.608	2018-1 08:27:53
200	23	12	42.440000	41.000000	0.000000	0.000000	2018-11-08 08:27:10.839	2018-1 08:27:11
200	23	12	42.440000	41.000000	0.000000	0.000000	2018-11-08 08:27:10.846	2018-1 08:27:11
160	14	12	91.566957	38.695652	71.000000	39.913043	2018-11-08 08:27:10.612	2018-1 08:27:56

Event types dominating task runtime

In [37]:

```
event_deltas = final_df[final_df['eventName'] != 'TotalRender'].groupby(
    ['eventName']).apply(lambda x: x.stop_time - x.start_time)

# sum execution times
event_deltas.groupby(['eventName']).sum().plot(kind = 'bar')

plt.ylabel('Time')
plt.title('Event Types dominating task runtime')
plt.rcParams['figure.figsize'] = [15, 8]
```

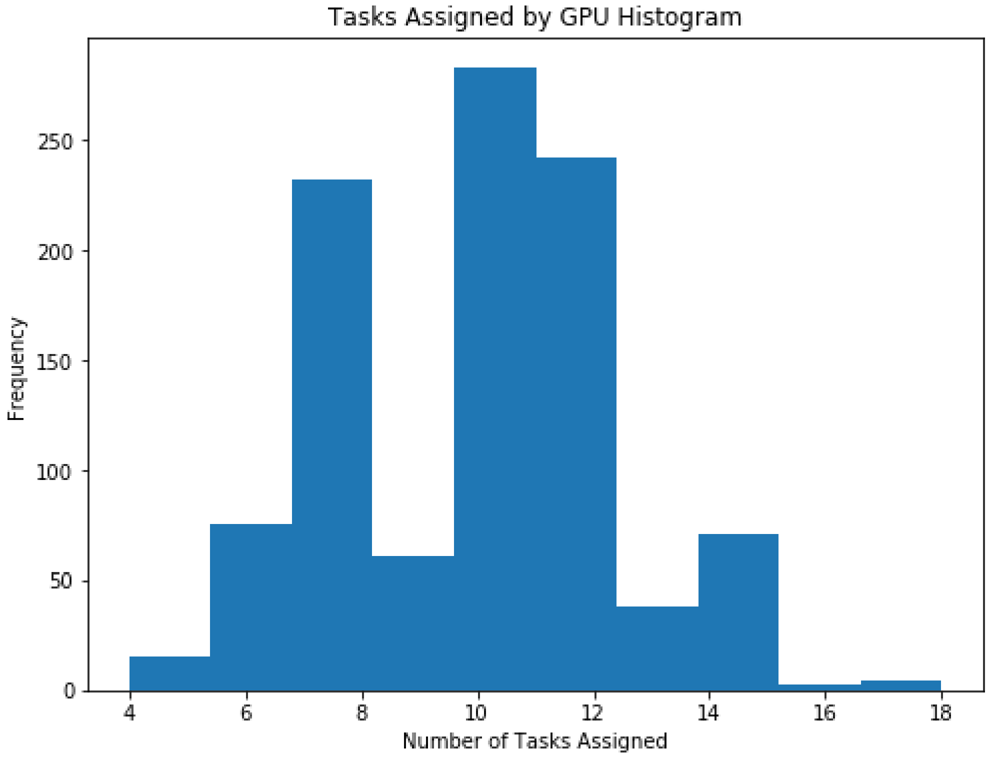


It looks like rendering event took most of the time in GPU. Whereas saving configuration hardly had any impact on GPU

No. of tasks assigned by GPU

In [144]:

```
final_df['hostname'].value_counts().plot(kind = 'hist')
plt.xlabel('Number of Tasks Assigned')
plt.title('Tasks Assigned by GPU Histogram')

plt.rcParams['figure.figsize'] = [15, 8]


plt.show()
```

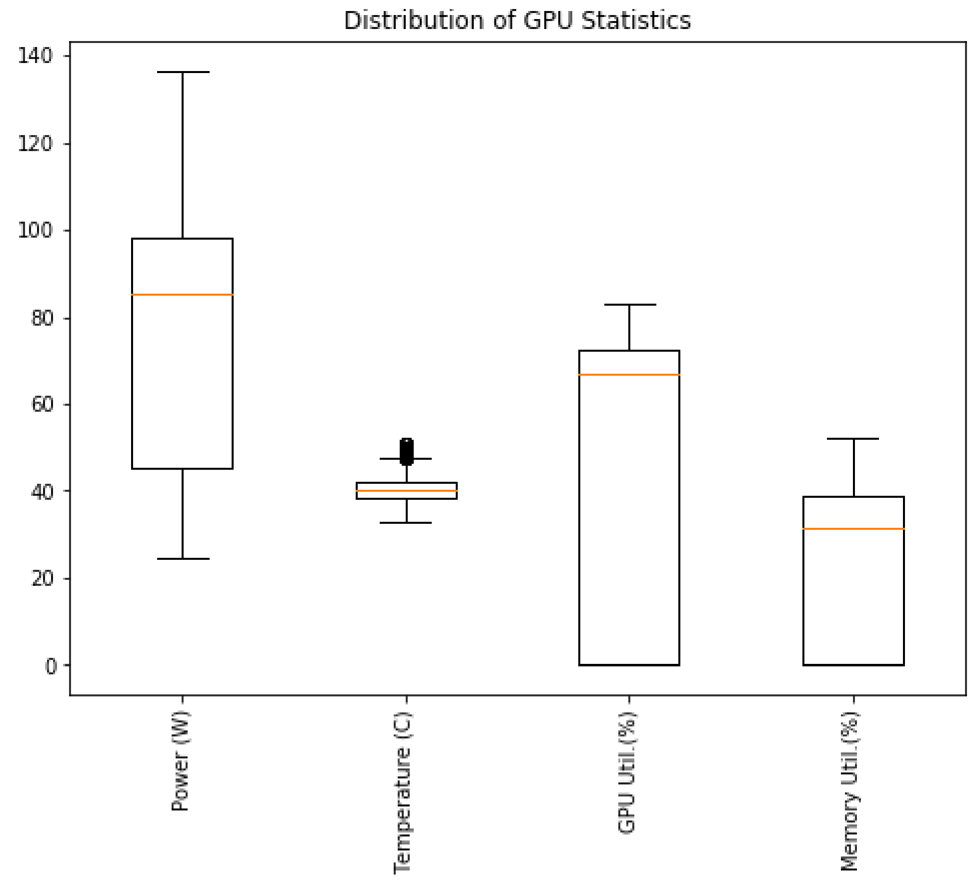


The majority of GPUs are assigned 7 to 12 tasks on an average

Distribution of GPU statistics

In [279]:

```
gpu_stats_labels = ['Power (W)','Temperature (C)','GPU Util.(%)','Memory Util.(%)']
plt.boxplot([final_df['powerDrawWatt'], final_df['gpuTempC'],
             final_df['gpuUtilPerc'], final_df['gpuMemUtilPerc']])
plt.xticks([i+1 for i, _ in enumerate(gpu_stats_labels)],
           gpu_stats_labels, rotation='vertical')
plt.title('Distribution of GPU Statistics')
plt.rcParams['figure.figsize'] = [20, 8]

plt.show()
```



The power consumption by the GPUs had an average of 80%, while the memory consumption and temperature were the least as in around 40C. The GPU utilisation was around 70% which seems to be decent enough

Identify particular GPU cards (based on their serial numbers) whose performance differs to other cards?

In [139]:

```
slower_gpu_df=final_df[(final_df['time_difference'] >= render_time_median)]
slower_gpu_hostname=slower_gpu_df.hostname
merged_df=gpu_data.merge(slower_gpu_df,on="hostname")
slower_gpu_df_sorted= slower_gpu_df.sort_values('time_difference', ascending=False)
```

In [176]:

```
top10_slowest=slower_gpu_df_sorted.nlargest(10,"time_difference")
top10_slowestgpu=top10_slowest["hostname"]
```

In [188]:

```
top10_slowestgpu
```

Out[188]:

```
3259    0745914f4de046078517041d70b22fe7000009
3260    0745914f4de046078517041d70b22fe7000009
2595    6139a35676de44d6b61ec247f0ed865700001B
2596    6139a35676de44d6b61ec247f0ed865700001B
2987    2ecb9d8d51bc457aac88073f6da0546100000F
3183    04dc4e9647154250beeee51b866b0715000001
2988    2ecb9d8d51bc457aac88073f6da0546100000F
4730    b9a1fa7ae2f74eb68f25f607980f97d700000H
3184    04dc4e9647154250beeee51b866b0715000001
2935    83ea61ac1ef54f27a3bf7bd0f41ecaa7000011
Name: hostname, dtype: object
```

In [199]:

```
serial_gpu_data=gpu_data[["hostname","gpuSerial"]]

slowest_gpu_data=serial_gpu_data.merge(top10_slowestgpu.to_frame(),left_index=True, right_i
```

Top 10 slowest performing GPUs by their serial number

In [201]:

```
slowest_gpu_data["gpuSerial"]
```

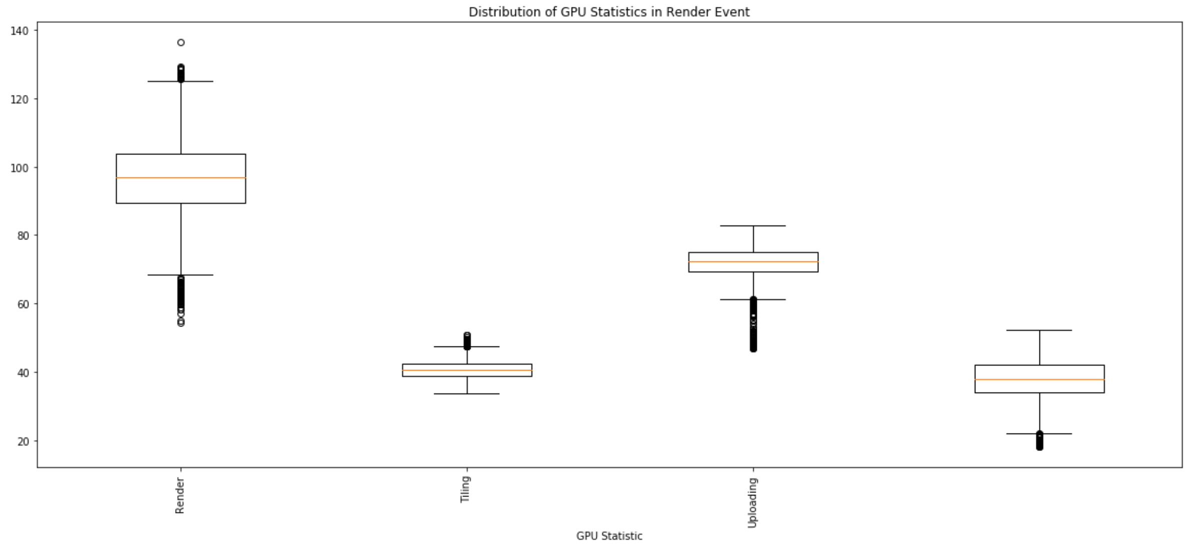
Out[201]:

```
2595    323617021242
2596    323617020414
2935    325017048638
2987    325217085174
2988    325017019589
3183    323617020145
3184    323617020179
3259    325117172395
3260    320118119713
4730    320218055639
Name: gpuSerial, dtype: int64
```

Render event statistics

In [251]:

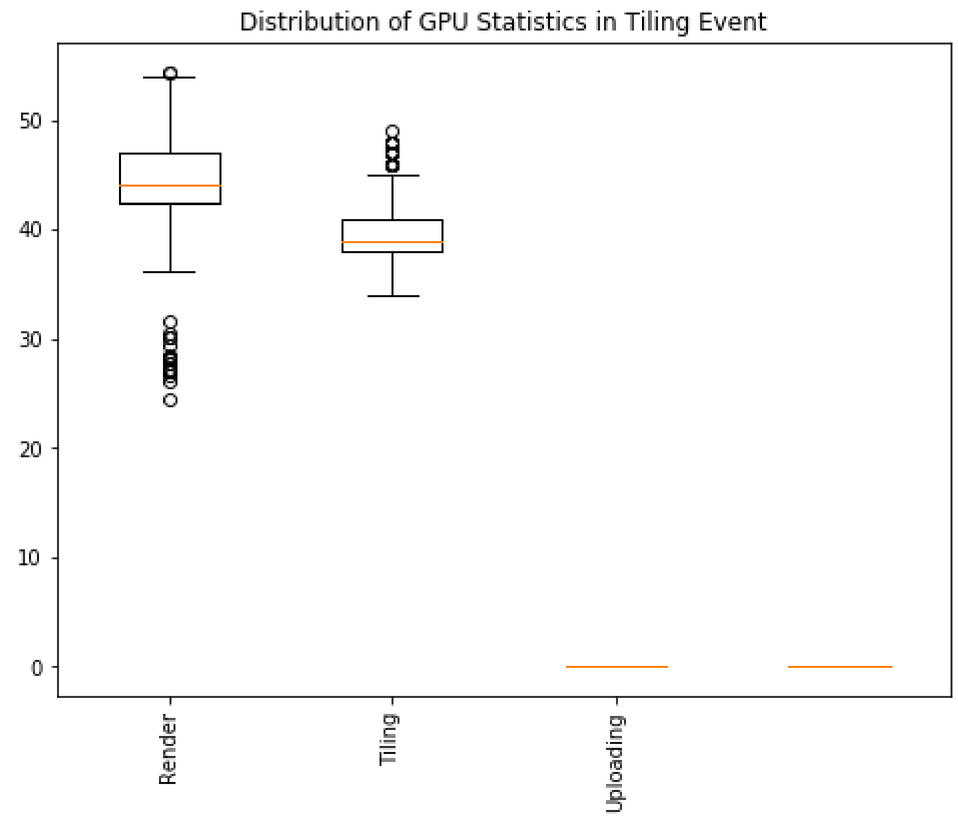
```
plt.boxplot(
    [final_df[final_df['eventName'] == 'Render']['powerDrawWatt'],
    final_df[final_df['eventName'] == 'Render']['gpuTempC'],
    final_df[final_df['eventName'] == 'Render']['gpuUtilPerc'],
    final_df[final_df['eventName'] == 'Render']['gpuMemUtilPerc']])

# setup labels and titles

plt.title('Distribution of GPU Statistics in Render Event')
plt.xlabel('GPU Statistic')
plt.xticks([i+1 for i, _ in enumerate(gpu_stats_labels)],
           gpu_stats_labels, rotation='vertical')


# draw plot

plt.rcParams['figure.figsize'] = [8, 6]
plt.show()
```



Tiling event statistics

In [252]:

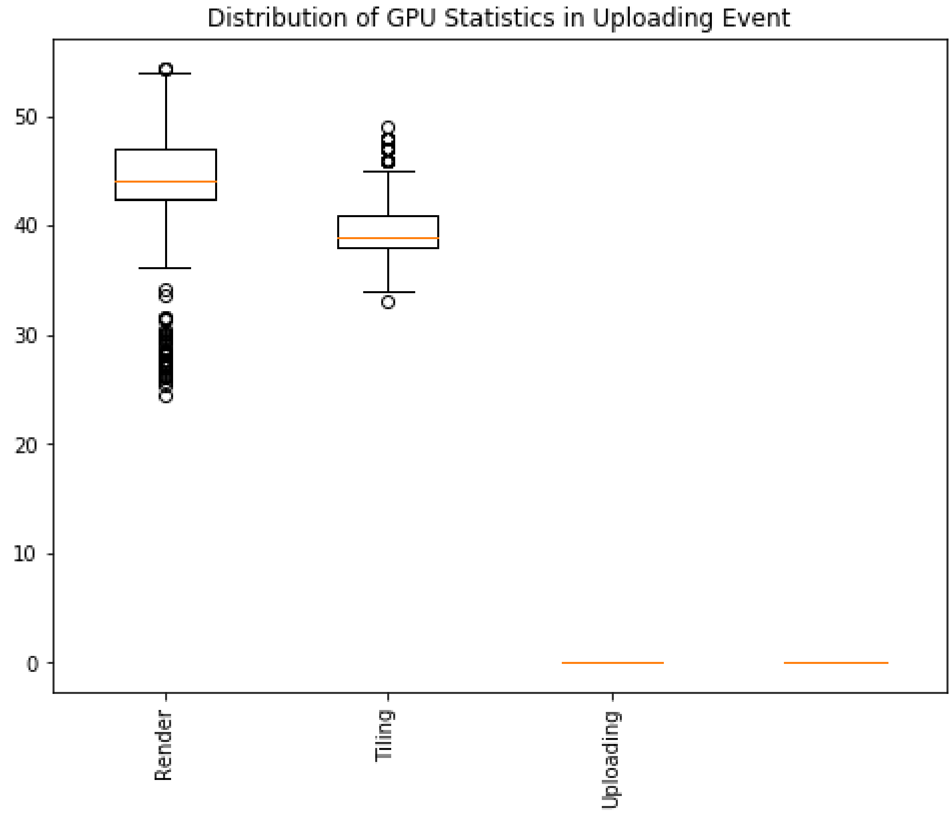
```


plt.boxplot(
    [final_df[final_df['eventName'] == 'Tiling']['powerDrawWatt'],
    final_df[final_df['eventName'] == 'Tiling']['gpuTempC'],
    final_df[final_df['eventName'] == 'Tiling']['gpuUtilPerc'],
    final_df[final_df['eventName'] == 'Tiling']['gpuMemUtilPerc']])

# setup labels and titles

plt.title('Distribution of GPU Statistics in Tiling Event')
plt.xticks([i+1 for i, _ in enumerate(gpu_stats_labels)],
           gpu_stats_labels, rotation='vertical')


# draw plot

plt.rcParams['figure.figsize'] = [8, 6]
plt.show()
```



Uploading event statistics

In [253]:

```
plt.boxplot(
    [final_df[final_df['eventName'] == 'Uploading']['powerDrawWatt'],
     final_df[final_df['eventName'] == 'Uploading']['gpuTempC'],
     final_df[final_df['eventName'] == 'Uploading']['gpuUtilPerc'],
     final_df[final_df['eventName'] == 'Uploading']['gpuMemUtilPerc']])

# setup labels and titles

plt.title('Distribution of GPU Statistics in Uploading Event')
plt.xticks([i+1 for i, _ in enumerate(gpu_stats_labels)],
           gpu_stats_labels, rotation='vertical')


# draw plot

plt.rcParams['figure.figsize'] = [8, 6]
plt.show()
```



Interplay between GPU temperature and performance

In [273]:

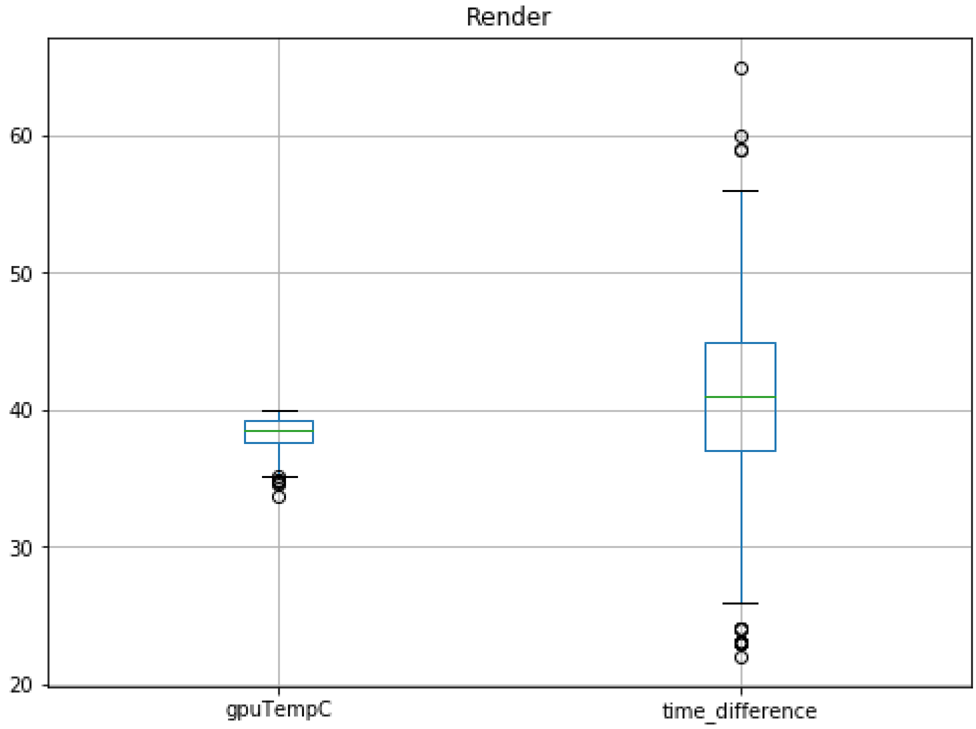
```
# Calculating the median temperature of the GPU and creating two datasets with values above
temp_med = statistics.median(final_df['gpuTempC'])
below_med_temp = final_df[(final_df['gpuTempC'] <= temp_med) &(final_df['eventName'] == 'Re
above_med_temp = final_df[(final_df['gpuTempC'] >= temp_med) &(final_df['eventName'] == 'Re
```

In [274]:

```
below_med_temp.boxplot(column=["gpuTempC","time_difference"])
```

Out[274]:

```
Render    AxesSubplot(0.1,0.15;0.8x0.75)
dtype: object
```

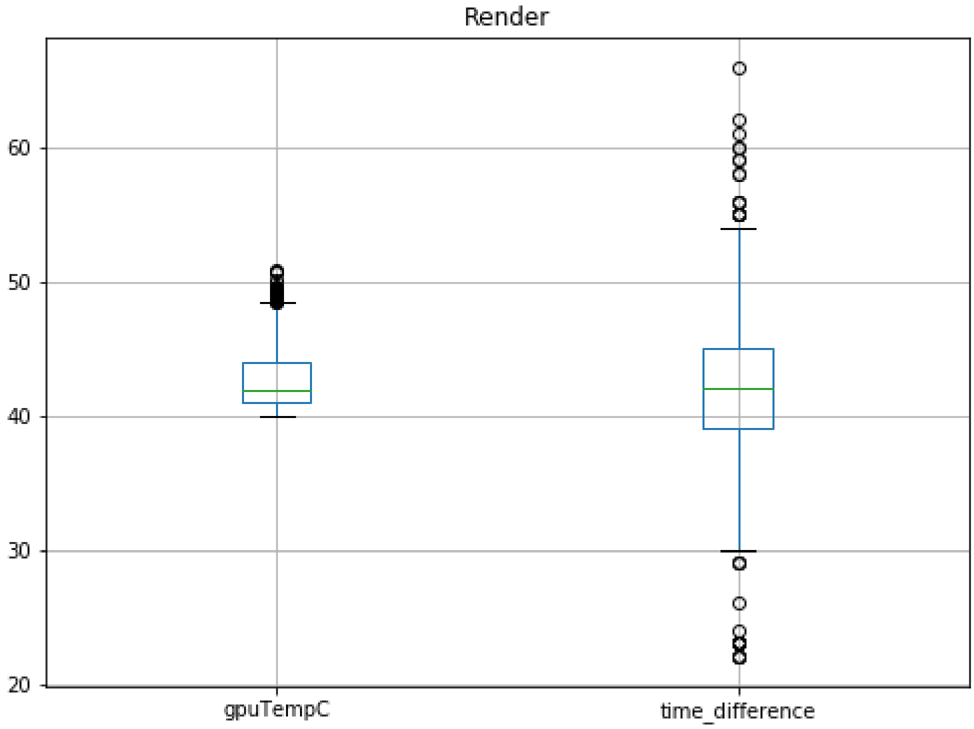


In [275]:

```
above_med_temp.boxplot(column=["gpuTempC","time_difference"])
```

Out[275]:

```
Render    AxesSubplot(0.1,0.15;0.8x0.75)
dtype: object
```



Interplay between increased power draw and render time

In [276]:

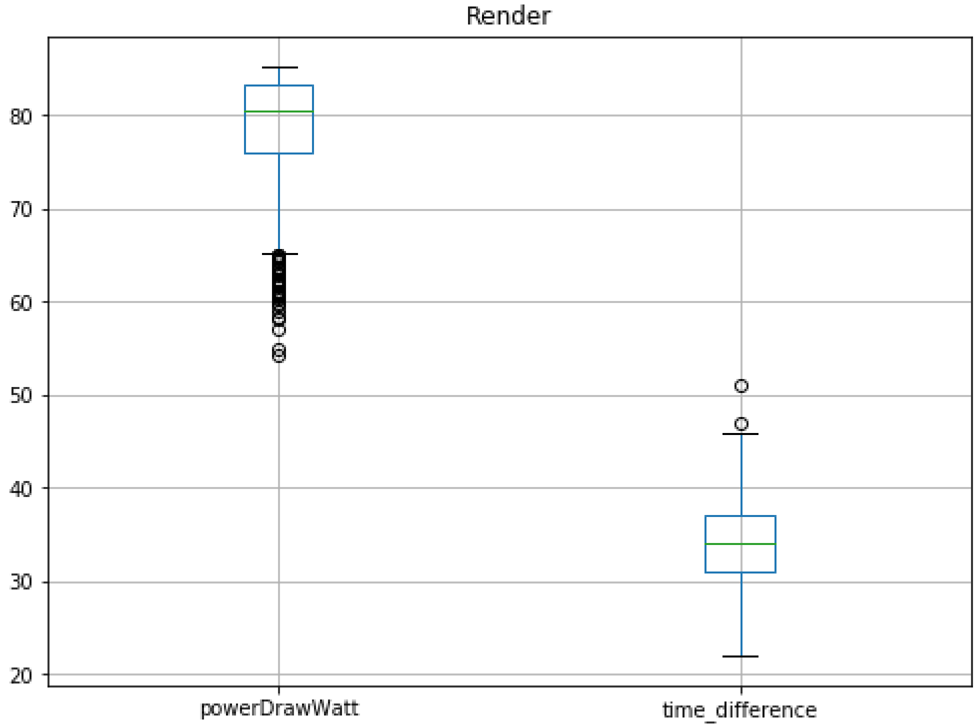
```
# Calculating the median power drawn of the GPU and creating two datasets with values above
power_med = statistics.median(final_df['powerDrawWatt'])
below_med_power = final_df[(final_df['powerDrawWatt'] <= power_med) &(final_df['eventName']
above_med_power = final_df[(final_df['powerDrawWatt'] >= power_med) &(final_df['eventName']
```

In [277]:

```
below_med_power.boxplot(column=["powerDrawWatt","time_difference"])
```

Out[277]:

```
Render    AxesSubplot(0.1,0.15;0.8x0.75)
dtype: object
```

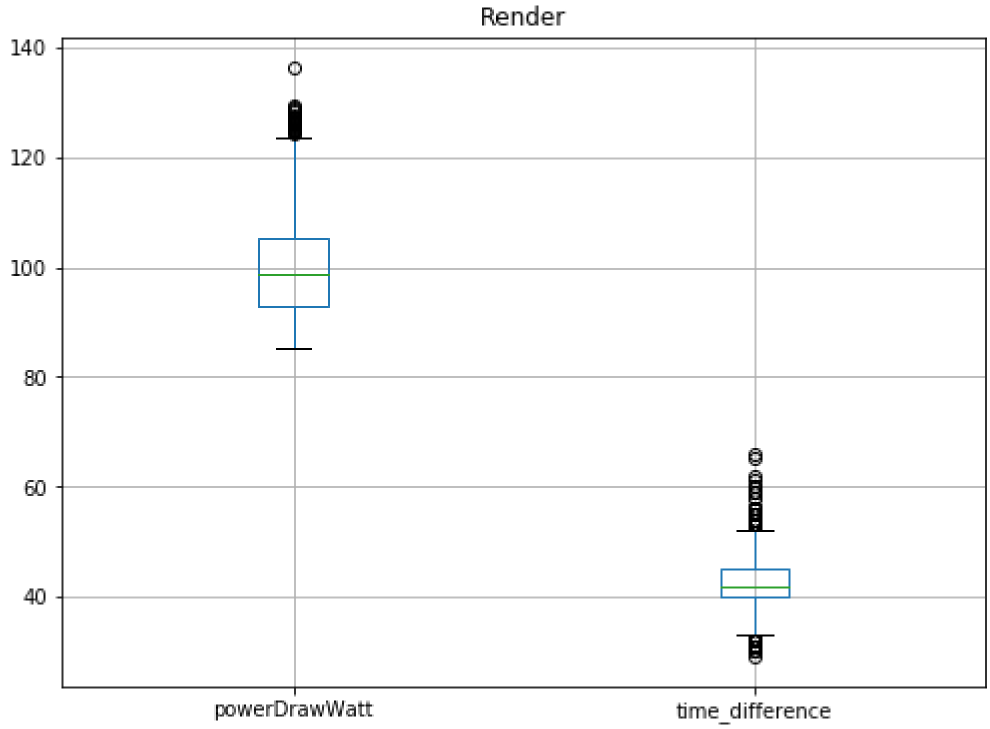


In [278]:

```
above_med_power.boxplot(column=["powerDrawWatt","time_difference"])
```

Out[278]:

```
Render    AxesSubplot(0.1,0.15;0.8x0.75)
dtype: object
```



In [280]:

```
power_med
```

Out[280]:

```
85.31480158730157
```

```
In [ ]:
```