A^k-UCB

June 26, 2020

# 1 0. Module

[2]:
```
from tqdm import notebook
import controller as ct
import matplotlib.pyplot as plt
import Envir_setting as env
import pickle
import numpy as np
import networkx as nx
```

# 2 1-1. Set the variables

- **Graph configuration**
  - Randomly generated network with #nodes = 50, #edges = 200
  - Total time = frame_size(500) * frame_rep(20) = $10^4$ time slots
- **Arrival rates and transmission rates setting**
  - Arrival rate of each link is determined in $[0.4, 0.7]$ at random
  - Transmission rate of each link is determined in $[0.25, 0.75]$ at random
- **Algorithm setting**
  - Implement $A^k$-UCB and $dA^k$-UCB with $k = 3, 6, 9$
  - Compare the result of both algorithm with GMM which uses UCB as estimator
- **Result setting**
  - Results (section 3) are the expected results with 10 times repition

[4]:
```
lower = 0.4
upper = 0.7
frame_size=500
div = 10
result_rep = 10
```

# 3 1-2. Generate arrival patterns and transmission rates

*Note:* If you want to get new arrival patterns and transmission rates, then run the below cell

[8]:
```
env.generate_random_arrival_rates(200, lower, upper)
for i in range(1, div+1):
```

```
    env.generate_arrivals(200, lower, upper, i / div, frame_size, 20)

generate_transmissions(200,0.25,0.75)
```

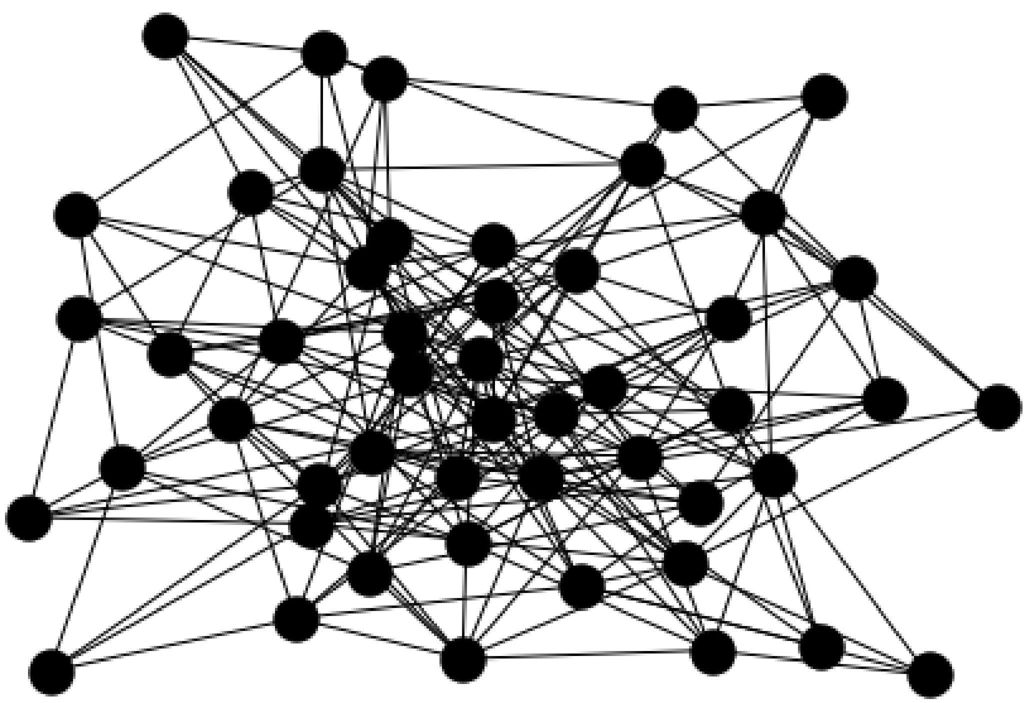
# 4 1-3. Generate graph

- *Note:*
  - If you want to generate new graph, run the first below cell
  - If you want to reuse the exising graph, run the second below cell

[10]:
```
graph = ct.set_environment(50,200, lower , upper , 0.25, 0.75, frame_size, 20)
with open('graph_info.txt', 'wb') as f:
    pickle.dump(graph,f)
```

[5]:
```
with open('graph_info.txt', 'rb') as f:
    graph = pickle.load(f)
```

[121]:
```
# with open('graph_info.txt', 'rb') as f:
#     graph = pickle.load(f)
fig = plt.figure()
pos = nx.spring_layout(graph.graph)
nx.draw(graph.graph,pos=pos,node_color='k')
fig.savefig('Network topology ',bbox_inches = "tight")
```



# 5 2-1. Implement $A^k$-UCB algorithm

[ ]:
```
for rep in notebook.tqdm(range(1,result_rep+1)):
    queue_trace_A_3 = []
    queue_trace_A_6 = []
    queue_trace_A_9 = []
    queue_trace_GMM = []

    for i in notebook.tqdm(range(1, div + 1)):
        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
 ↪75, frame_size, 20)
        queue_trace_A_3.append(ct.A_k_algorithm(0.3, 3, graph, 'UCB',␣
 ↪frame_size, 20))

        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
 ↪75, frame_size, 20)
        queue_trace_A_6.append(ct.A_k_algorithm(0.3, 6, graph, 'UCB',␣
 ↪frame_size, 20))

        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
 ↪75, frame_size, 20)
        queue_trace_A_9.append(ct.A_k_algorithm(0.3, 9, graph, 'UCB',␣
 ↪frame_size, 20))

        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
 ↪75, frame_size, 20)
        queue_trace_GMM.append(ct.GMM_algorithm(graph, 'UCB', frame_size,20))


    plt.plot(queue_trace_A_3, 'r--', label='A^3-UCB')
    plt.plot(queue_trace_A_6, 'b--', label='A^6-UCB')
    plt.plot(queue_trace_A_9, 'g--', label='A^9-UCB')

    plt.plot(queue_trace_GMM, 'k--', label='GMM')
    plt.xlabel('lambda', fontsize=15)
    plt.ylabel('Queue', fontsize=15)
    plt.ylim(0,5000)
    plt.legend()
    plt.show()

    result1 = ' '.join(map(str,queue_trace_A_3))
    result2 = ' '.join(map(str,queue_trace_A_6))
    result3 = ' '.join(map(str,queue_trace_A_9))
```

```
    with open('./results/' + f'A^k-UCB{rep}(nodes {50}, edges {200},k {3},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result1)
    with open('./results/' + f'A^k-UCB{rep}(nodes {50}, edges {200},k {6},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result2)
    with open('./results/' + f'A^k-UCB{rep}(nodes {50}, edges {200},k {9},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result3)

    result4 = ' '.join(map(str,queue_trace_GMM))
    with open('./results/' + f'GMM-UCB{rep}(nodes {50}, edges {200}.txt','w')␣
↪as f:
            f.write(result4)
```

# 6 2-2. Implement $dA^k$-UCB algorithm

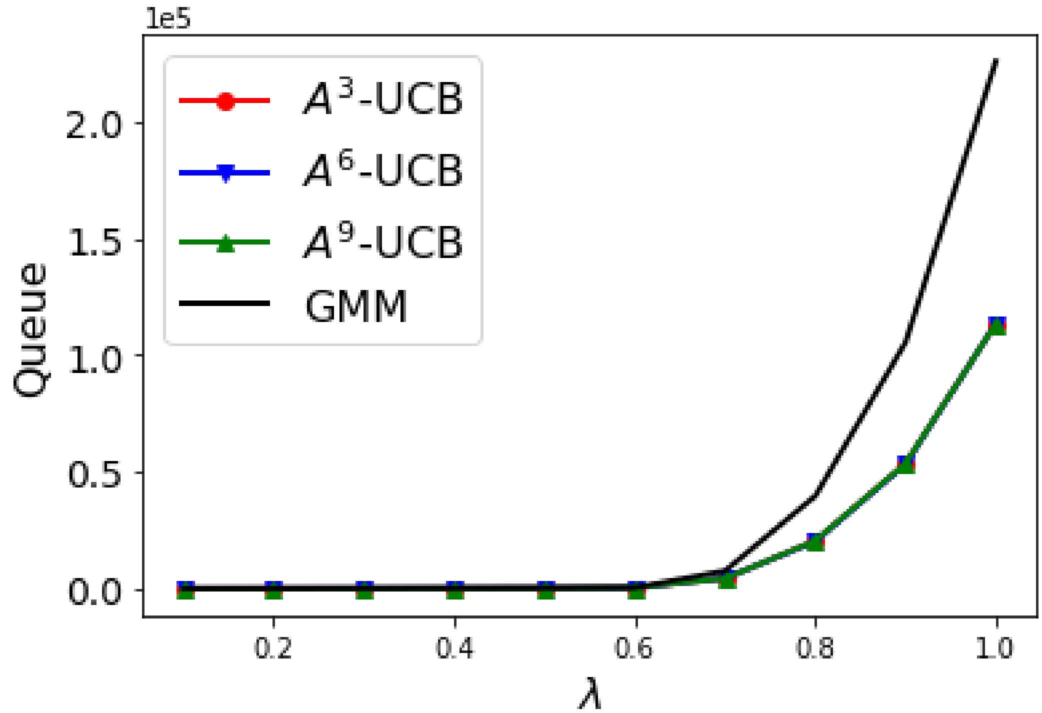
[ ]:
```
for rep in notebook.tqdm(range(1,result_rep+1)):
    queue_trace_A_3 = []
    queue_trace_A_6 = []
    queue_trace_A_9 = []
    queue_trace_GMM = []

    for i in notebook.tqdm(range(1, div + 1)):
        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
↪75, frame_size, 20)
        queue_trace_A_3.append(ct.dA_k_algorithm(0.3, 3, graph, 'UCB',␣
↪frame_size, 20))

        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
↪75, frame_size, 20)
        queue_trace_A_6.append(ct.dA_k_algorithm(0.3, 6, graph, 'UCB',␣
↪frame_size, 20))

        graph.reset_environment(200, lower * i / div, upper * i / div, 0.25, 0.
↪75, frame_size, 20)
        queue_trace_A_9.append(ct.dA_k_algorithm(0.3, 9, graph, 'UCB',␣
↪frame_size, 20))

        with open('./results/' + f'GMM-UCB{i}(nodes {50}, edges {200}.txt','r')␣
↪as f:
            queue_trace_GMM = f.read().split()
            queue_trace_GMM = list(map(int, queue_trace_GMM))
```

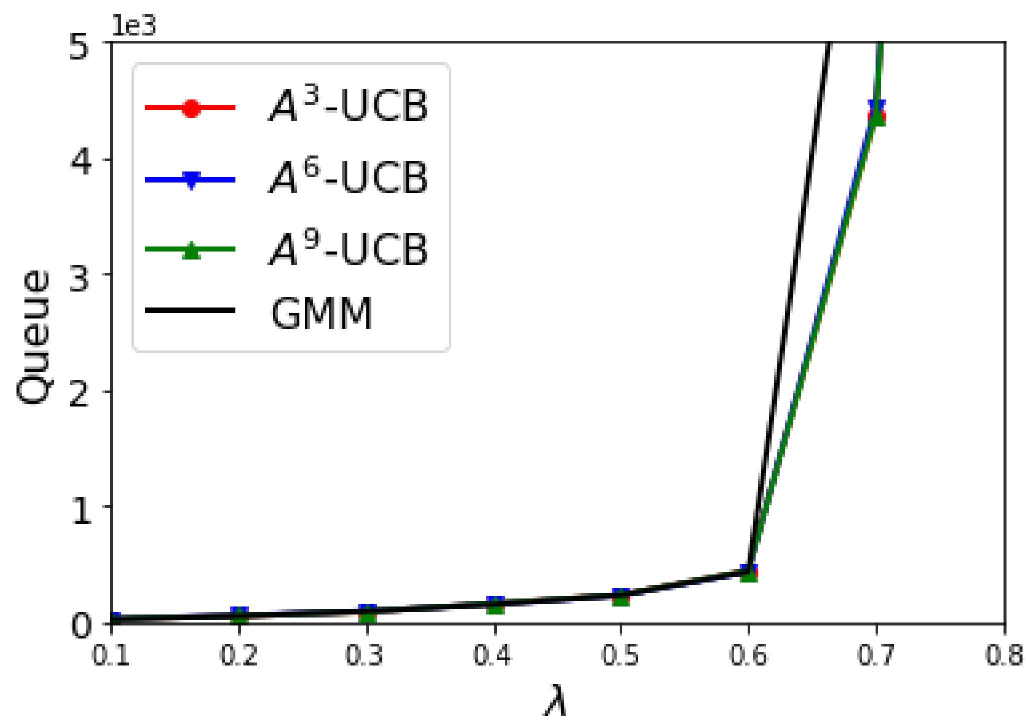
```
    plt.plot(queue_trace_A_3, 'r--', label='A^3-UCB')
    plt.plot(queue_trace_A_6, 'b--', label='A^6-UCB')
    plt.plot(queue_trace_A_9, 'g--', label='A^9-UCB')

    plt.plot(queue_trace_GMM, 'k--', label='GMM')
    plt.xlabel('lambda', fontsize=15)
    plt.ylabel('Queue', fontsize=15)
    plt.ylim(0,5000)
    plt.legend()
    plt.show()

    result1 = ' '.join(map(str,queue_trace_A_3))
    result2 = ' '.join(map(str,queue_trace_A_6))
    result3 = ' '.join(map(str,queue_trace_A_9))

    with open('./results/' + f'dA^k-UCB{rep}(nodes {50}, edges {200},k {3},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result1)
    with open('./results/' + f'dA^k-UCB{rep}(nodes {50}, edges {200},k {6},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result2)
    with open('./results/' + f'dA^k-UCB{rep}(nodes {50}, edges {200},k {9},␣
↪p_seed {0.3}.txt','w') as f:
            f.write(result3)
```

# 7 3-1. Draw the expected result of $A^k$-UCB

[11]:
```
mean_queue_trace_A_3=np.zeros(div)
mean_queue_trace_A_6=np.zeros(div)
mean_queue_trace_A_9=np.zeros(div)
mean_queue_trace_GMM=np.zeros(div)

for i in range(1,div+1):
    with open('./results/' + f'A^k-UCB{i}(nodes {50}, edges {200},k {3}, p_seed␣
↪{0.3}.txt','r') as f:
            queue_trace_A_3=f.read().split()
            mean_queue_trace_A_3 += np.array(list(map(int,queue_trace_A_3)))
    with open('./results/' + f'A^k-UCB{i}(nodes {50}, edges {200},k {6}, p_seed␣
↪{0.3}.txt','r') as f:
            queue_trace_A_6=f.read().split()
            mean_queue_trace_A_6 += np.array(list(map(int,queue_trace_A_6)))
    with open('./results/' + f'A^k-UCB{i}(nodes {50}, edges {200},k {3}, p_seed␣
↪{0.3}.txt','r') as f:
            queue_trace_A_9=f.read().split()
            mean_queue_trace_A_9 += np.array(list(map(int,queue_trace_A_9)))
```

```
    with open('./results/' + f'GMM-UCB{i}(nodes {50}, edges {200}.txt','r') as␣
↪f:
            queue_trace_GMM = f.read().split()
            mean_queue_trace_GMM += np.array(list(map(int,queue_trace_GMM)))

fig1=plt.figure()
plt.ticklabel_format(axis='y', style='sci', scilimits=(0, 5)); plt.
↪yticks(fontsize=14)

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_3/div, 'or-',␣
↪linewidth=2, label=r'$A^3$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_6/div, 'vb-',␣
↪linewidth=2, label=r'$A^6$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_9/div, '^g-',␣
↪linewidth=2, label=r'$A^9$-UCB')

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_GMM/div, 'k-',␣
↪linewidth=2, label='GMM')
plt.xlabel(r'$\lambda$', fontsize=16)
plt.ylabel('Queue', fontsize=16)
plt.legend(fontsize=16)
fig1.savefig('Original Stability for $A^k-UCB$',bbox_inches = "tight")


fig2=plt.figure()
plt.ticklabel_format(axis='y', style='sci', scilimits=(0, 3)); plt.
↪yticks(fontsize=14)

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_3/div, 'or-',␣
↪linewidth=2, label=r'$A^3$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_6/div, 'vb-',␣
↪linewidth=2, label=r'$A^6$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_A_9/div, '^g-',␣
↪linewidth=2, label=r'$A^9$-UCB')

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_GMM/div, 'k-',␣
↪linewidth=2, label='GMM')
plt.xlabel(r'$\lambda$', fontsize=16)
plt.ylabel('Queue', fontsize=16)
plt.ylim(0,5000)
plt.xlim(0.1,0.8)
plt.legend(fontsize=16)
fig2.savefig('Edited Stability for $A^k-UCB$',bbox_inches = "tight")

plt.show()
```

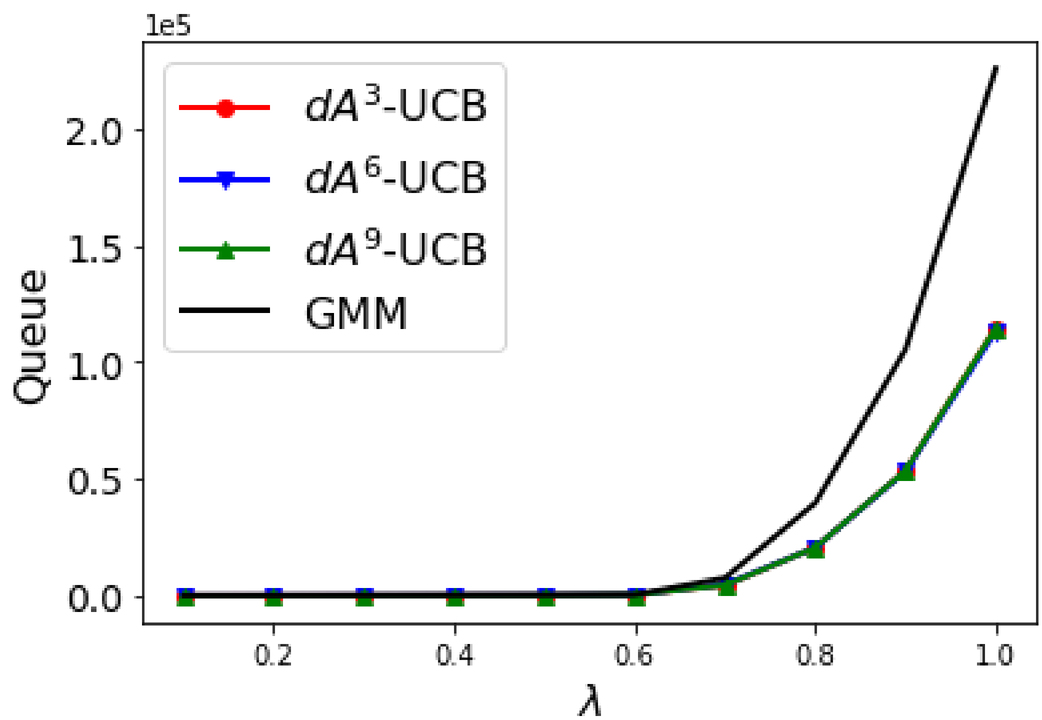

1e5
$A^3$-UCB
$A^6$-UCB
$A^9$-UCB
GMM
Queue
2.0
1.5
1.0
0.5
0.0
0.2
0.4
0.6
0.8
1.0
$\lambda$

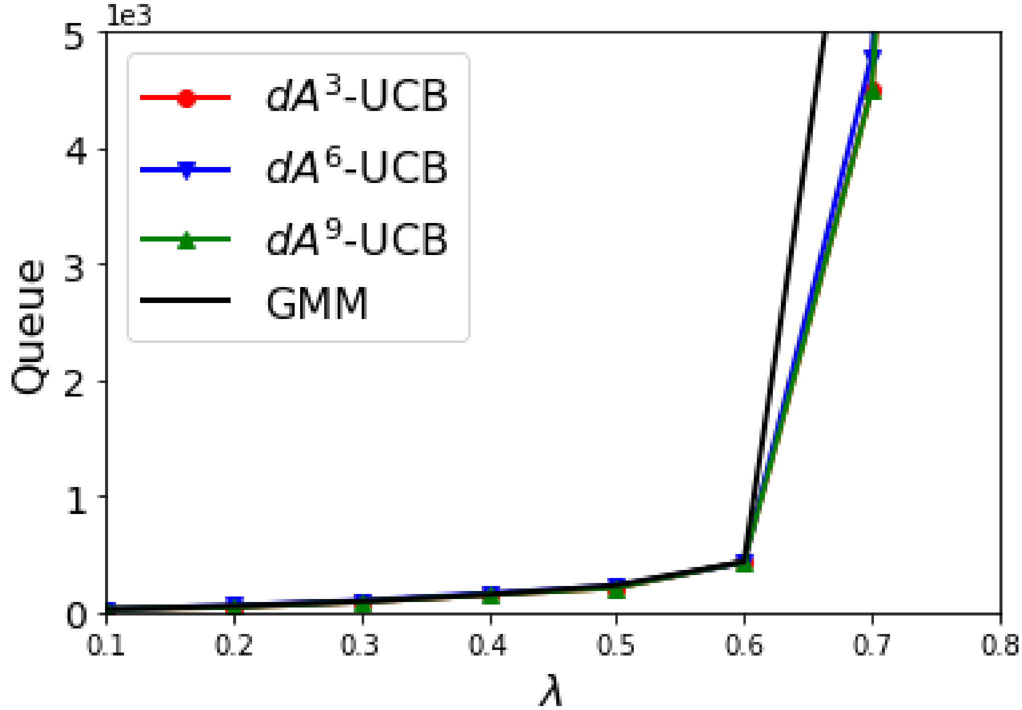

1e3
$A^3$-UCB
$A^6$-UCB
$A^9$-UCB
GMM
Queue
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
$\lambda$

## 8 3-2. Draw the expected result of $dA^k$-UCB

[15]:
```
mean_queue_trace_dA_3=np.zeros(div)
mean_queue_trace_dA_6=np.zeros(div)
mean_queue_trace_dA_9=np.zeros(div)
mean_queue_trace_GMM=np.zeros(div)

for i in range(1,div+1):
    with open('./results/' + f'dA^k-UCB{i}(nodes {50}, edges {200},k {3},␣
 ↪p_seed {0.3}.txt','r') as f:
            queue_trace_dA_3=f.read().split()
            mean_queue_trace_dA_3 += np.array(list(map(int,queue_trace_A_3)))
    with open('./results/' + f'dA^k-UCB{i}(nodes {50}, edges {200},k {6},␣
 ↪p_seed {0.3}.txt','r') as f:
            queue_trace_dA_6=f.read().split()
            mean_queue_trace_dA_6 += np.array(list(map(int,queue_trace_A_6)))
    with open('./results/' + f'dA^k-UCB{i}(nodes {50}, edges {200},k {3},␣
 ↪p_seed {0.3}.txt','r') as f:
            queue_trace_dA_9=f.read().split()
            mean_queue_trace_dA_9 += np.array(list(map(int,queue_trace_A_9)))
    with open('./results/' + f'GMM-UCB{i}(nodes {50}, edges {200}.txt','r') as␣
 ↪f:
            queue_trace_GMM = f.read().split()
            mean_queue_trace_GMM += np.array(list(map(int,queue_trace_GMM)))

fig1=plt.figure()
plt.ticklabel_format(axis='y', style='sci', scilimits=(0, 5)); plt.
 ↪yticks(fontsize=14)

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_3/div, 'or-',␣
 ↪linewidth=2, label=r'$dA^3$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_6/div, 'vb-',␣
 ↪linewidth=2, label=r'$dA^6$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_9/div, '^g-',␣
 ↪linewidth=2, label=r'$dA^9$-UCB')

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_GMM/div, 'k-',␣
 ↪linewidth=2, label='GMM')
plt.xlabel(r'$\lambda$', fontsize=16)
plt.ylabel('Queue', fontsize=16)
plt.legend(fontsize=16)
fig1.savefig('Original Stability for $dA^k-UCB$',bbox_inches = "tight")
```

```python
fig2=plt.figure()
plt.ticklabel_format(axis='y', style='sci', scilimits=(0, 3)); plt.
 ↪yticks(fontsize=14)

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_3/div, 'or-',␣
 ↪linewidth=2, label=r'$dA^3$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_6/div, 'vb-',␣
 ↪linewidth=2, label=r'$dA^6$-UCB')
plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_dA_9/div, '^g-',␣
 ↪linewidth=2, label=r'$dA^9$-UCB')

plt.plot([i/div for i in range(1,div+1)],mean_queue_trace_GMM/div, 'k-',␣
 ↪linewidth=2, label='GMM')
plt.xlabel(r'$\lambda$', fontsize=16)
plt.ylabel('Queue', fontsize=16)
plt.ylim(0,5000)
plt.xlim(0.1,0.8)
plt.legend(fontsize=16)
fig2.savefig('Edited Stability for $dA^k-UCB$',bbox_inches = "tight")

plt.show()
```





1e3
Queue
λ
dA³-UCB
dA⁶-UCB
dA⁹-UCB
GMM
0
1
2
3
4
5
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8