Quantitative Methods and Simulation

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Para cada una de las siguientes situaciones determina NURX, esto es:

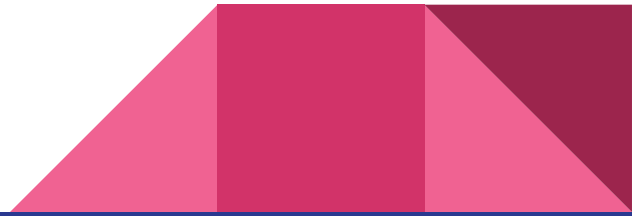
i) Número medio de tareas en el búfer
ii) Utilización de la red Wifi
iii) Tiempo promedio de residencia en el búfer
iv) Rendimiento promedio de la red Wifi
v) Probabilidad de saturación del búfer

Lo que se desea saber es lo siguiente:

a) Dada un cierto tamaño de buffer n=50, 100, 250, 500 (tamaño máximo de cola en paquetes), una probabilidad de error e=0.001*k, suponiendo la cantidad de usuarios k = 5, 10, 15, 20 y si queremos que la probabilidad de saturación G sea menor o igual a 0.05, 0.01 o 0.001,¿cuál es el tamaño n (en paquetes) que debe tener el buffer de transmisión?
b) ¿Existe una cantidad máxima de usuarios que se puede atender incluso si no hay errores en la red?

For the saturation probability be equal or less than 0.05, 0.01 or 0.001

n can have any of the following values tested: 50, 100, 250, 500. This implies that The maximum capacity of the buffer irrelevant of the limit chosen between the four cases, it’ll have a low probability of saturation.



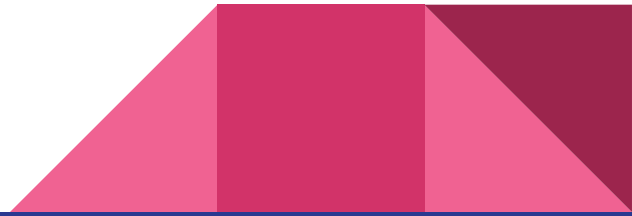
Summary of tests realized for the different cases

k	n	N	U	R	X	probability buffer full
5	50	0.7998	0.6629	0.00017977	4449.1299	0.000038
10	50	0.8942	0.6633	0.00020331	4398.4449	0.000086
15	50	0.9311	0.6632	0.00021375	4356.1322	0.000141
20	50	1.0908	0.6632	0.00025303	4311.1253	0.000254
5	100	0.8438	0.6627	0.00018973	4447.7547	0.000026
10	100	0.9545	0.6633	0.000217	4398.6799	0.000074
15	100	1.0181	0.6632	0.00023369	4356.6113	0.000121
20	100	1.2175	0.6632	0.00028242	4311.0408	0.000168
5	250	0.9615	0.6629	0.00021635	4444.3314	0
10	250	1.1769	0.6634	0.00026749	4399.9686	0.000038
15	250	1.282	0.6633	0.00029431	4356.2852	0.000086
20	250	1.5194	0.6633	0.00035243	4311.4168	0.000133
5	500	0.9615	0.6629	0.00021638	4443.8924	0
10	500	1.2427	0.6634	0.00028251	4398.908	0
15	500	1.6863	0.6635	0.00038718	4355.3556	0.000026
20	500	2.0214	0.6633	0.00046893	4310.8794	0.000074

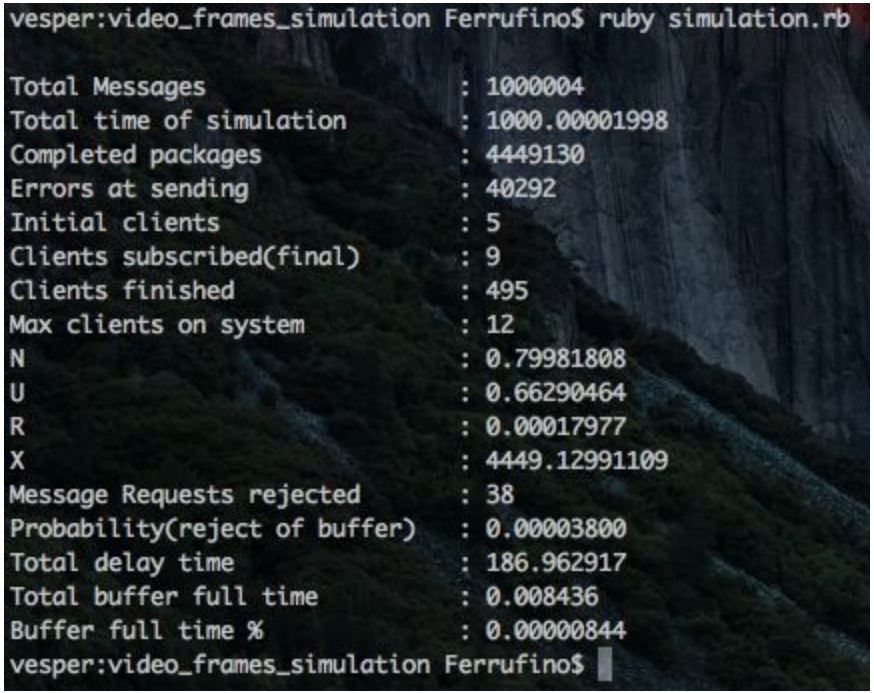
Evidence

Next slides prove the detailed evidence of every test case for n and k tested.

After that, it’ll show the graphs realized with conclusions interpreted from it.



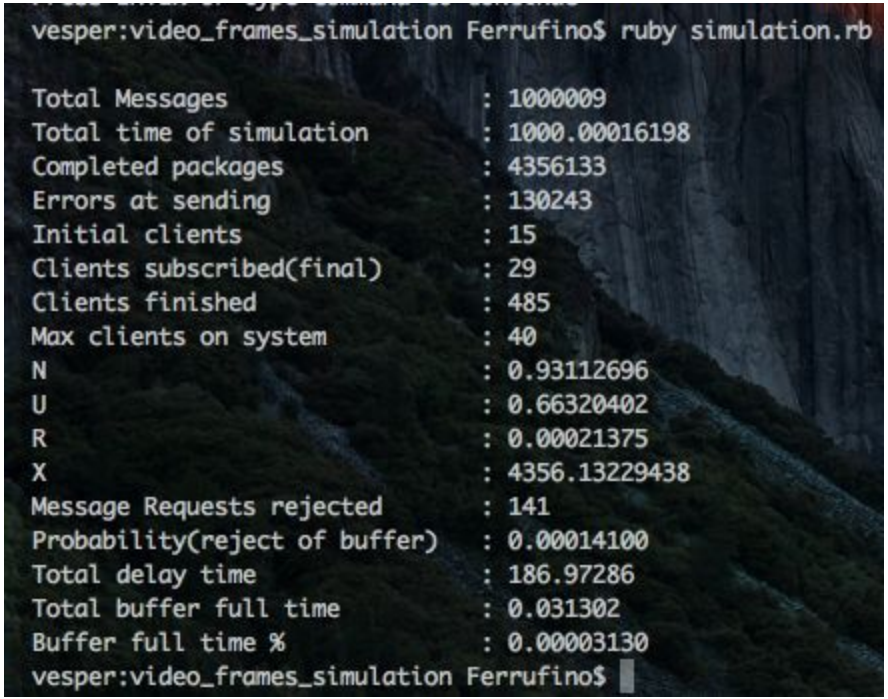
n= 50 & k =5


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000004
Total time of simulation : 1000.00001998
Completed packages : 4449130
Errors at sending : 40292
Initial clients : 5
Clients subscribed(final) : 9
Clients finished : 495
Max clients on system : 12
N : 0.79981808
U : 0.66290464
R : 0.00017977
X : 4449.12991109
Message Requests rejected : 38
Probability(reject of buffer) : 0.00003800
Total delay time : 186.962917
Total buffer full time : 0.008436
Buffer full time % : 0.00000844
vesper:video_frames_simulation Ferrufino$

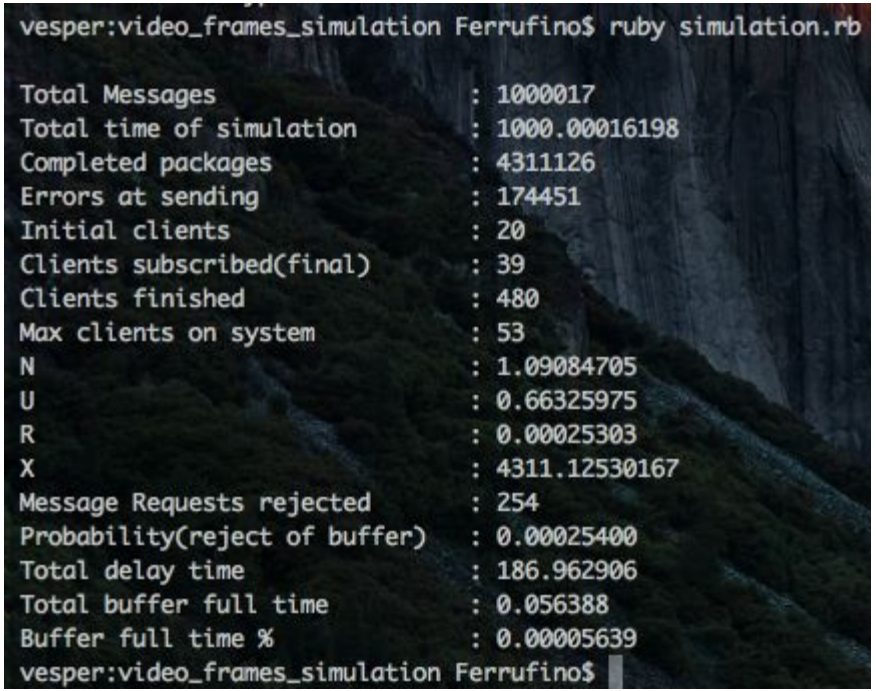
n=50 & k=10

```
vesper:video_frames_simulation Ferrufino$ ruby simulation.rb

Total Messages                  : 1000006
Total time of simulation        : 1000.00001198
Completed packages              : 4398445
Errors at sending               : 85118
Initial clients                 : 10
Clients subscribed(final)       : 19
Clients finished                : 490
Max clients on system           : 26
N                               : 0.89422865
U                               : 0.66337062
R                               : 0.00020331
X                               : 4398.44494729
Message Requests rejected       : 86
Probability(reject of buffer)   : 0.00008600
Total delay time                : 186.965619
Total buffer full time          : 0.019092
Buffer full time %              : 0.00001909
vesper:video_frames_simulation Ferrufino$
```

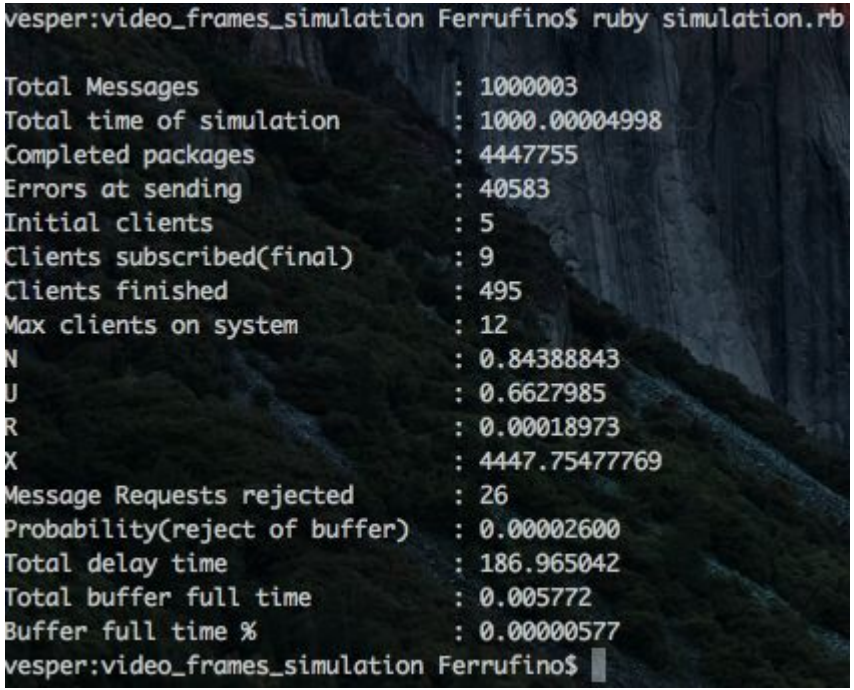
n=50 & k=15


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000009
Total time of simulation : 1000.00016198
Completed packages : 4356133
Errors at sending : 130243
Initial clients : 15
Clients subscribed(final) : 29
Clients finished : 485
Max clients on system : 40
N : 0.93112696
U : 0.66320402
R : 0.00021375
X : 4356.13229438
Message Requests rejected : 141
Probability(reject of buffer) : 0.00014100
Total delay time : 186.97286
Total buffer full time : 0.031302
Buffer full time % : 0.00003130
vesper:video_frames_simulation Ferrufino$

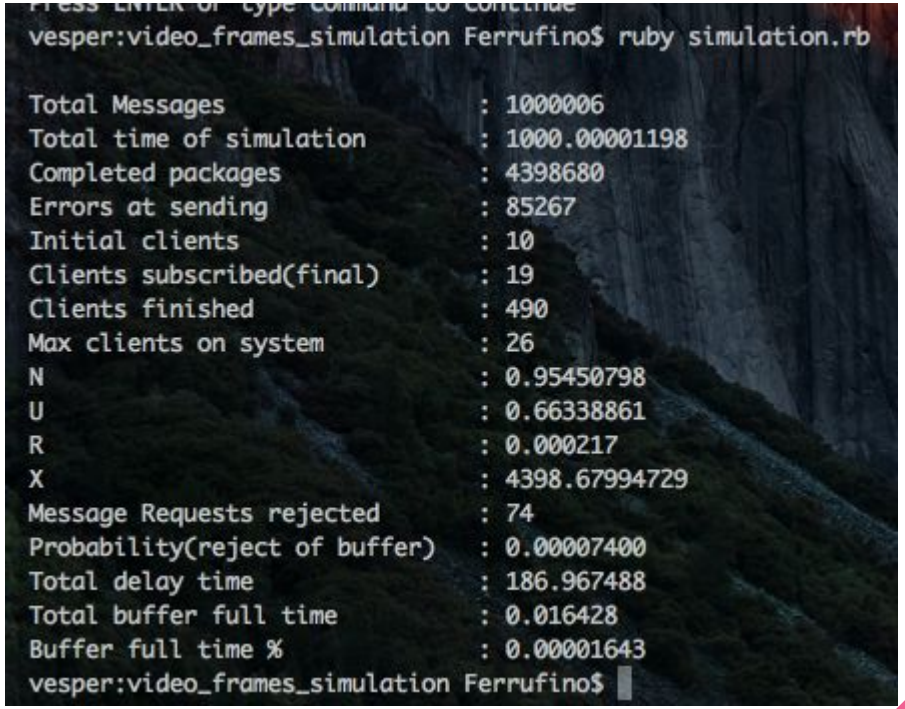
n=50 & k=20


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000017
Total time of simulation : 1000.00016198
Completed packages : 4311126
Errors at sending : 174451
Initial clients : 20
Clients subscribed(final) : 39
Clients finished : 480
Max clients on system : 53
N : 1.09084705
U : 0.66325975
R : 0.00025303
X : 4311.12530167
Message Requests rejected : 254
Probability(reject of buffer) : 0.00025400
Total delay time : 186.962906
Total buffer full time : 0.056388
Buffer full time % : 0.00005639
vesper:video_frames_simulation Ferrufino$

n=100 & k=5


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000003
Total time of simulation : 1000.00004998
Completed packages : 4447755
Errors at sending : 40583
Initial clients : 5
Clients subscribed(final) : 9
Clients finished : 495
Max clients on system : 12
N : 0.84388843
U : 0.6627985
R : 0.00018973
X : 4447.75477769
Message Requests rejected : 26
Probability(reject of buffer) : 0.00002600
Total delay time : 186.965042
Total buffer full time : 0.005772
Buffer full time % : 0.00000577
vesper:video_frames_simulation Ferrufino$

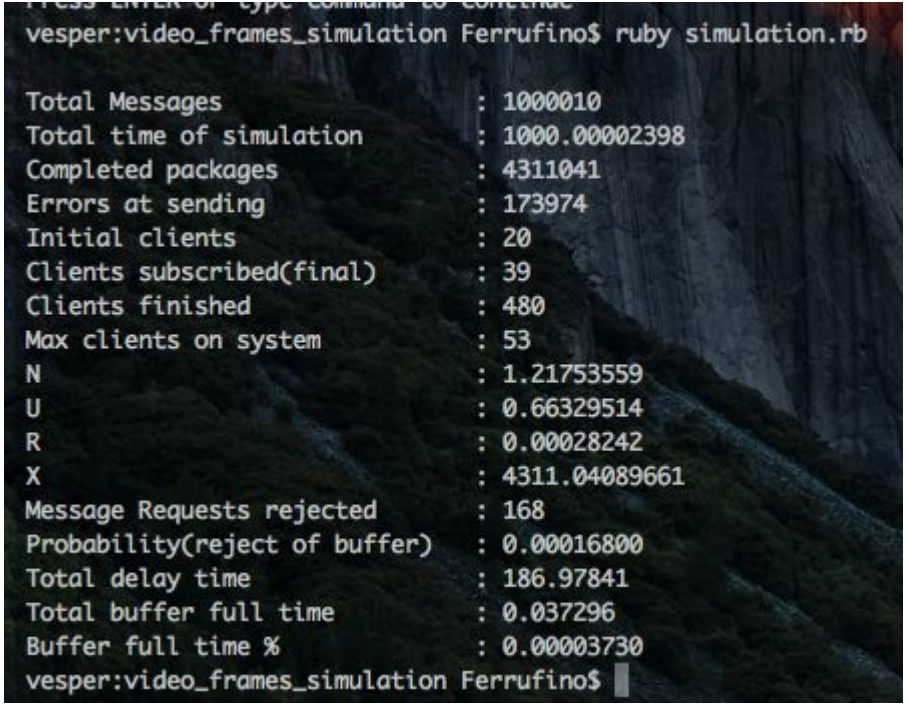
n=100 & k=10


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000006
Total time of simulation : 1000.00001198
Completed packages : 4398680
Errors at sending : 85267
Initial clients : 10
Clients subscribed(final) : 19
Clients finished : 490
Max clients on system : 26
N : 0.95450798
U : 0.66338861
R : 0.000217
X : 4398.67994729
Message Requests rejected : 74
Probability(reject of buffer) : 0.00007400
Total delay time : 186.967488
Total buffer full time : 0.016428
Buffer full time % : 0.00001643
vesper:video_frames_simulation Ferrufino$

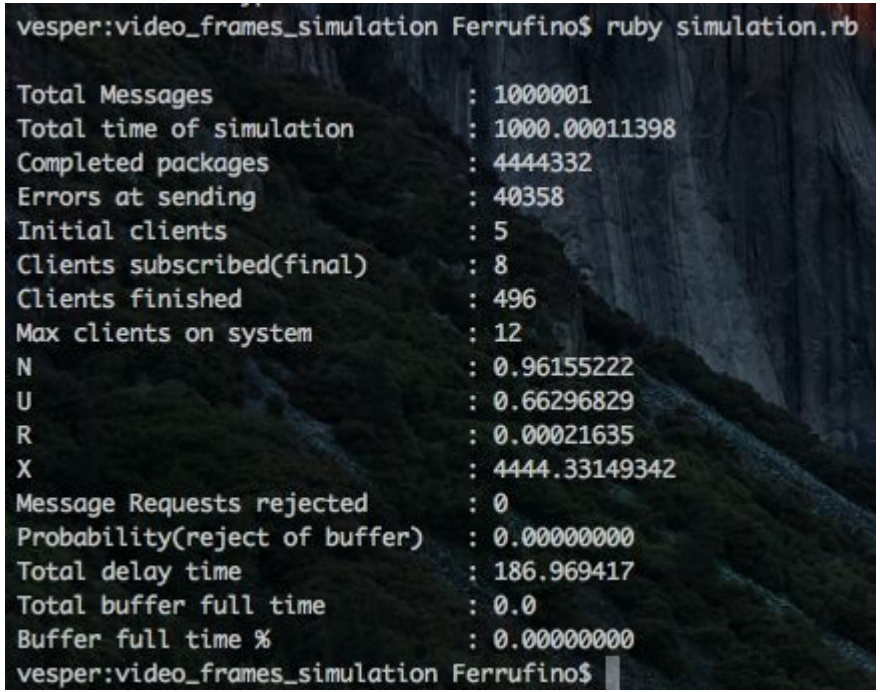
n=100 & k=15

```
vesper:video_frames_simulation Ferrufino$ ruby simulation.rb

Total Messages                  : 1000008
Total time of simulation        : 1000.00015198
Completed packages              : 4356612
Errors at sending               : 130105
Initial clients                 : 15
Clients subscribed(final)       : 29
Clients finished                : 485
Max clients on system           : 40
N                               : 1.01811683
U                               : 0.66325709
R                               : 0.00023369
X                               : 4356.61133787
Message Requests rejected       : 121
Probability(reject of buffer)   : 0.00012100
Total delay time                : 186.975742
Total buffer full time          : 0.026862
Buffer full time %              : 0.00002686
vesper:video_frames_simulation Ferrufino$
```

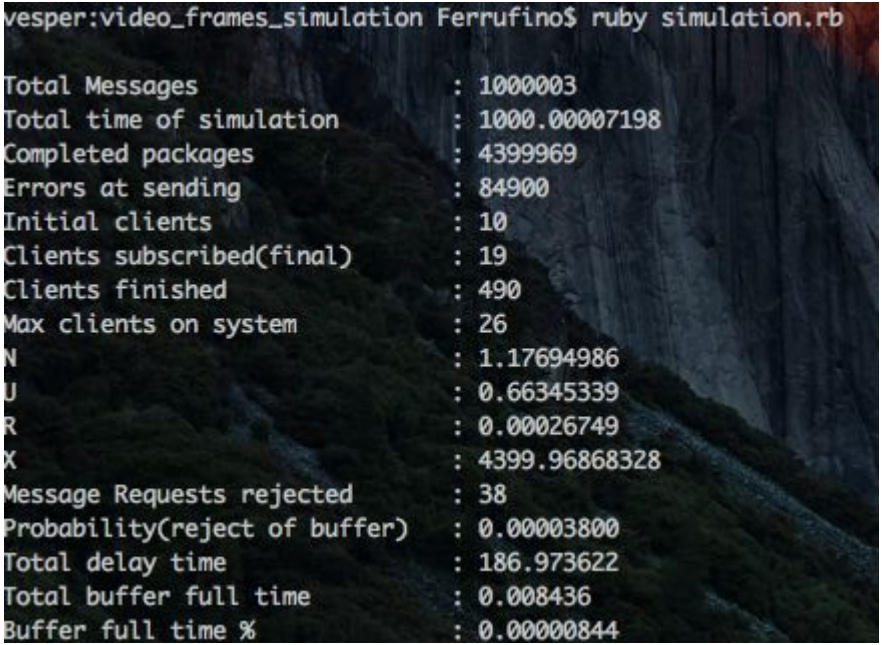
n=100 & k=20


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000010
Total time of simulation : 1000.00002398
Completed packages : 4311041
Errors at sending : 173974
Initial clients : 20
Clients subscribed(final) : 39
Clients finished : 480
Max clients on system : 53
N : 1.21753559
U : 0.66329514
R : 0.00028242
X : 4311.04089661
Message Requests rejected : 168
Probability(reject of buffer) : 0.00016800
Total delay time : 186.97841
Total buffer full time : 0.037296
Buffer full time % : 0.00003730
vesper:video_frames_simulation Ferrufino$

n=250 & k=5


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000001
Total time of simulation : 1000.00011398
Completed packages : 4444332
Errors at sending : 40358
Initial clients : 5
Clients subscribed(final) : 8
Clients finished : 496
Max clients on system : 12
N : 0.96155222
U : 0.66296829
R : 0.00021635
X : 4444.33149342
Message Requests rejected : 0
Probability(reject of buffer) : 0.00000000
Total delay time : 186.969417
Total buffer full time : 0.0
Buffer full time % : 0.00000000
vesper:video_frames_simulation Ferrufino$

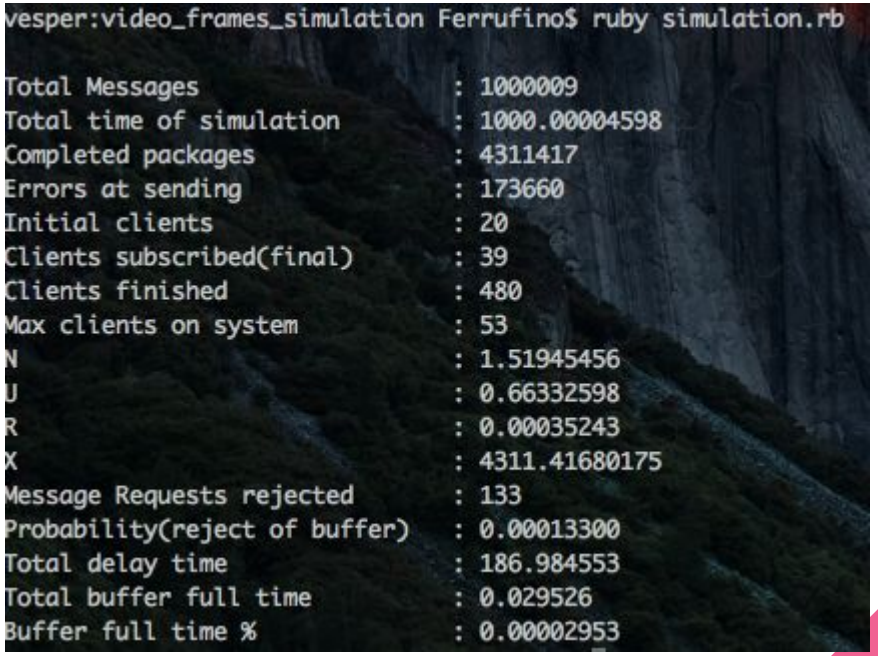
n=250 & k=10


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000003
Total time of simulation : 1000.00007198
Completed packages : 4399969
Errors at sending : 84900
Initial clients : 10
Clients subscribed(final) : 19
Clients finished : 490
Max clients on system : 26
N : 1.17694986
U : 0.66345339
R : 0.00026749
X : 4399.96868328
Message Requests rejected : 38
Probability(reject of buffer) : 0.00003800
Total delay time : 186.973622
Total buffer full time : 0.008436
Buffer full time % : 0.00000844

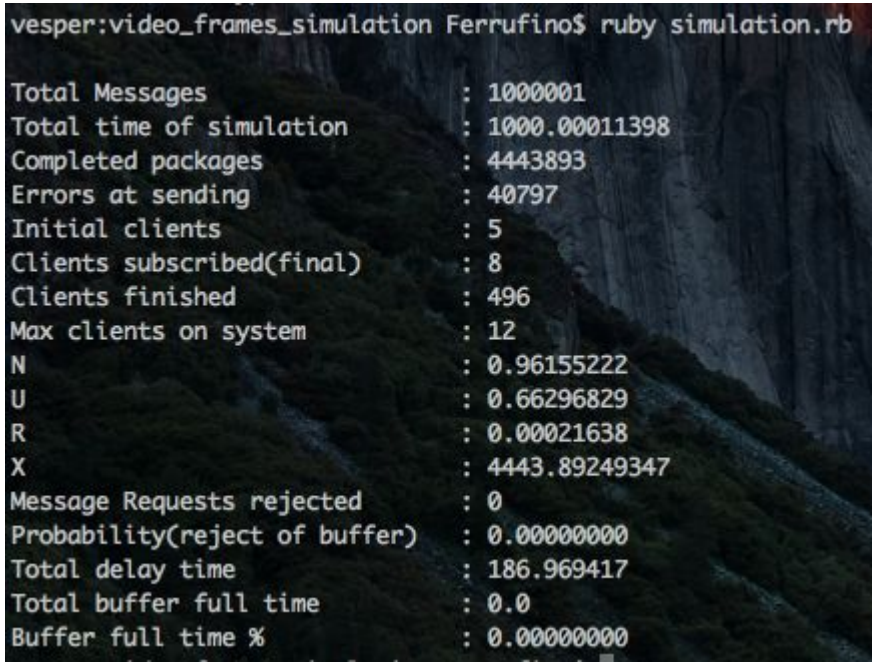
n=250 & k=15

```
vesper:video_frames_simulation Ferrufino$ ruby simulation.rb

Total Messages                  : 1000006
Total time of simulation        : 1000.00017998
Completed packages              : 4356286
Errors at sending               : 129537
Initial clients                 : 15
Clients subscribed(final)       : 29
Clients finished                : 485
Max clients on system           : 40
N                               : 1.28209622
U                               : 0.66334787
R                               : 0.00029431
X                               : 4356.28521594
Message Requests rejected       : 86
Probability(reject of buffer)   : 0.00008600
Total delay time                : 186.982371
Total buffer full time          : 0.019092
Buffer full time %              : 0.00001909
```

n=250 & k=20


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000009
Total time of simulation : 1000.00004598
Completed packages : 4311417
Errors at sending : 173660
Initial clients : 20
Clients subscribed(final) : 39
Clients finished : 480
Max clients on system : 53
N : 1.51945456
U : 0.66332598
R : 0.00035243
X : 4311.41680175
Message Requests rejected : 133
Probability(reject of buffer) : 0.00013300
Total delay time : 186.984553
Total buffer full time : 0.029526
Buffer full time % : 0.00002953

n=500 & k=5


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000001
Total time of simulation : 1000.00011398
Completed packages : 4443893
Errors at sending : 40797
Initial clients : 5
Clients subscribed(final) : 8
Clients finished : 496
Max clients on system : 12
N : 0.96155222
U : 0.66296829
R : 0.00021638
X : 4443.89249347
Message Requests rejected : 0
Probability(reject of buffer) : 0.00000000
Total delay time : 186.969417
Total buffer full time : 0.0
Buffer full time % : 0.00000000

n=500 & k=10

```
vesper:video_frames_simulation Ferrufino$ ruby simulation.rb

Total Messages                  : 1000001
Total time of simulation        : 1000.00020998
Completed packages              : 4398909
Errors at sending               : 84485
Initial clients                 : 10
Clients subscribed(final)       : 18
Clients finished                : 491
Max clients on system           : 26
N                               : 1.24271362
U                               : 0.66342666
R                               : 0.00028251
X                               : 4398.9080763
Message Requests rejected       : 0
Probability(reject of buffer)   : 0.00000000
Total delay time                : 186.979951
Total buffer full time          : 0.0
Buffer full time %              : 0.00000000
```

n=500 & k=15


vesper:video_frames_simulation Ferrufino$ ruby simulation.rb
Total Messages : 1000003
Total time of simulation : 1000.00008998
Completed packages : 4355356
Errors at sending : 129549
Initial clients : 15
Clients subscribed(final) : 29
Clients finished : 485
Max clients on system : 39
N : 1.6863036
U : 0.66350621
R : 0.00038718
X : 4355.35560809
Message Requests rejected : 26
Probability(reject of buffer) : 0.00002600
Total delay time : 186.991263
Total buffer full time : 0.005772
Buffer full time % : 0.00000577

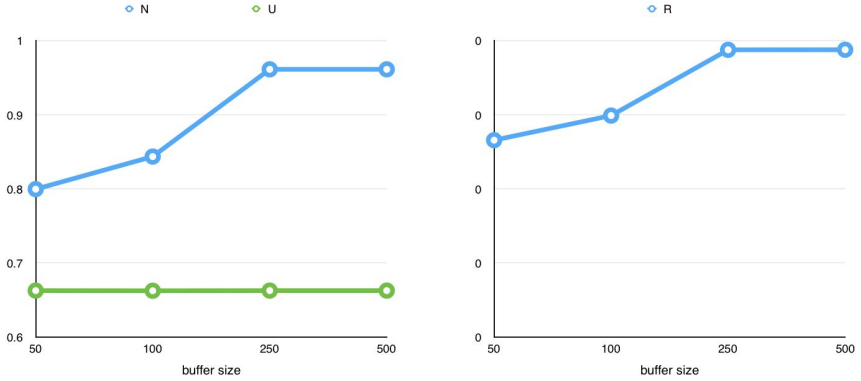
n=500 & k=20

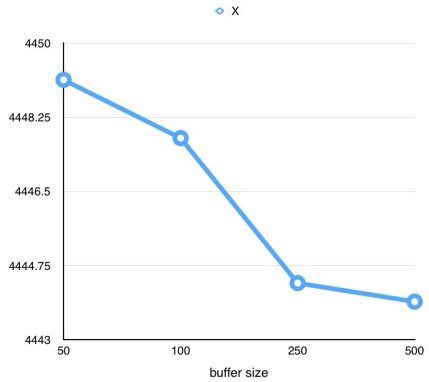
```
vesper:video_frames_simulation Ferrufino$ ruby simulation.rb

Total Messages                  : 1000005
Total time of simulation        : 1000.00011798
Completed packages              : 4310880
Errors at sending               : 173802
Initial clients                 : 20
Clients subscribed(final)       : 39
Clients finished                : 480
Max clients on system           : 53
N                               : 2.02148465
U                               : 0.66333304
R                               : 0.00046893
X                               : 4310.87949139
Message Requests rejected       : 74
Probability(reject of buffer)   : 0.00007400
Total delay time                : 186.994692
Total buffer full time          : 0.016428
Buffer full time %              : 0.00001643
```

Graphs for NURX depending on the value of k

These graphs were made using the values from the results of the previous slides.

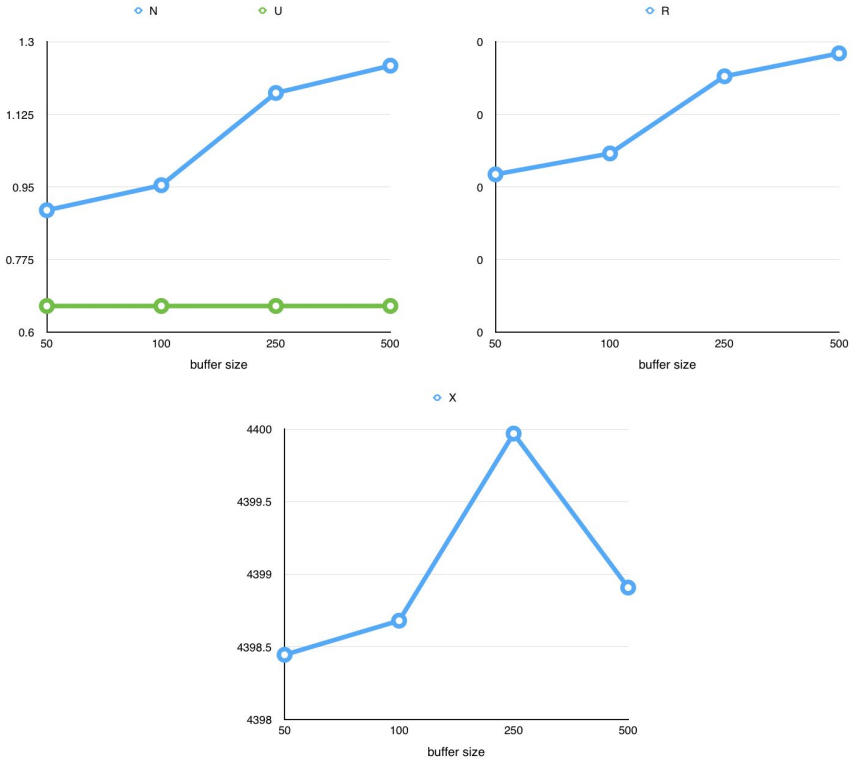
Graph for k = 5





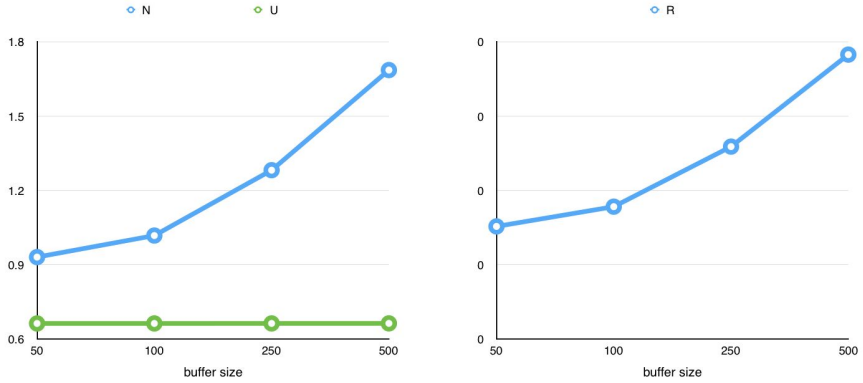
These graphs show how the buffer size doesn’t affect the utilization, but it increases, number of jobs on system and residence time, but reduces the throughput.

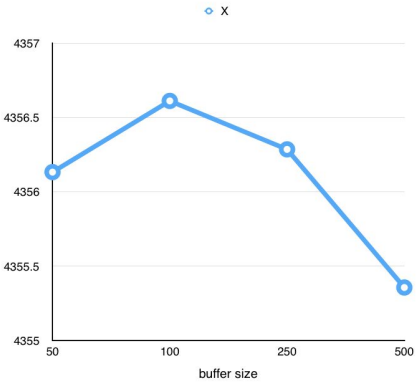
Graph for k = 10



When starting with 10 users, we see similar results, except that in this case the throughput actually increases, until the buffer size reaches its maximum size, where the throughput is reduced again.

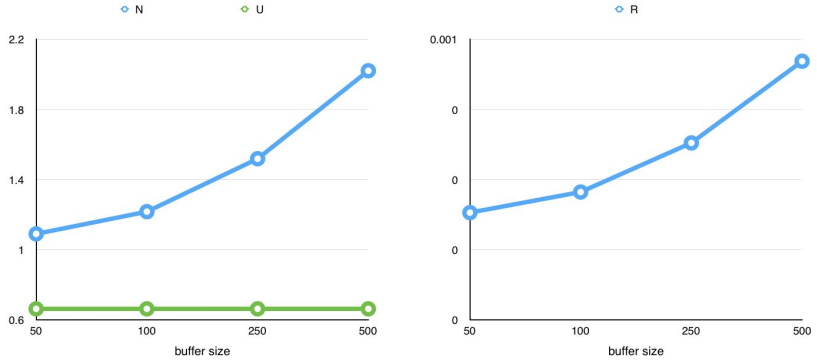
Graph for k = 15

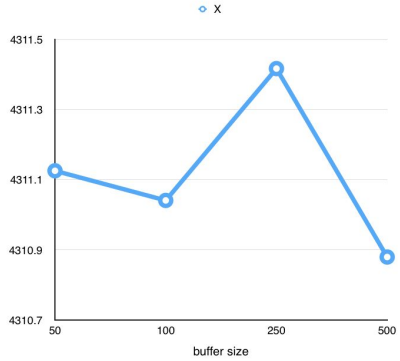




Similar to the last example, but in this case throughput is only increased the first time the buffer size is increased, after which the throughput is once again reduced.

Graph for k = 20





On this last example, we have a more unpredictable behaviour, where the throughput jumps up and down. Otherwise, N, U, and R behave in a similar manner as all other previous examples.