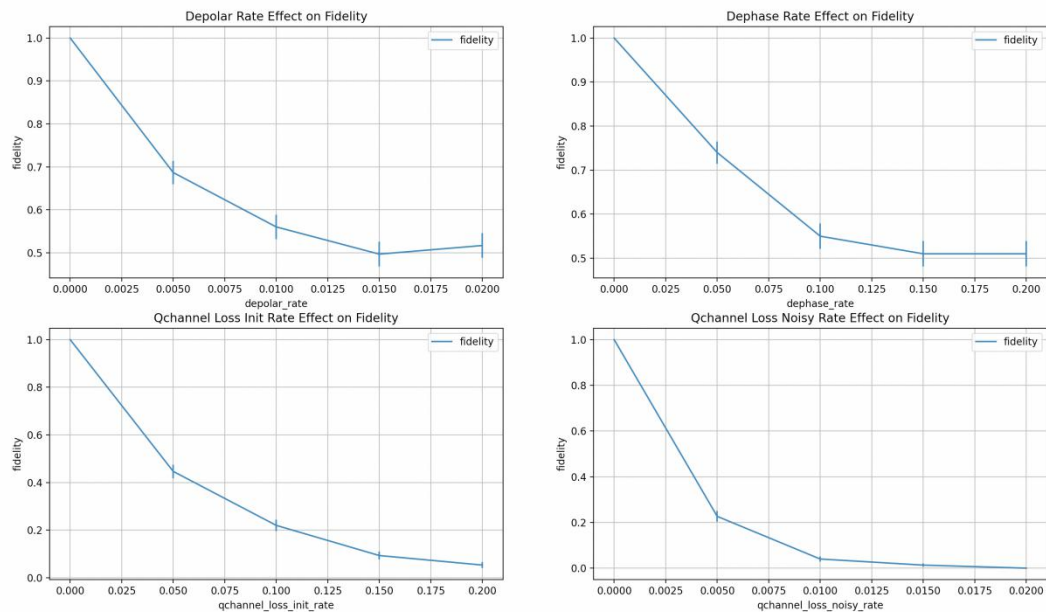# environmental_parameter_effect_test.py



```
depolar_rate fidelity
   depolar_rate  fidelity       sem
0        0.000  1.000000  0.000000
1        0.005  0.686667  0.026825
2        0.010  0.560000  0.028707
3        0.015  0.496667  0.028915
4        0.020  0.516667  0.028900
dephase_rate fidelity
   dephase_rate  fidelity       sem
0        0.00      1.00  0.000000
1        0.05      0.74  0.025367
2        0.10      0.55  0.028771
3        0.15      0.51  0.028910
4        0.20      0.51  0.028910
qchannel_loss_init_rate fidelity
   qchannel_loss_init_rate  fidelity       sem
0                     0.00  1.000000  0.000000
1                     0.05  0.446667  0.028751
2                     0.10  0.220000  0.023956
3                     0.15  0.093333  0.016823
4                     0.20  0.053333  0.012995
qchannel_loss_noisy_rate fidelity
   qchannel_loss_noisy_rate  fidelity       sem
0                     0.000  1.000000  0.000000
1                     0.005  0.226667  0.024213
2                     0.010  0.040000  0.011333
3                     0.015  0.013333  0.006633
4                     0.020  0.000000  0.000000
```

route_hops_effect_test.py

Route-Hops Effect on Fidelity with Enviromental-Parameter
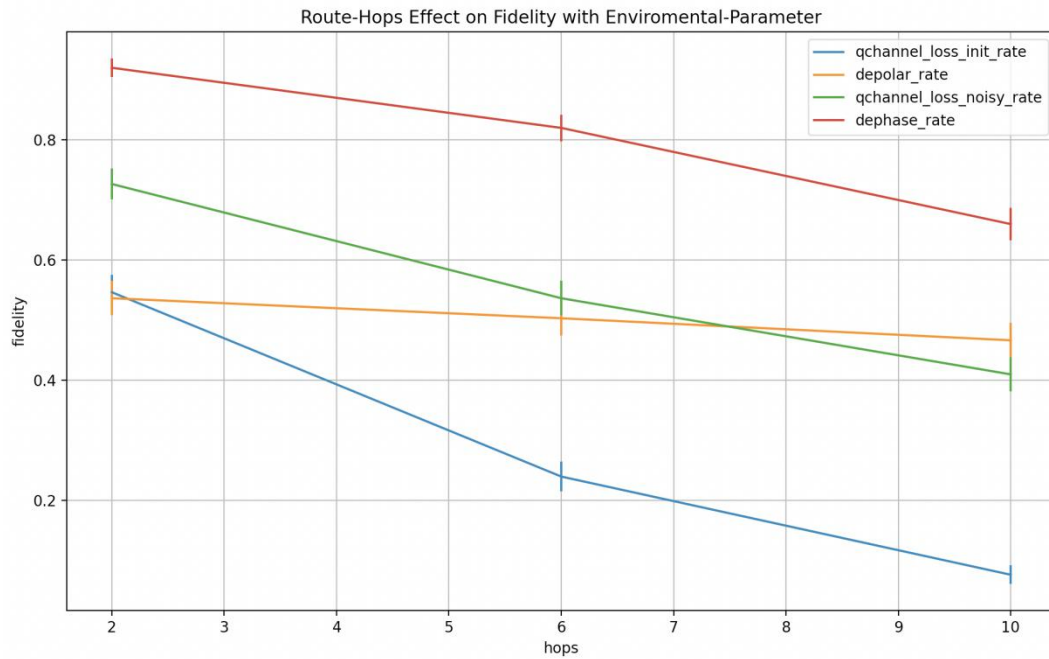
```
qchannel_loss_init_rate(fidelity)
   hops  fidelity       sem
0     2  0.546667  0.028790
1     6  0.240000  0.024699
2    10  0.076667  0.015387
depolar_rate(fidelity)
   hops  fidelity       sem
0     2  0.536667  0.028838
1     6  0.503333  0.028915
2    10  0.466667  0.028851
qchannel_loss_noisy_rate(fidelity)
   hops  fidelity       sem
0     2  0.726667  0.025774
1     6  0.536667  0.028838
2    10  0.410000  0.028443
dephase_rate(fidelity)
   hops  fidelity       sem
0     2      0.92  0.015689
1     6      0.82  0.022218
2    10      0.66  0.027395
```

path_with_different_environmental_parameter_effect_test.py
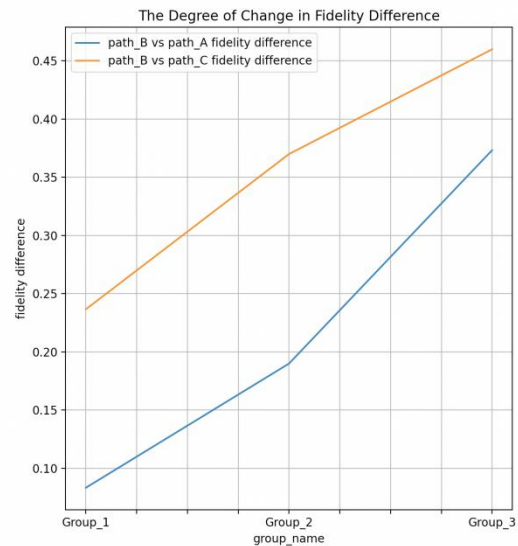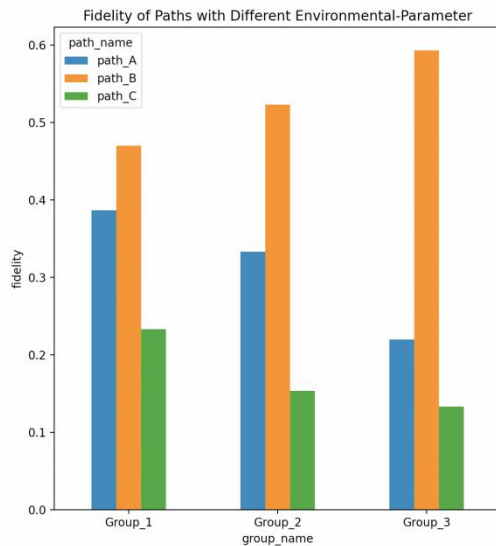

```
fidelity data
path_name      path_A      path_B      path_C
group_name
Group_1     0.386667   0.470000   0.233333
Group_2     0.333333   0.523333   0.153333
Group_3     0.220000   0.593333   0.133333

group_1_sem,path_A,path_B,path_C
0    0.028163
1    0.028864
2    0.024460
Name: sem, dtype: float64

group_2_sem,path_A,path_B,path_C
0    0.027262
1    0.028884
2    0.020837
Name: sem, dtype: float64

group_3_sem,path_A,path_B,path_C
0    0.023956
1    0.028408
2    0.019659
Name: sem, dtype: float64

fidelity_difference_data_path_B_vs_path_A
   group_name  fidelity_difference
0    Group_1             0.083333
1    Group_2             0.190000
2    Group_3             0.373333

fidelity_difference_data_path_B_vs_path_C
   group_name  fidelity_difference
0    Group_1             0.236667
1    Group_2             0.370000
2    Group_3             0.460000
```

entanglement_distribution_solution_test.py

Fidelity in Different Entanglement Distribution Solutions
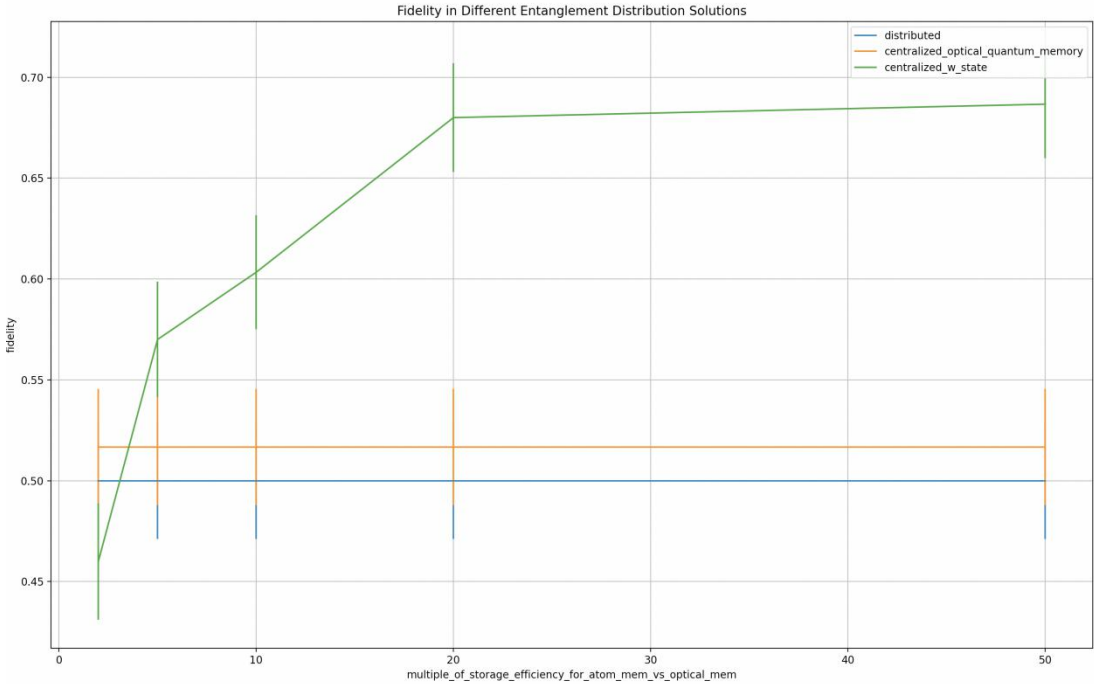
```
    multiple_of_storage_efficiency_for_atom_mem_vs_optical_mem  fidelity       sem
0                                                    2               0.5  0.028916
1                                                    5               0.5  0.028916
2                                                   10               0.5  0.028916
3                                                   20               0.5  0.028916
4                                                   50               0.5  0.028916
    multiple_of_storage_efficiency_for_atom_mem_vs_optical_mem  fidelity       sem
0                                                    2          0.516667    0.0289
1                                                    5          0.516667    0.0289
2                                                   10          0.516667    0.0289
3                                                   20          0.516667    0.0289
4                                                   50          0.516667    0.0289
    multiple_of_storage_efficiency_for_atom_mem_vs_optical_mem  fidelity       sem
0                                                    2          0.460000  0.028823
1                                                    5          0.570000  0.028631
2                                                   10          0.603333  0.028291
3                                                   20          0.680000  0.026977
4                                                   50          0.686667  0.026825
```

routing_algorithm_comparison_equivalent_parameter_network.py
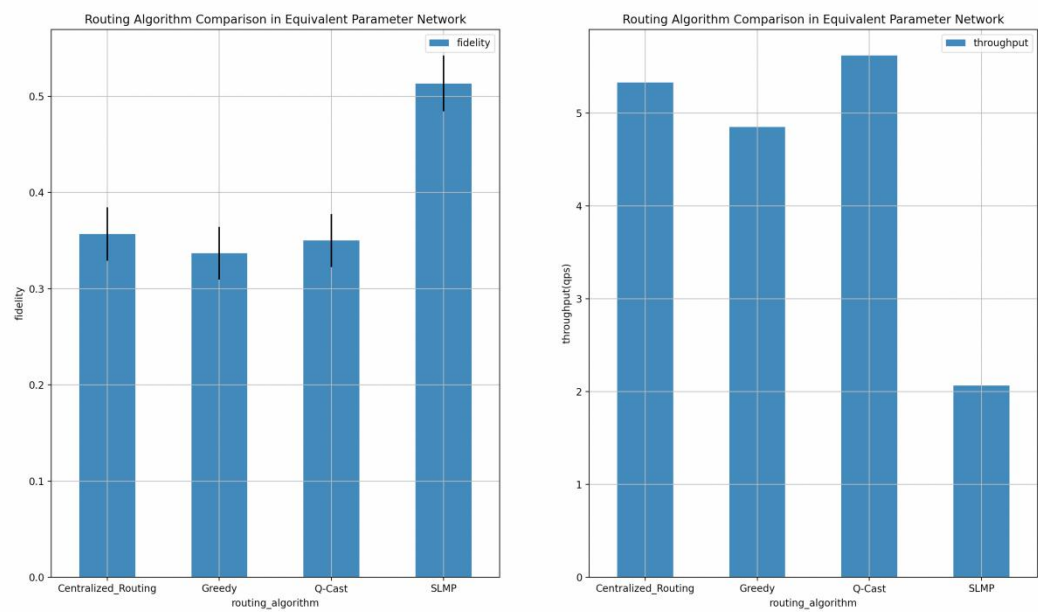

```
###### Complete Teleportation Process######
#### Complete to teleport target qubit ####
     routing_algorithm  fidelity        sem
0  Centralized_Routing  0.356667  0.027702
1               Greedy  0.336667  0.027329
2               Q-Cast  0.350000  0.027584
3                 SLMP  0.513333  0.028905
     routing_algorithm  entanglement_pair_consumption
0  Centralized_Routing                       5.000000
1               Greedy                       5.000000
2               Q-Cast                       5.076667
3                 SLMP                      33.000000
     routing_algorithm  throughput
0  Centralized_Routing    5.332356
1               Greedy    4.851366
2               Q-Cast    5.621357
3                 SLMP    2.065394
```

routing_algorithm_comparison_diversified_paramet er_network_dephase.py
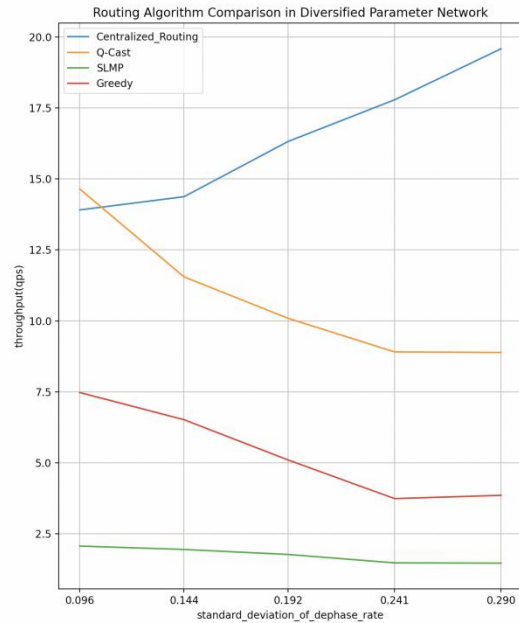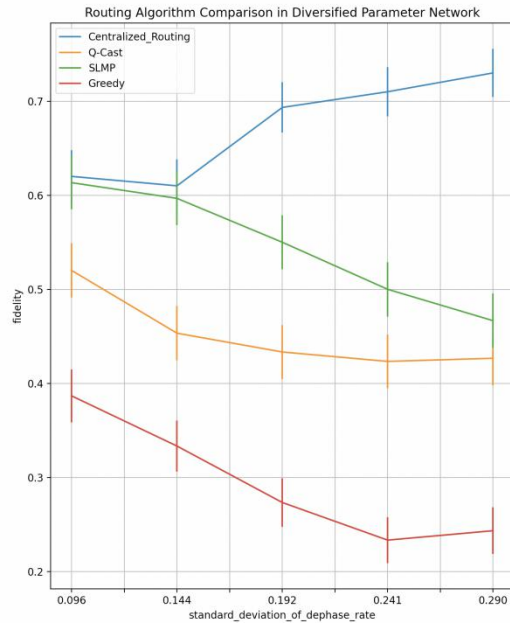

```
     standard_deviation_of_dephase_rate  fidelity       sem
0                                 0.096  0.620000  0.028071
1                                 0.144  0.610000  0.028207
2                                 0.192  0.693333  0.026667
3                                 0.241  0.710000  0.026242
4                                 0.290  0.730000  0.025675
     standard_deviation_of_dephase_rate  fidelity       sem
0                                 0.096  0.520000  0.028893
1                                 0.144  0.453333  0.028790
2                                 0.192  0.433333  0.028658
3                                 0.241  0.423333  0.028574
4                                 0.290  0.426667  0.028603
     standard_deviation_of_dephase_rate  fidelity       sem
0                                 0.096  0.613333  0.028163
1                                 0.144  0.596667  0.028370
2                                 0.192  0.550000  0.028771
3                                 0.241  0.500000  0.028916
4                                 0.290  0.466667  0.028851
     standard_deviation_of_dephase_rate  fidelity       sem
0                                 0.096  0.386667  0.028163
1                                 0.144  0.333333  0.027262
2                                 0.192  0.273333  0.025774
3                                 0.241  0.233333  0.024460
4                                 0.290  0.243333  0.024815
     standard_deviation_of_dephase_rate  entanglement_pair_consumption
0                                 0.096                            6.0
1                                 0.144                            6.0
2                                 0.192                            6.0
3                                 0.241                            6.0
4                                 0.290                            6.0
     standard_deviation_of_dephase_rate  entanglement_pair_consumption
0                                 0.096                       5.030000
1                                 0.144                       5.056667
2                                 0.192                       5.030000
3                                 0.241                       5.033333
4                                 0.290                       5.036667
     standard_deviation_of_dephase_rate  entanglement_pair_consumption
0                                 0.096                           33.0
1                                 0.144                           33.0
2                                 0.192                           33.0
3                                 0.241                           33.0
4                                 0.290                           33.0
     standard_deviation_of_dephase_rate  entanglement_pair_consumption
0                                 0.096                            5.0
1                                 0.144                            5.0
2                                 0.192                            5.0
3                                 0.241                            5.0
4                                 0.290                            5.0
```

```
     standard_deviation_of_dephase_rate  throughput
0                                 0.096   13.906511
1                                 0.144   14.371614
2                                 0.192   16.318798
3                                 0.241   17.784659
4                                 0.290   19.580231
     standard_deviation_of_dephase_rate  throughput
0                                 0.096   14.646480
1                                 0.144   11.550459
2                                 0.192   10.089395
3                                 0.241    8.907182
4                                 0.290    8.887015
     standard_deviation_of_dephase_rate  throughput
0                                 0.096    2.071390
1                                 0.144    1.952029
2                                 0.192    1.775634
3                                 0.241    1.479225
4                                 0.290    1.470419
     standard_deviation_of_dephase_rate  throughput
0                                 0.096    7.477342
1                                 0.144    6.521250
2                                 0.192    5.101319
3                                 0.241    3.741859
4                                 0.290    3.858137
```
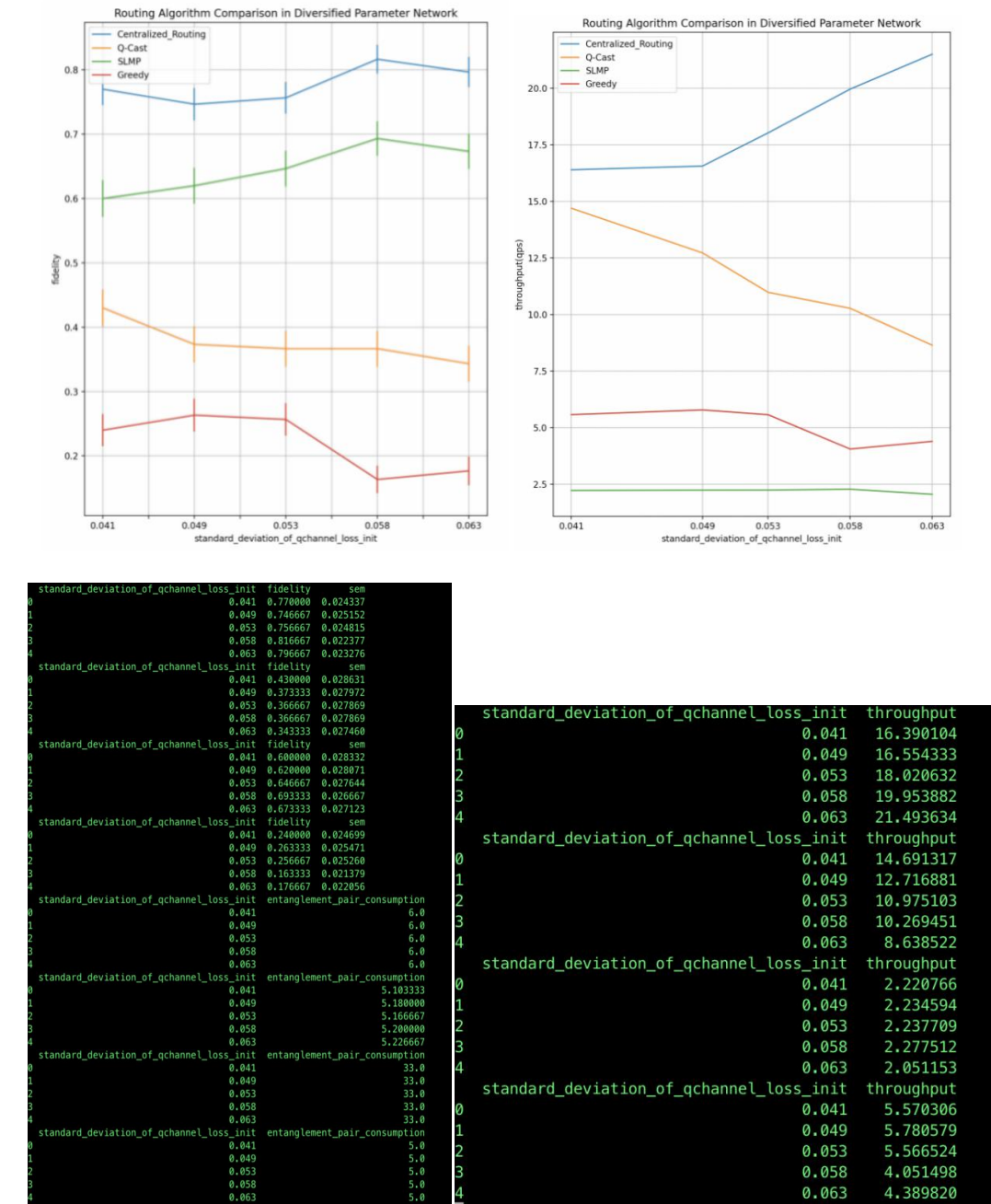
```
Centralized_Routing Time Cost:
0.0037106513977050778
Q-Cast Time Cost:
0.0009645462036132812
SLMP Time Cost:
0.13884557762146
Greedy Time Cost:
0.0001452445983886718
```
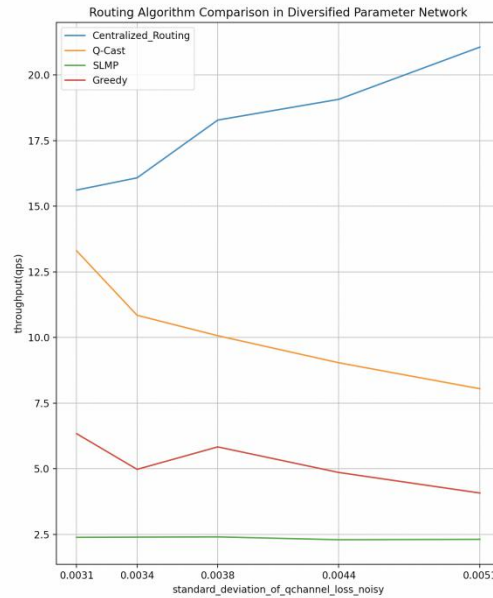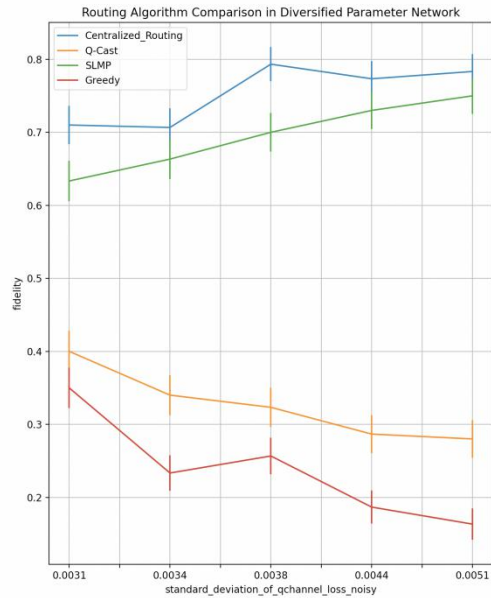
routing_algorithm_comparison_diversified_paramet er_network_loss_init.py

standard_deviation_of_qchannel_loss_init	fidelity	sem
0	0.041	0.770000	0.024337
1	0.049	0.746667	0.025152
2	0.053	0.756667	0.024815
3	0.058	0.816667	0.022377
4	0.063	0.796667	0.023276

standard_deviation_of_qchannel_loss_init	fidelity	sem
0	0.041	0.430000	0.028631
1	0.049	0.373333	0.027972
2	0.053	0.366667	0.027869
3	0.058	0.366667	0.027869
4	0.063	0.343333	0.027460

standard_deviation_of_qchannel_loss_init	fidelity	sem
0	0.041	0.600000	0.028332
1	0.049	0.620000	0.028071
2	0.053	0.646667	0.027644
3	0.058	0.693333	0.026667
4	0.063	0.673333	0.027123

standard_deviation_of_qchannel_loss_init	fidelity	sem
0	0.041	0.240000	0.024699
1	0.049	0.263333	0.025471
2	0.053	0.256667	0.025260
3	0.058	0.163333	0.021379
4	0.063	0.176667	0.022056

standard_deviation_of_qchannel_loss_init	entanglement_pair_consumption
0	0.041	6.0
1	0.049	6.0
2	0.053	6.0
3	0.058	6.0
4	0.063	6.0

standard_deviation_of_qchannel_loss_init	entanglement_pair_consumption
0	0.041	5.103333
1	0.049	5.180000
2	0.053	5.166667
3	0.058	5.200000
4	0.063	5.226667

standard_deviation_of_qchannel_loss_init	entanglement_pair_consumption
0	0.041	33.0
1	0.049	33.0
2	0.053	33.0
3	0.058	33.0
4	0.063	33.0

standard_deviation_of_qchannel_loss_init	entanglement_pair_consumption
0	0.041	5.0
1	0.049	5.0
2	0.053	5.0
3	0.058	5.0
4	0.063	5.0

standard_deviation_of_qchannel_loss_init	throughput
0	0.041	16.390104
1	0.049	16.554333
2	0.053	18.020632
3	0.058	19.953882
4	0.063	21.493634

standard_deviation_of_qchannel_loss_init	throughput
0	0.041	14.691317
1	0.049	12.716881
2	0.053	10.975103
3	0.058	10.269451
4	0.063	8.638522

standard_deviation_of_qchannel_loss_init	throughput
0	0.041	2.220766
1	0.049	2.234594
2	0.053	2.237709
3	0.058	2.277512
4	0.063	2.051153

standard_deviation_of_qchannel_loss_init	throughput
0	0.041	5.570306
1	0.049	5.780579
2	0.053	5.566524
3	0.058	4.051498
4	0.063	4.389820

```
Centralized_Routing Time Cost:
0.0040203571319580075
Q-Cast Time Cost:
0.0009561061859130859
SLMP Time Cost:
0.13164684534072876
Greedy Time Cost:
0.0001415252685546875
```

routing_algorithm_comparison_diversified_paramet er_network_loss_noisy.py

```
standard_deviation_of_qchannel_loss_noisy  fidelity       sem
0                               0.0031  0.710000  0.026242
1                               0.0034  0.706667  0.026330
2                               0.0038  0.793333  0.023417
3                               0.0044  0.773333  0.024213
4                               0.0051  0.783333  0.023825
standard_deviation_of_qchannel_loss_noisy  fidelity       sem
0                               0.0031  0.400000  0.028332
1                               0.0034  0.340000  0.027395
2                               0.0038  0.323333  0.027051
3                               0.0044  0.286667  0.026152
4                               0.0051  0.280000  0.025966
standard_deviation_of_qchannel_loss_noisy  fidelity       sem
0                               0.0031  0.633333  0.027869
1                               0.0034  0.663333  0.027329
2                               0.0038  0.700000  0.026502
3                               0.0044  0.730000  0.025675
4                               0.0051  0.750000  0.025042
standard_deviation_of_qchannel_loss_noisy  fidelity       sem
0                               0.0031  0.350000  0.027584
1                               0.0034  0.233333  0.024460
2                               0.0038  0.256667  0.025260
3                               0.0044  0.186667  0.022534
4                               0.0051  0.163333  0.021379
standard_deviation_of_qchannel_loss_noisy  entanglement_pair_consumption
0                               0.0031                            6.0
1                               0.0034                            6.0
2                               0.0038                            6.0
3                               0.0044                            6.0
4                               0.0051                            6.0
standard_deviation_of_qchannel_loss_noisy  entanglement_pair_consumption
0                               0.0031                       5.063333
1                               0.0034                       5.136667
2                               0.0038                       5.216667
3                               0.0044                       5.273333
4                               0.0051                       5.290000
standard_deviation_of_qchannel_loss_noisy  entanglement_pair_consumption
0                               0.0031                           33.0
1                               0.0034                           33.0
2                               0.0038                           33.0
3                               0.0044                           33.0
4                               0.0051                           33.0
standard_deviation_of_qchannel_loss_noisy  entanglement_pair_consumption
0                               0.0031                            5.0
1                               0.0034                            5.0
2                               0.0038                            5.0
3                               0.0044                            5.0
4                               0.0051                            5.0
standard_deviation_of_qchannel_loss_noisy  throughput
0                               0.0031  15.617347
1                               0.0034  16.083621
2                               0.0038  18.284055
3                               0.0044  19.074036
4                               0.0051  21.064401
standard_deviation_of_qchannel_loss_noisy  throughput
0                               0.0031  13.305993
1                               0.0034  10.848833
2                               0.0038  10.069599
3                               0.0044   9.039730
4                               0.0051   8.049529
standard_deviation_of_qchannel_loss_noisy  throughput
0                               0.0031   2.389133
1                               0.0034   2.397641
2                               0.0038   2.406712
3                               0.0044   2.298262
4                               0.0051   2.313359
standard_deviation_of_qchannel_loss_noisy  throughput
0                               0.0031   6.339000
1                               0.0034   4.979334
2                               0.0038   5.834878
3                               0.0044   4.860543
4                               0.0051   4.077622
```

```
Centralized_Routing Time Cost:
0.0036687850952148438
Q-Cast Time Cost:
0.0009767532348632813
SLMP Time Cost:
0.1324252529144287
Greedy Time Cost:
0.00014963150024414063
```

3d_heat_map_centralized_routing.py

because the data only allow to groupby one dimension, manually combine qchannel_loss_noisy and dephase_rates , run 25 times experiment to get data

There is too much data for this experiment, so we only give the 3d heat map.
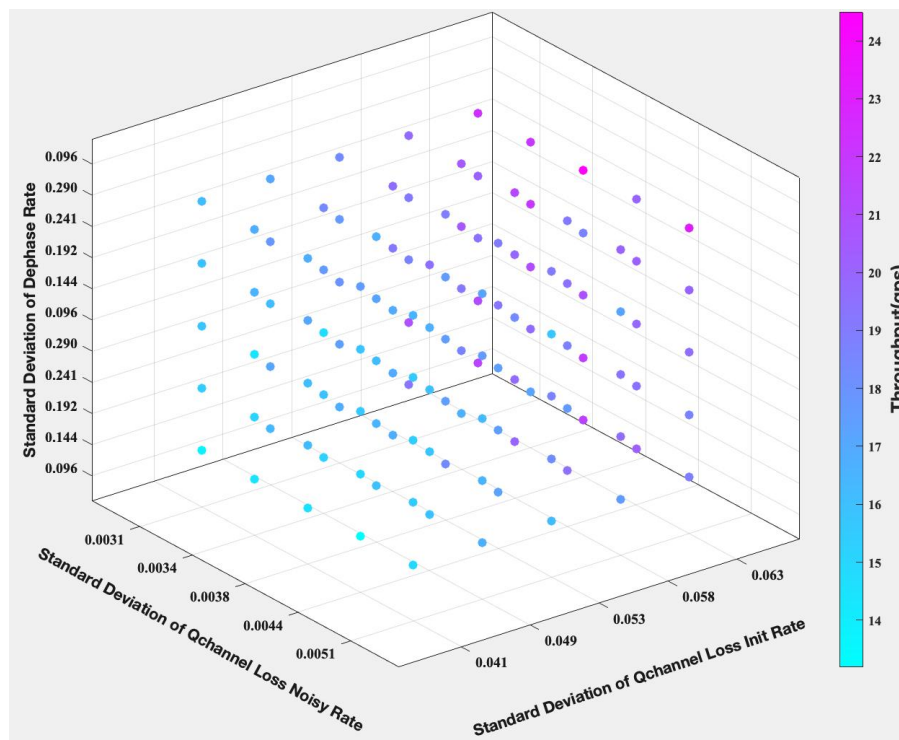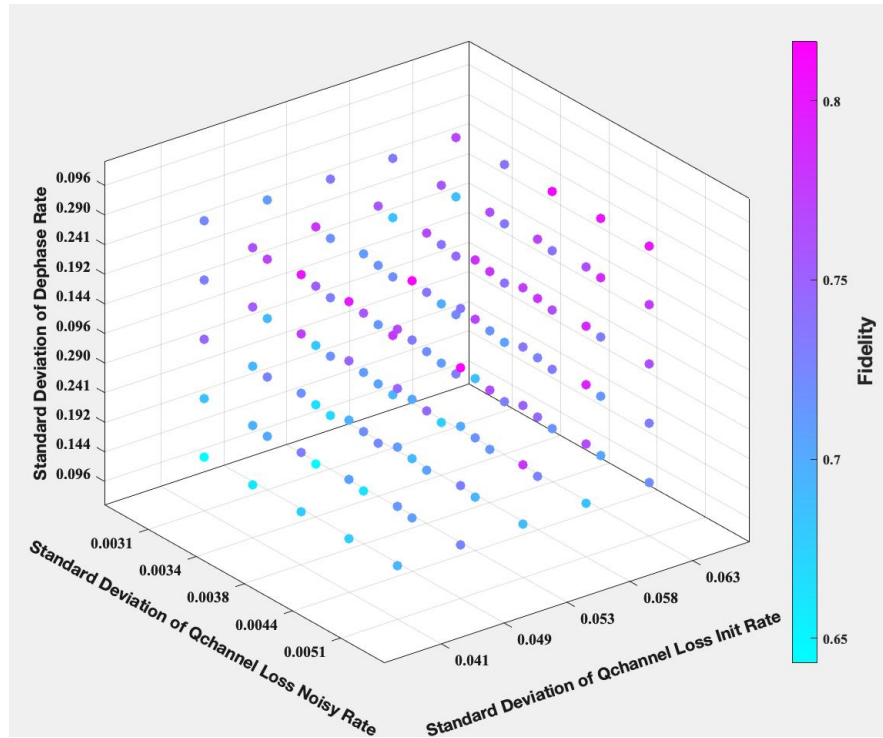
integrated_example.py

you can change the parameter here to obeserve the teleport result,depolar_rate(0~1),dephase_rate(0~1),qchannel_loss_init(0~1),qchannel_loss_noisy (0~n(No more than 0.2（noisy_limitation in this topo）is recommended),dB/km)

notice: this code set all devices parameter with same value, if you want different values in different devices ,you can define the arrays by yourself.

```
"""
there are some recommand values to check this programe:
#### if you want to see a success quantum communication example , please use the parameters:
    for i in range(29):
        depolar_rates.append(0)
    for i in range(29):
        dephase_rates.append(0)
    for i in range(32):
        qchannel_loss_init.append(0)
    for i in range(32):
        qchannel_loss_noisy.append(0)


    #### if you want to see a how the distribution failed due to the bad link_state , please use the parameters:
    for i in range(29):
        depolar_rates.append(0)
    for i in range(29):
        dephase_rates.append(0)
    for i in range(32):
        qchannel_loss_init.append(1)
    for i in range(32):
        qchannel_loss_noisy.append(0.2)


    #### if you want to see a how the swapping failed due to bad device parameter , please use the parameters:
    for i in range(29):
        depolar_rates.append(1)
    for i in range(29):
        dephase_rates.append(1)
    for i in range(32):
        qchannel_loss_init.append(0)
    for i in range(32):
        qchannel_loss_noisy.append(0)


    #### if you want to see a relative random result , please use the parameters:
    for i in range(29):
```

```
        depolar_rates.append(0.01)
    for i in range(29):
        dephase_rates.append(0.01)
    for i in range(32):
        qchannel_loss_init.append(0.01)
    for i in range(32):
        qchannel_loss_noisy.append(0.001)


    #### if you want to check how the routing algorithm(score evaluation) select the
optimal path(not have to be shortest path) due to the parameter, please define the arrays
with different values by yourself:
    such as :
    depolar_rates                                                              =
[0.004,0.005,0.001,0.002,0.009,0.008,0.009,0.003,0.001,0.008,0.006,0.001,0.008,0.006,
0.003,0.003,0.002,0.004,0.005,0.006,0.003,0.002,0.005,0.009,0.006,0.001,0.002,0.004,0.
006]
    dephase_rates                                                              =
[0.09,0.35,0.03,0.03,0.35,0.35,0.11,0.03,0.03,0.09,0.03,0.03,0.02,0.14,0.07,0.02,0.03,0.0
4,0.02,0.05,0.06,0.02,0.09,0.04,0.03,0.03,0.05,0.06,0.07]
    qchannel_loss_init                                                         =
[0.008,0.021,0.002,0.001,0.002,0.002,0.017,0.008,0.015,0.020,0.030,0.002,0.003,0.005,
0.002,0.024,0.004,0.006,0.008,0.007,0.002,0.047,0.010,0.053,0.003,0.002,0.008,0.002,0.
004,0.034,0.011,0.001]
    qchannel_loss_noisy                                                        =
[0.0006,0.0004,0.0004,0.0003,0.0002,0.0003,0.0015,0.0005,0.0003,0.0022,0.0033,0.000
1,0.0003,0.0003,0.0004,0.0026,0.0003,0.0004,0.0006,0.0004,0.0003,0.0046,0.0012,0.00
57,0.0002,0.0001,0.0006,0.0005,0.0003,0.0035,0.0014,0.0001]
    """
```