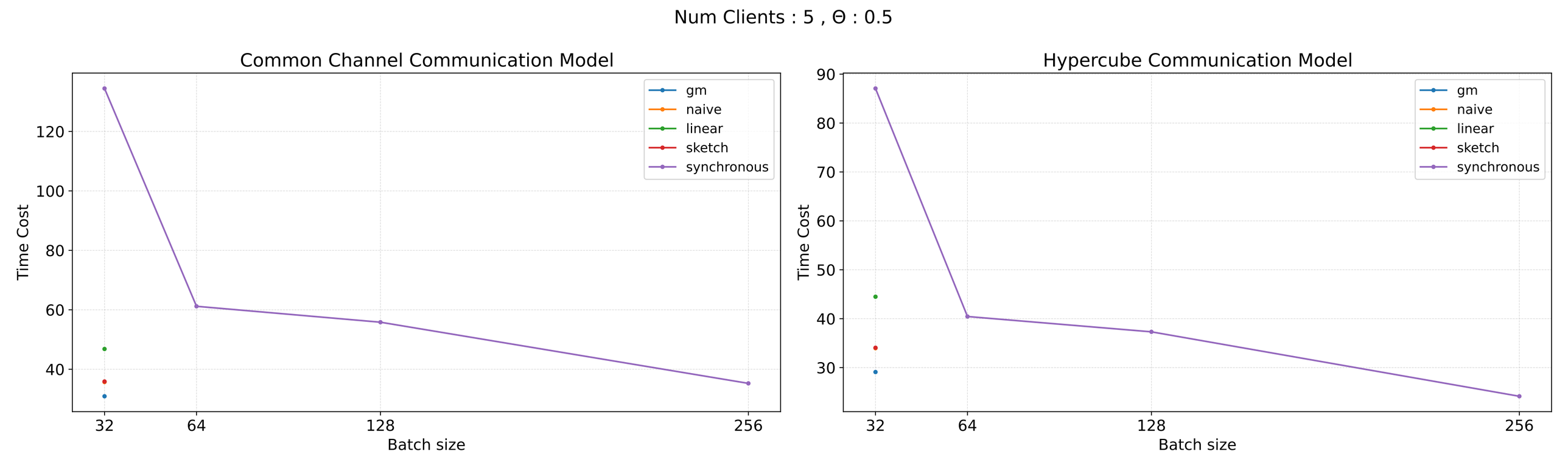
Num Clients : 5 , Θ : 0.5
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
120
100
80
60
40
90
70
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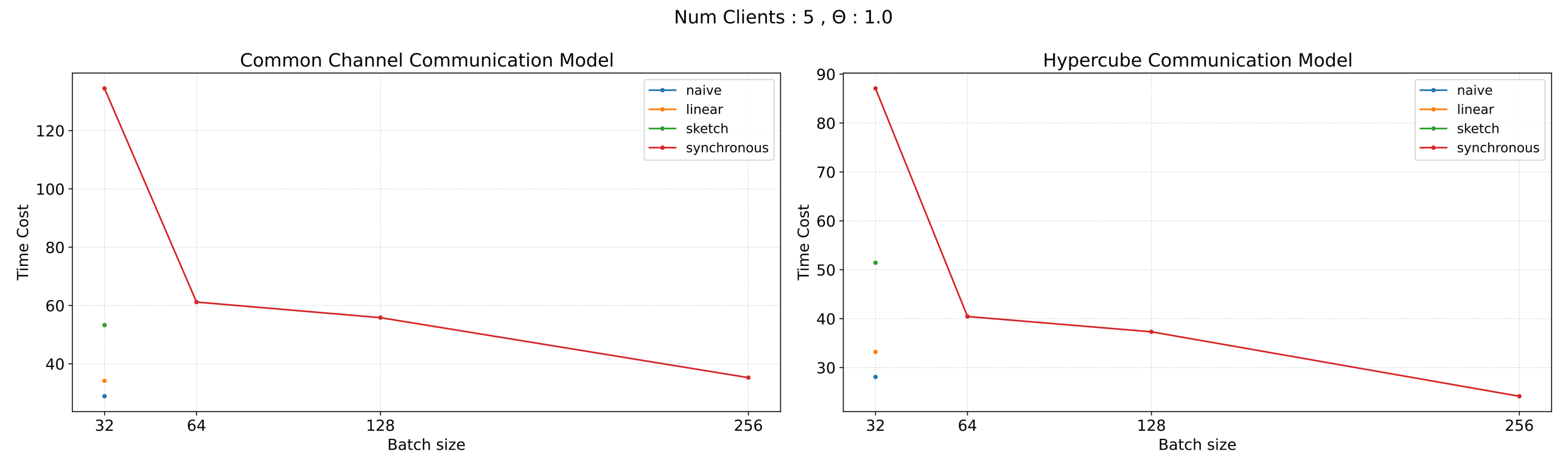
30
32
64
128
256


Num Clients : 5 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
naive
linear
sketch
synchronous
Time Cost
Batch size
120
100
80
60
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90
70
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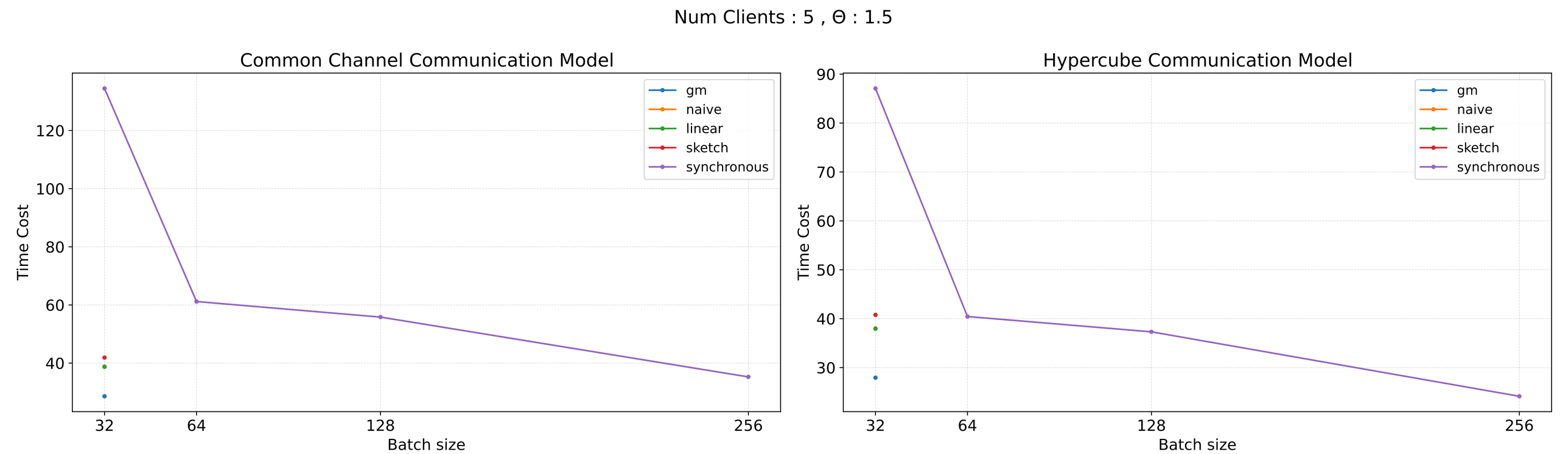
128
256


Num Clients : 5 , Θ : 1.5
Common Channel Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
120
100
80
60
40
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
90
80
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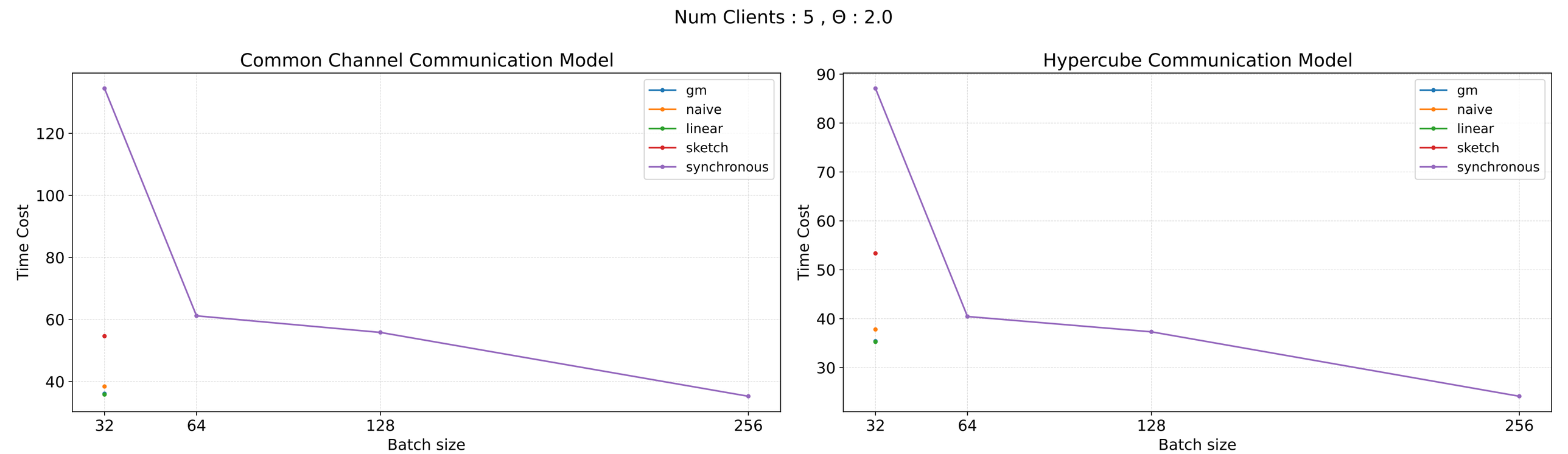
30
32
64
128
256


Num Clients : 5 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
120
100
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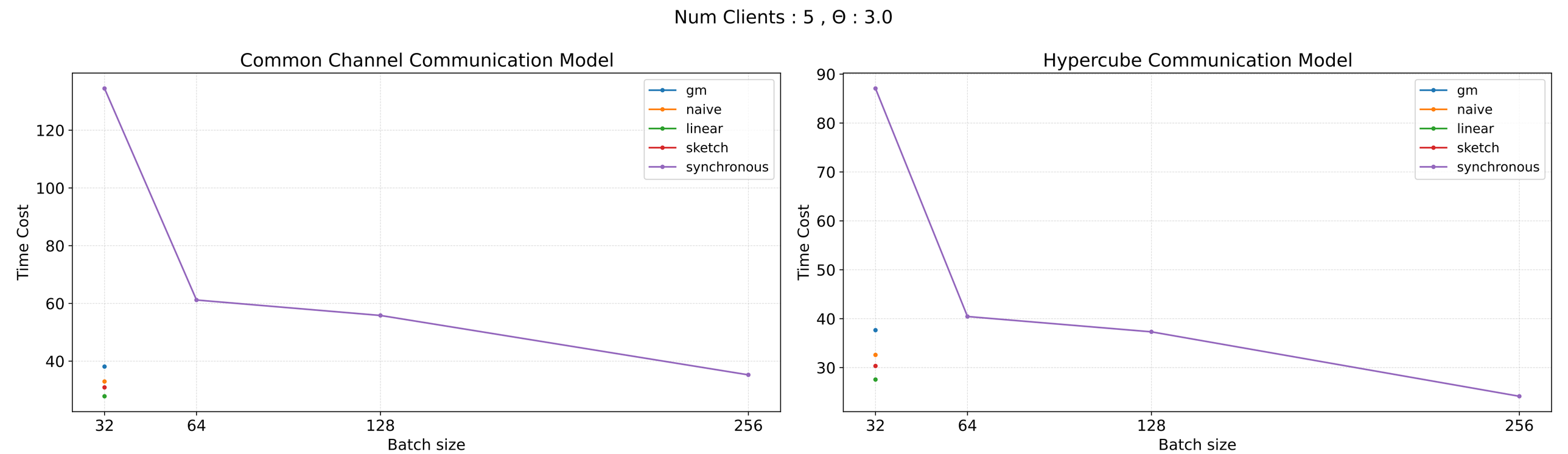
64
128
256


Num Clients : 5 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
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100
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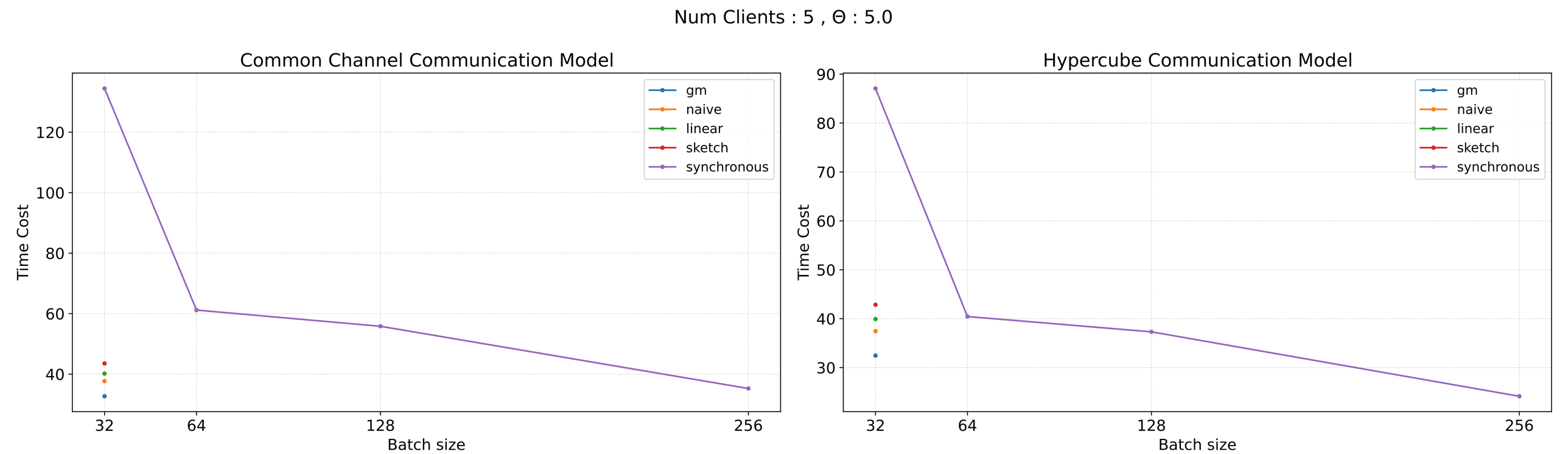
128
256


Num Clients : 5 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
120
100
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128
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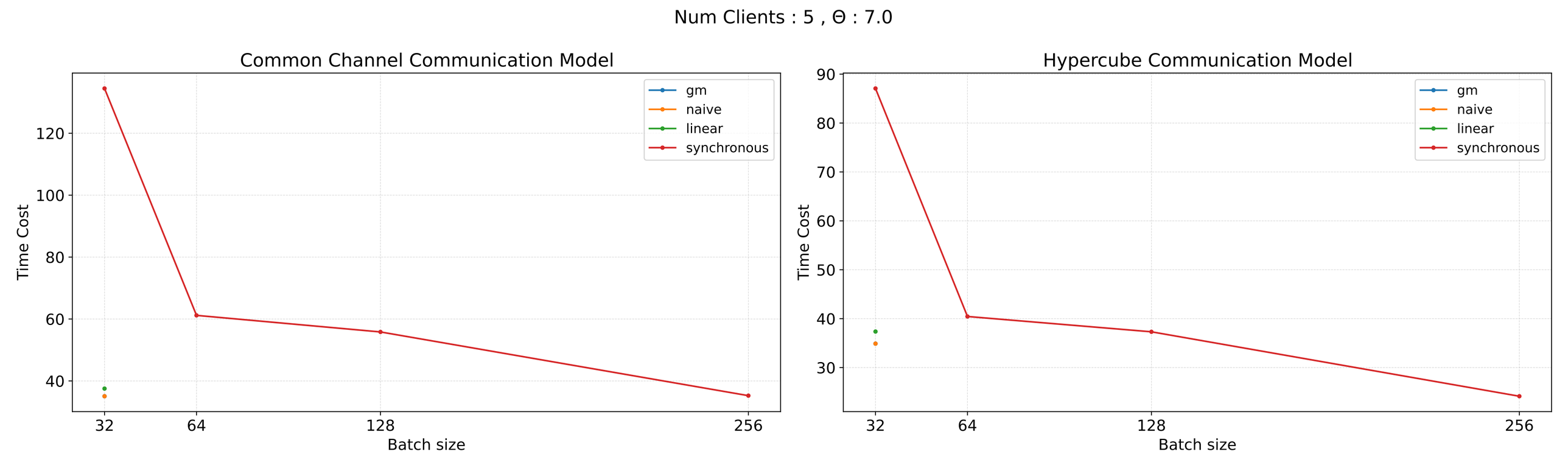
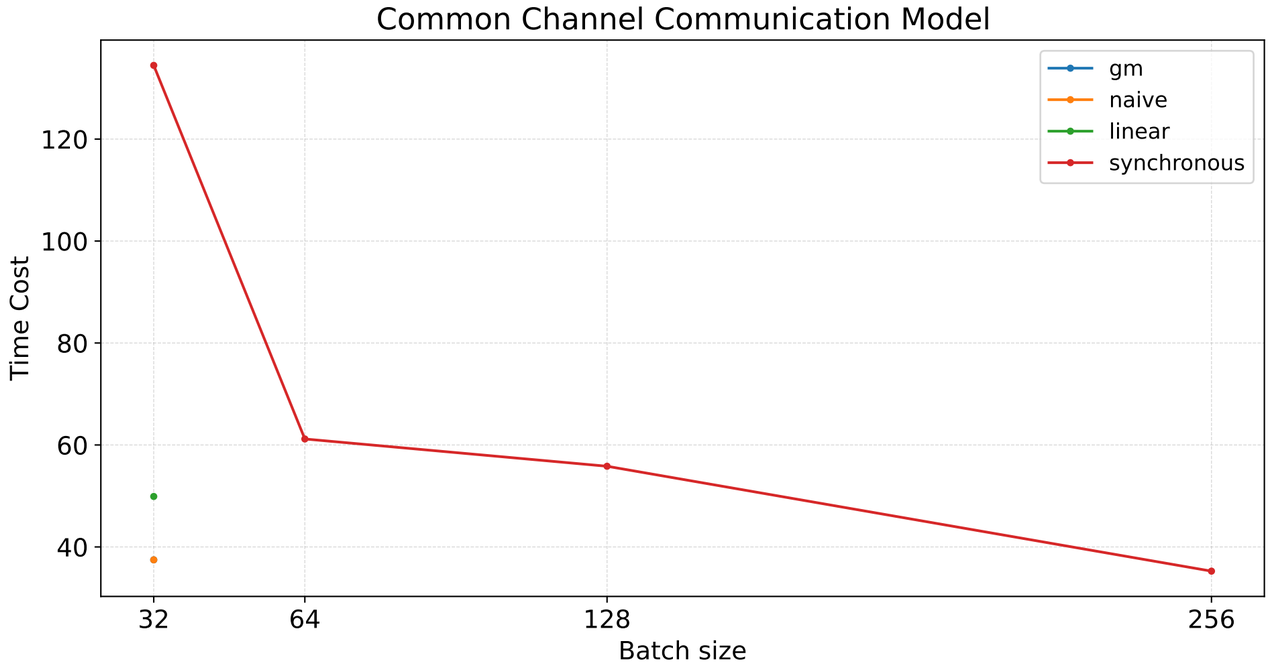
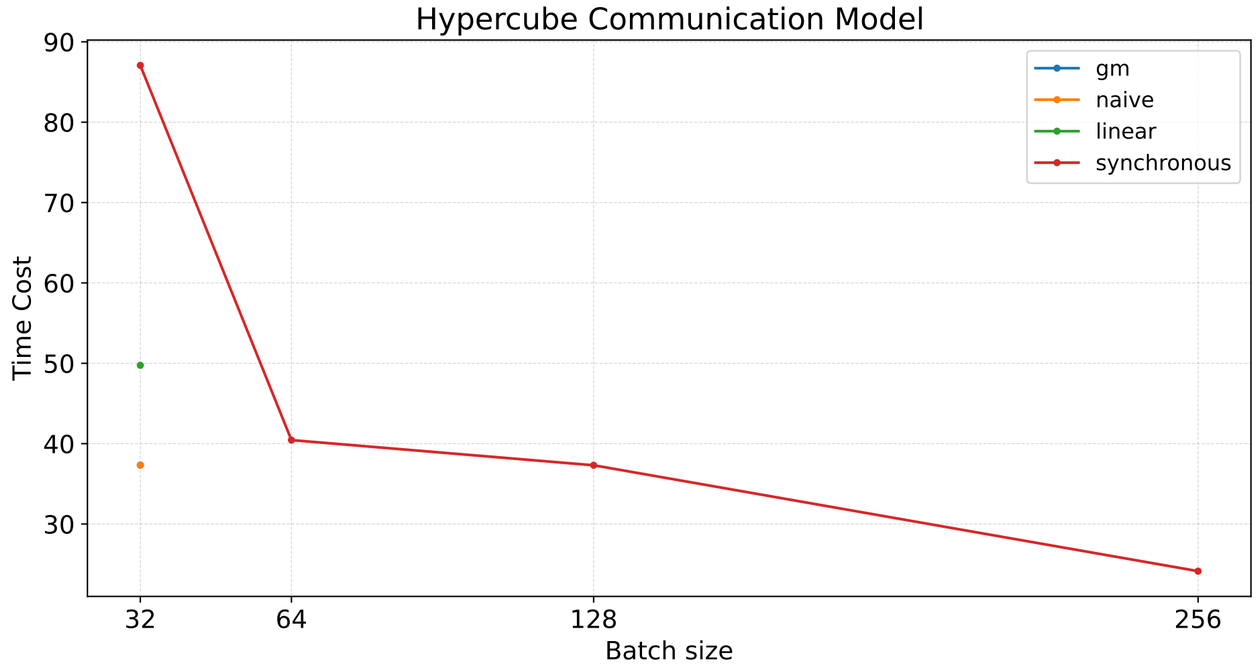
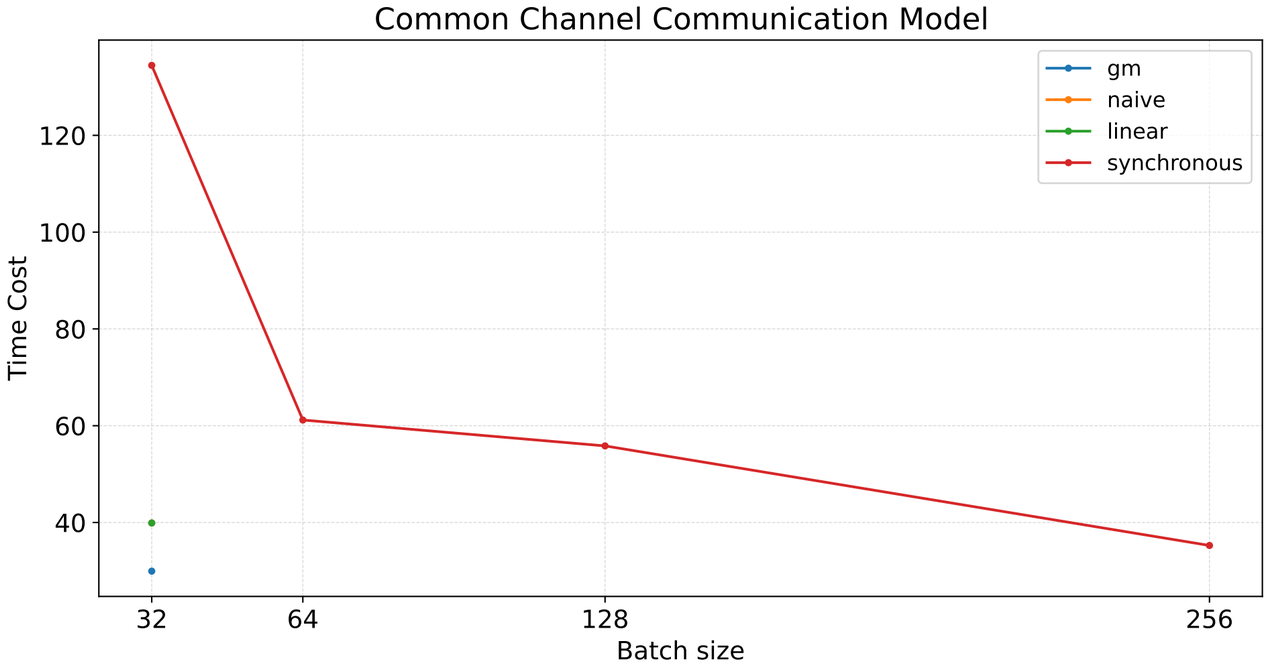

Num Clients : 5 , Θ : 7.0
Common Channel Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
120
100
80
60
40
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
90
80
70
60
50
40
30
32
64
128
256

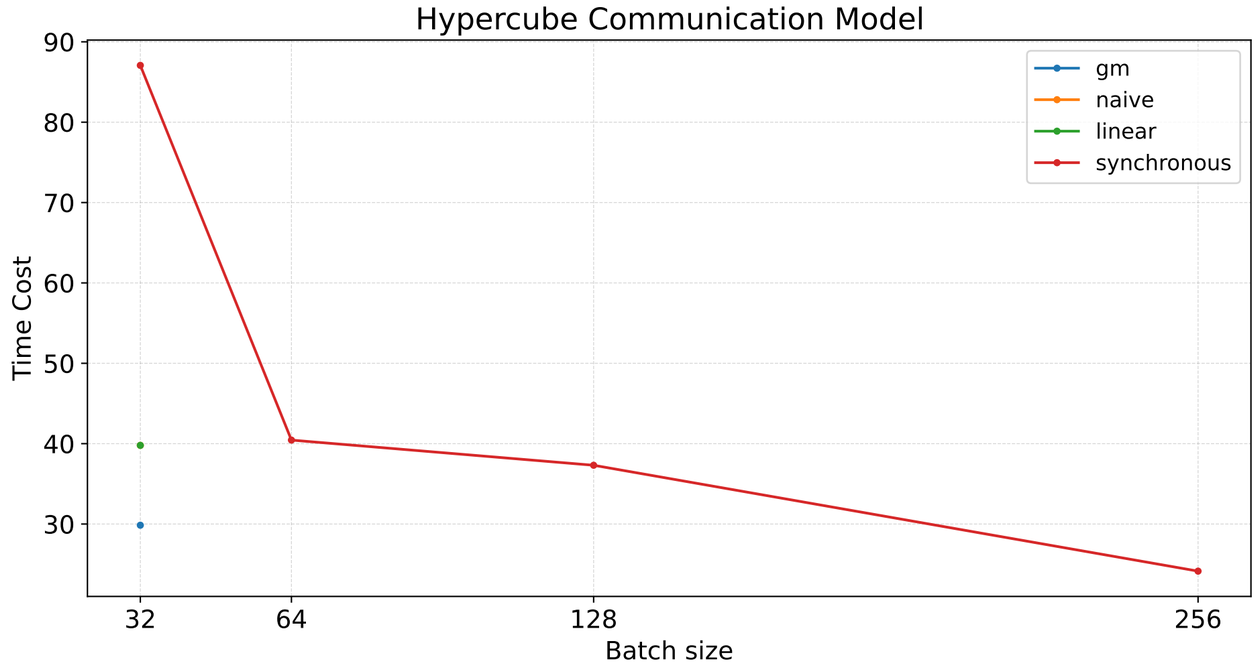
Num Clients : 5 , Θ : 10.0



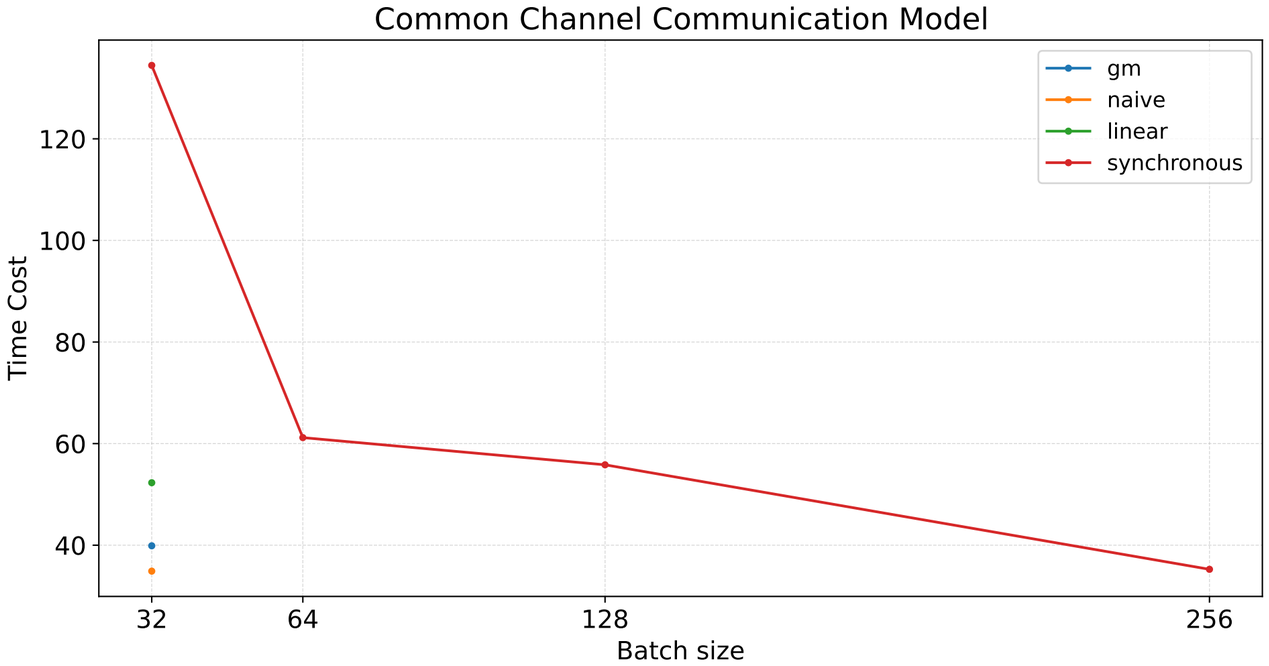


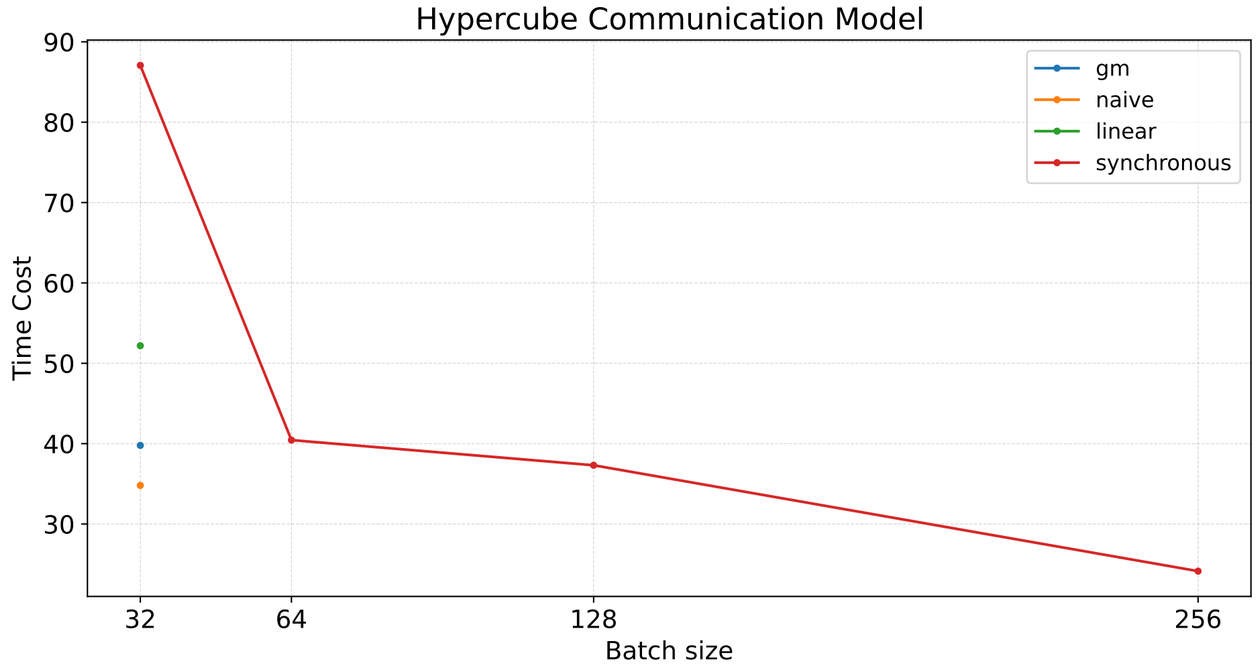
Num Clients : 5 , Θ : 12.0



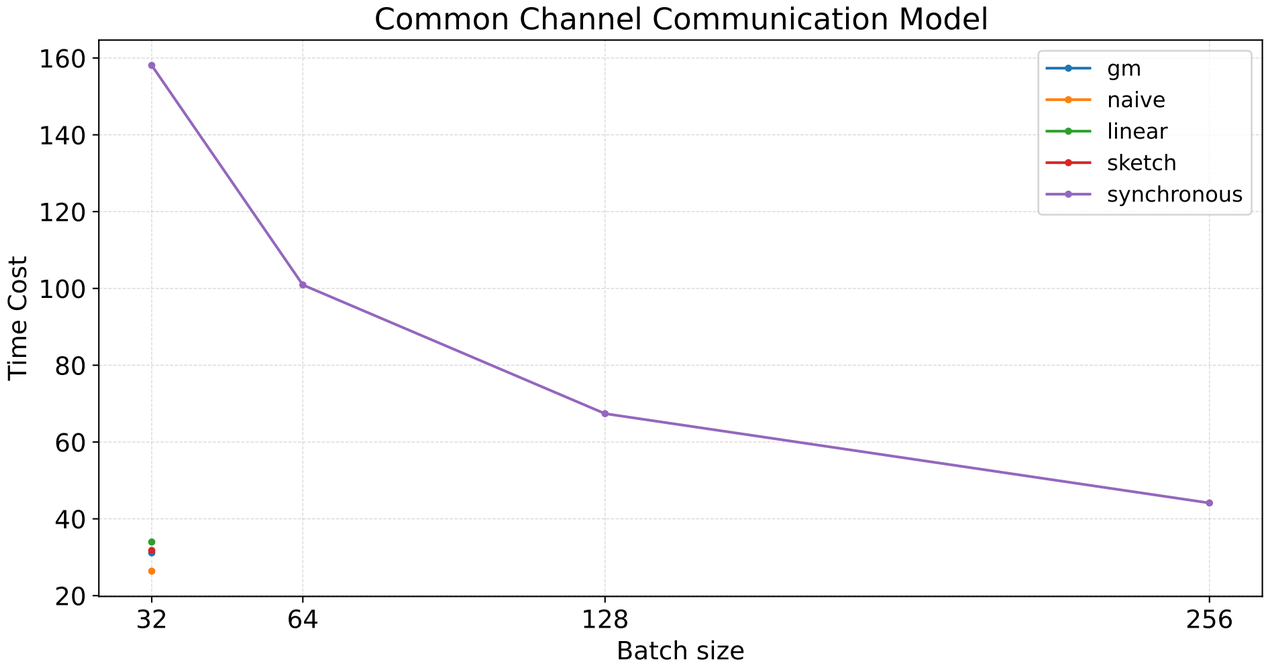


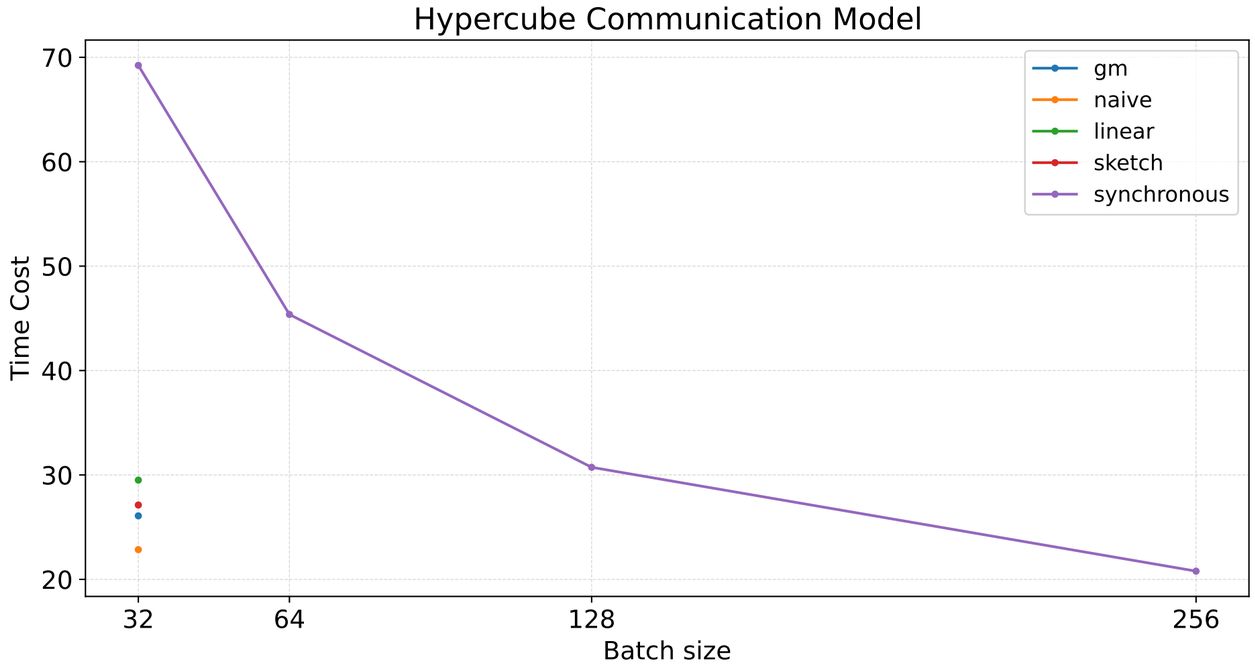
Num Clients : 5 , Θ : 15.0

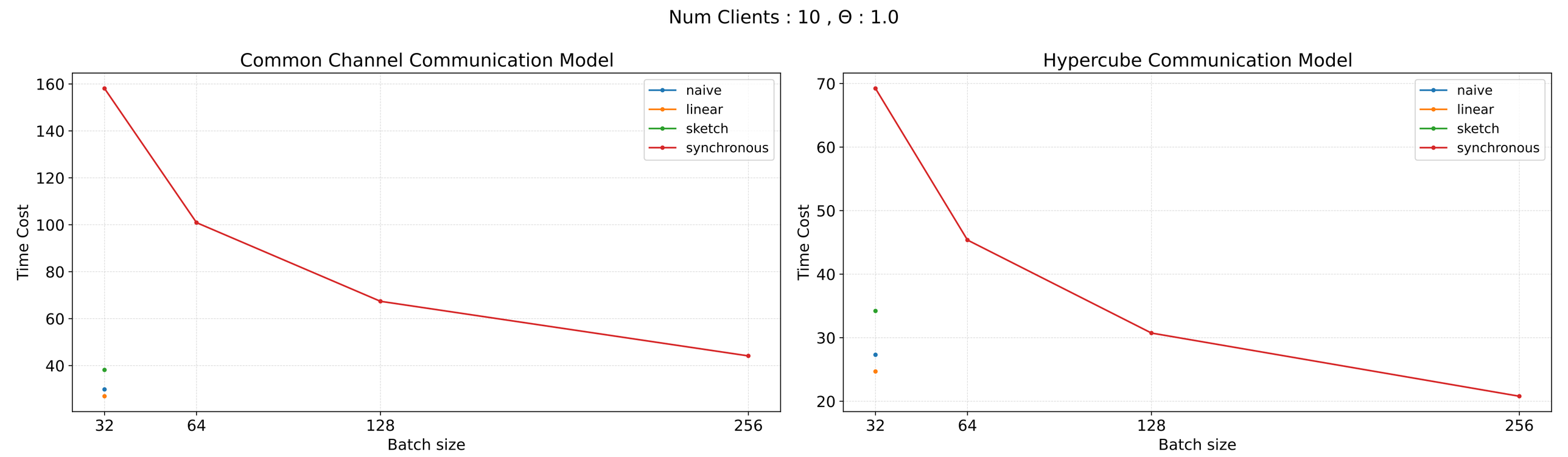




Num Clients : 10 , Θ : 0.5






Num Clients : 10 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
naive
linear
sketch
synchronous
160
140
120
100
80
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20
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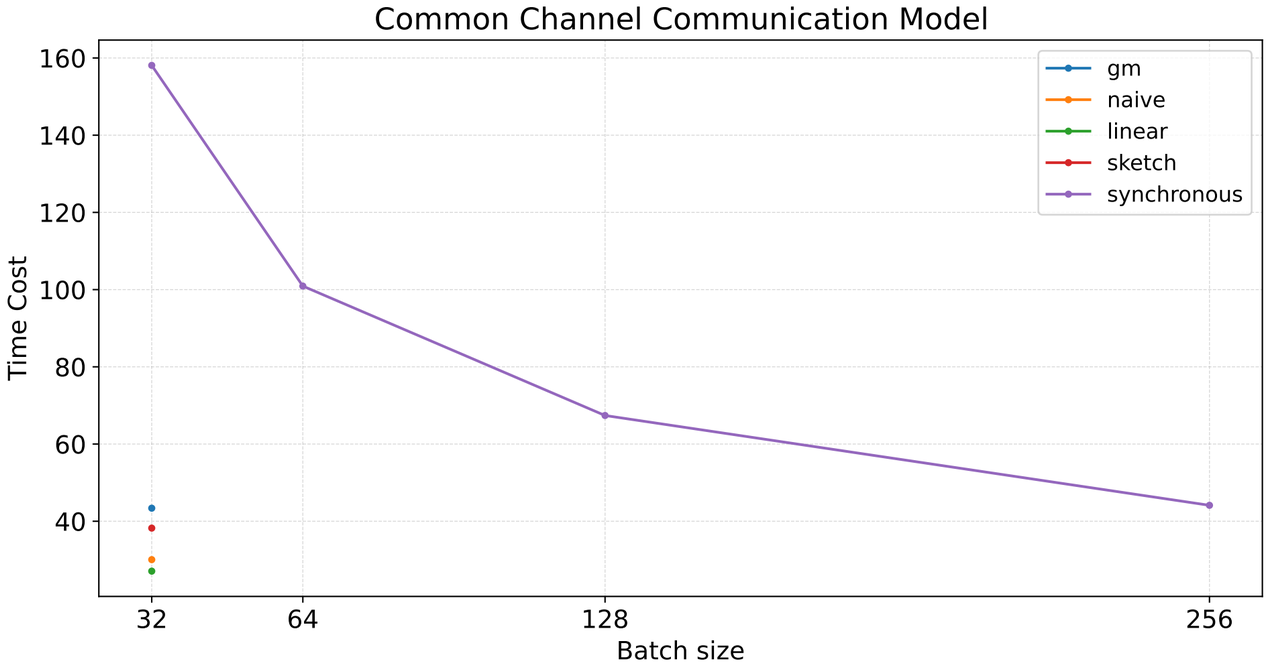
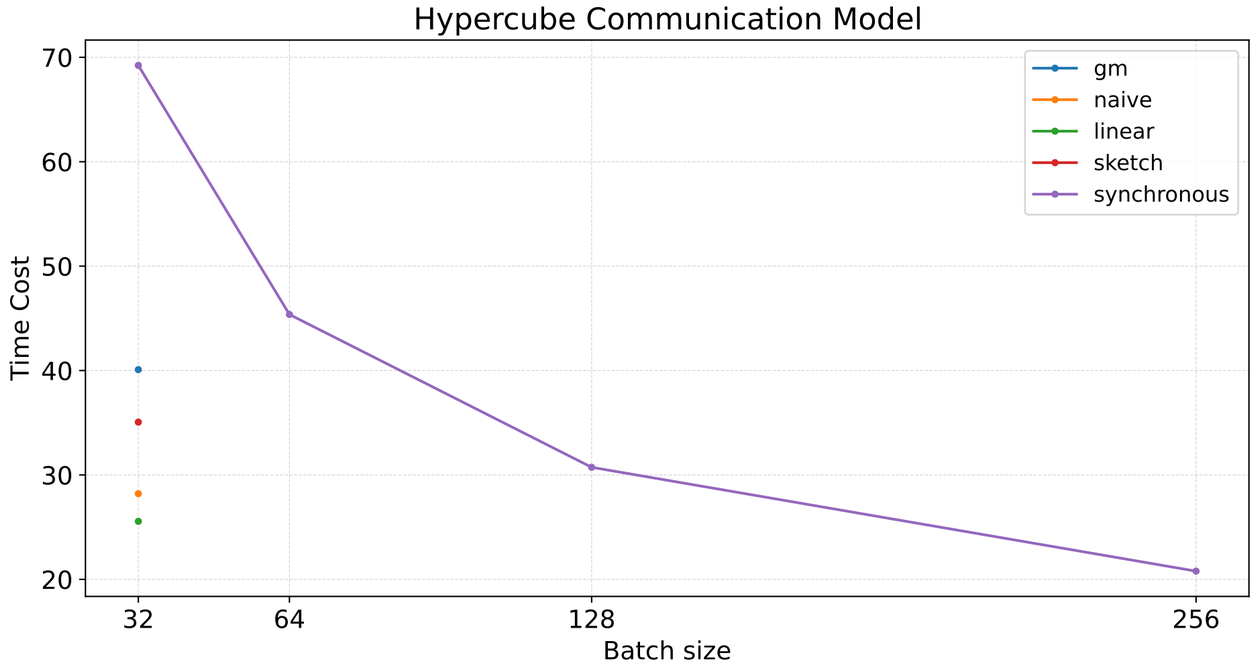
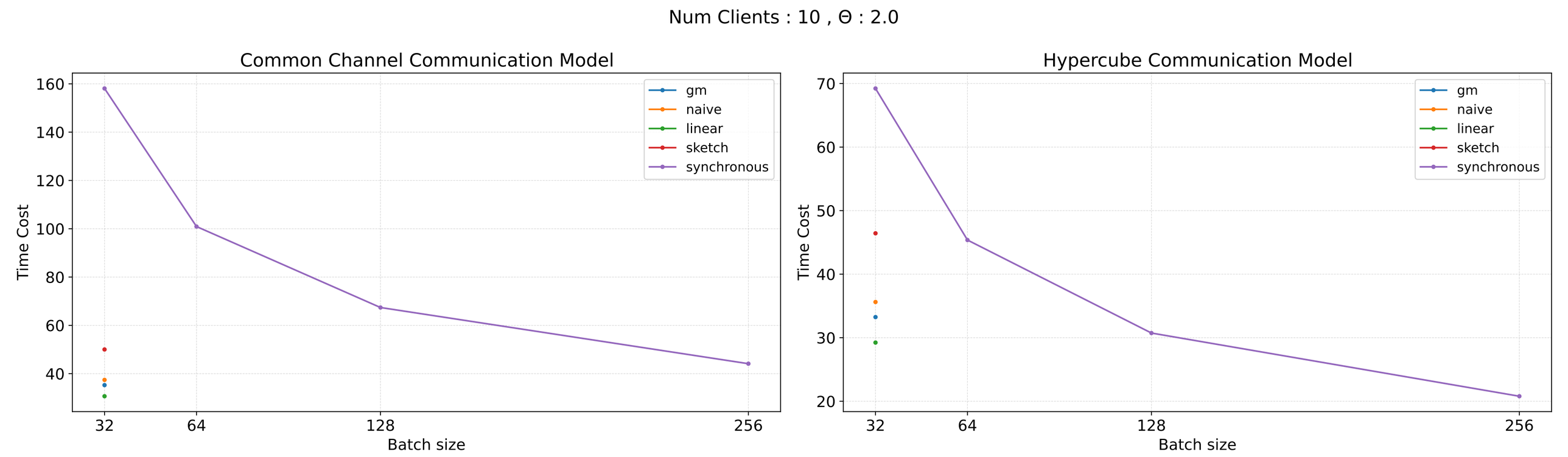
64
128
256

Num Clients : 10 , Θ : 1.5






Num Clients : 10 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
160
140
120
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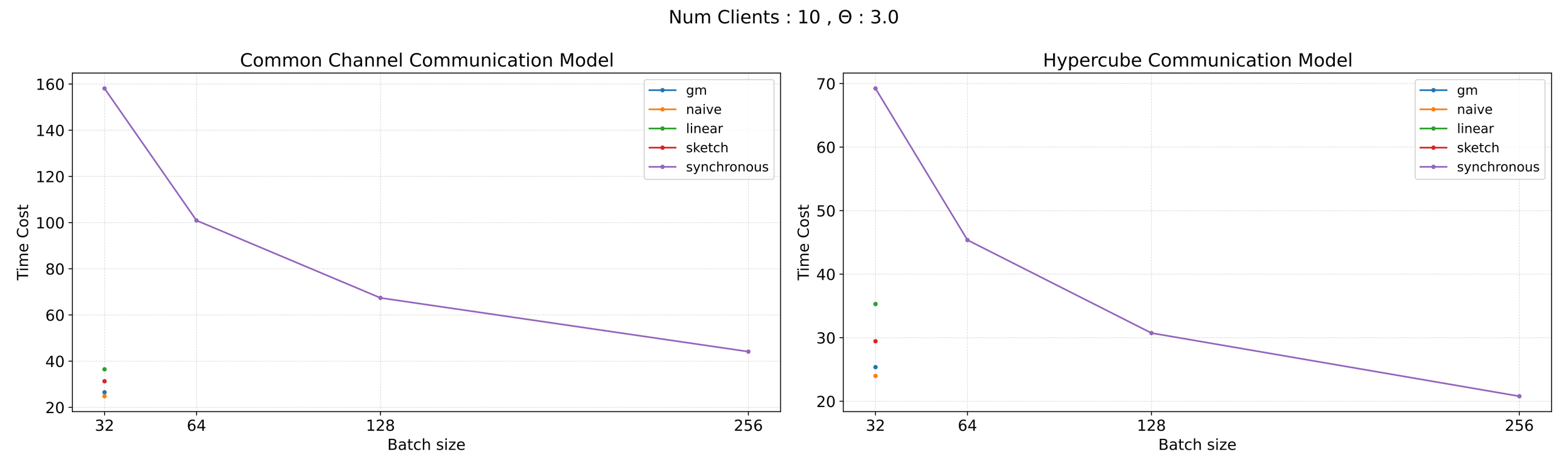
128
256


Num Clients : 10 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
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128
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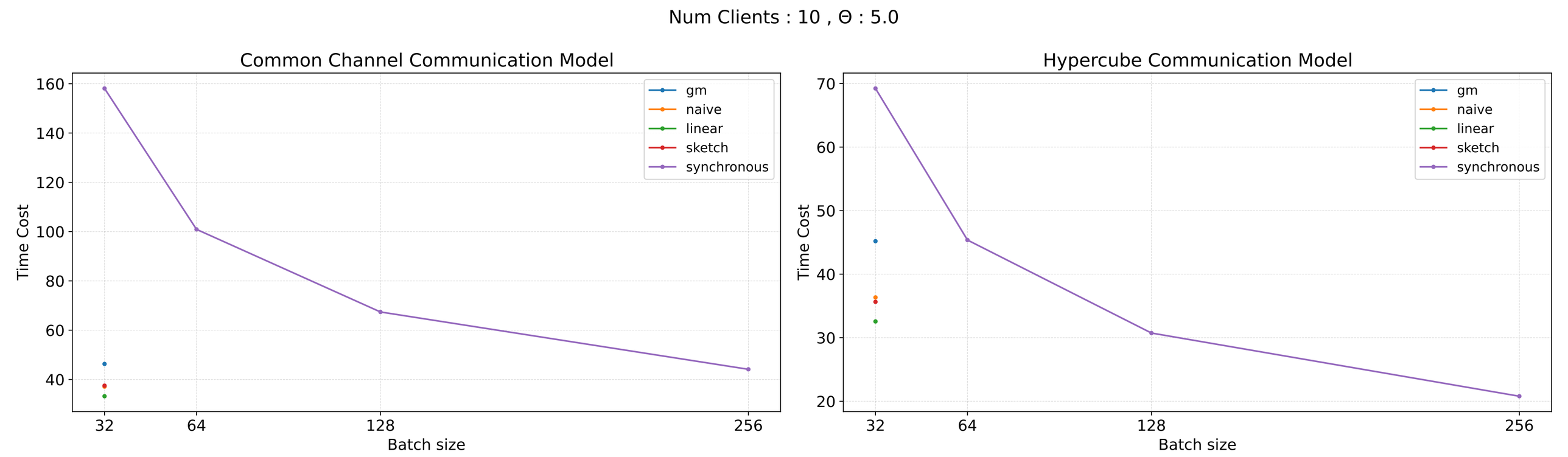
Num Clients : 10 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
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120
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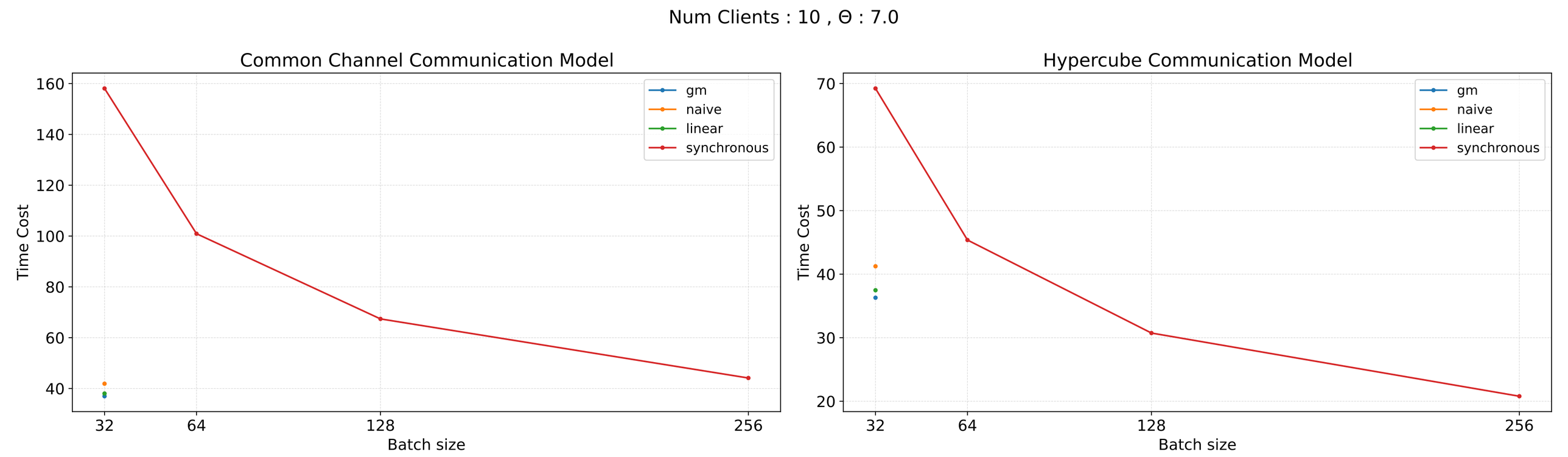
128
256


Num Clients : 10 , Θ : 7.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
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128
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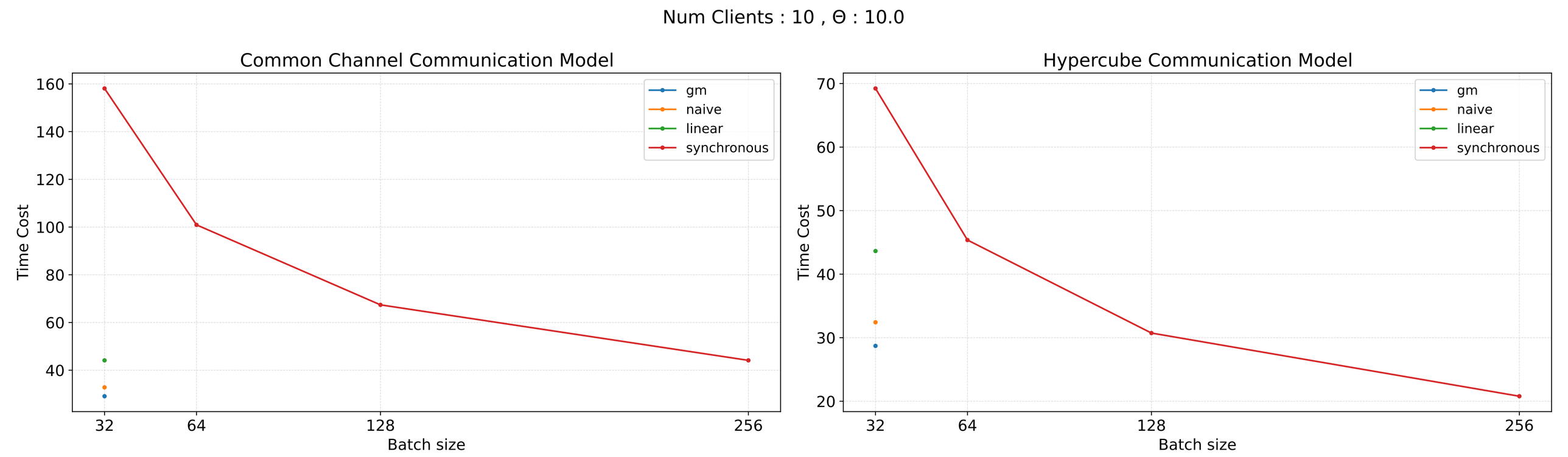
Num Clients : 10 , Θ : 10.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
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120
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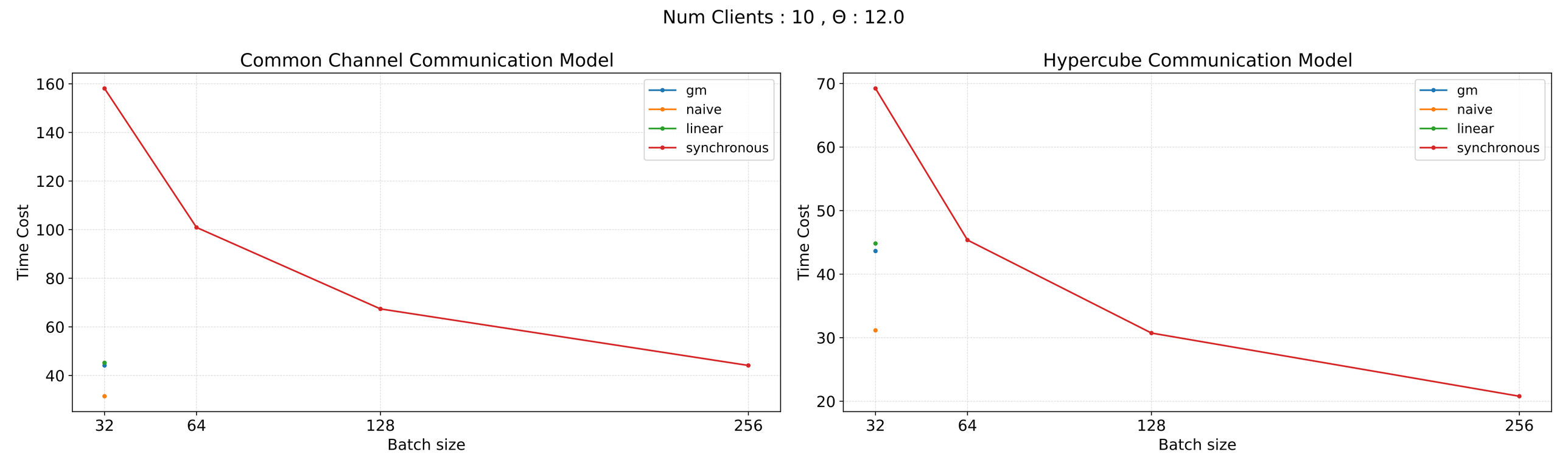
128
256


Num Clients : 10 , Θ : 12.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
160
140
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100
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30
20
32
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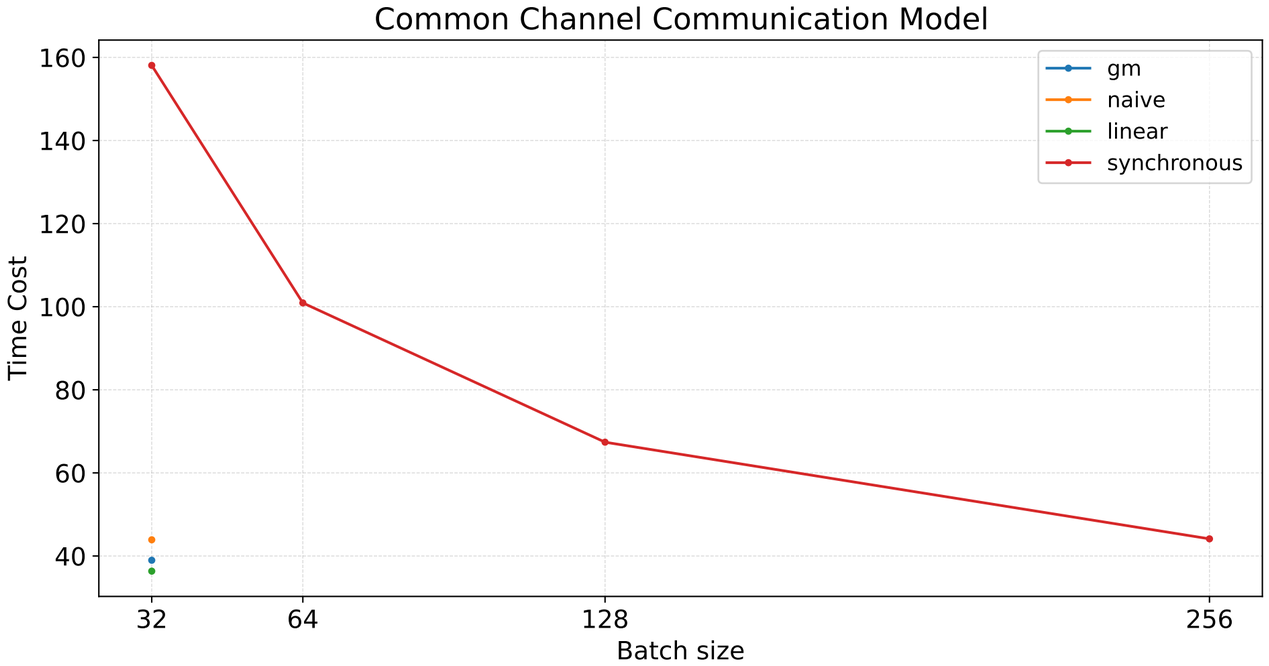
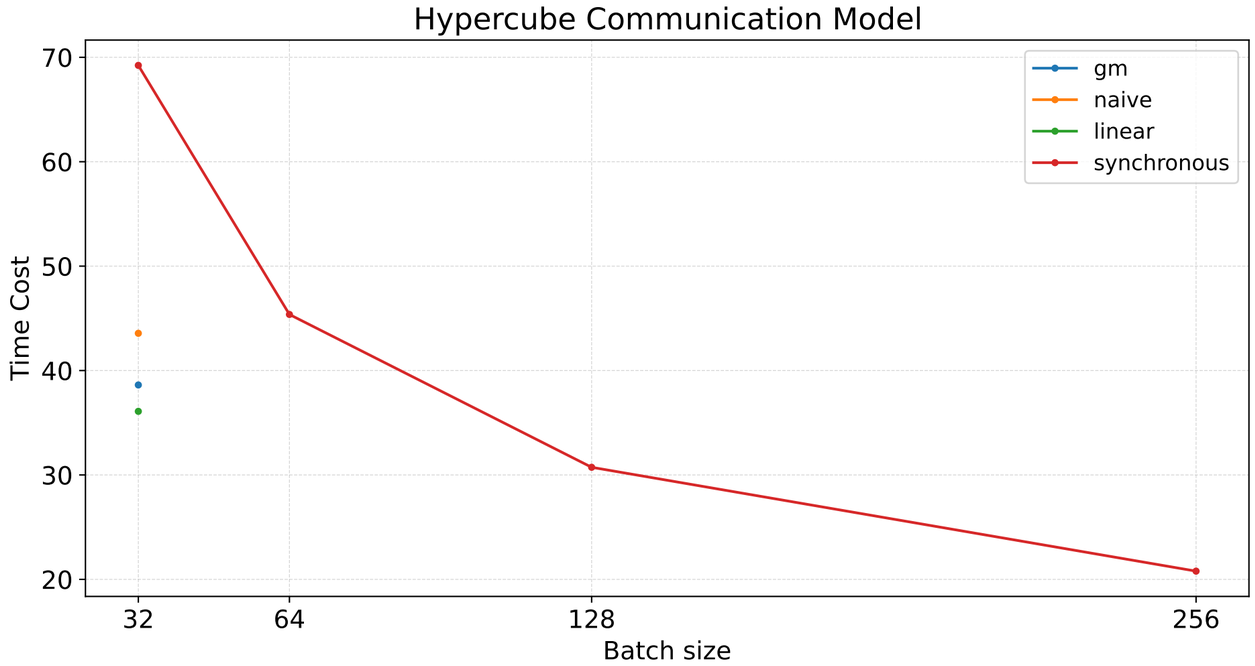
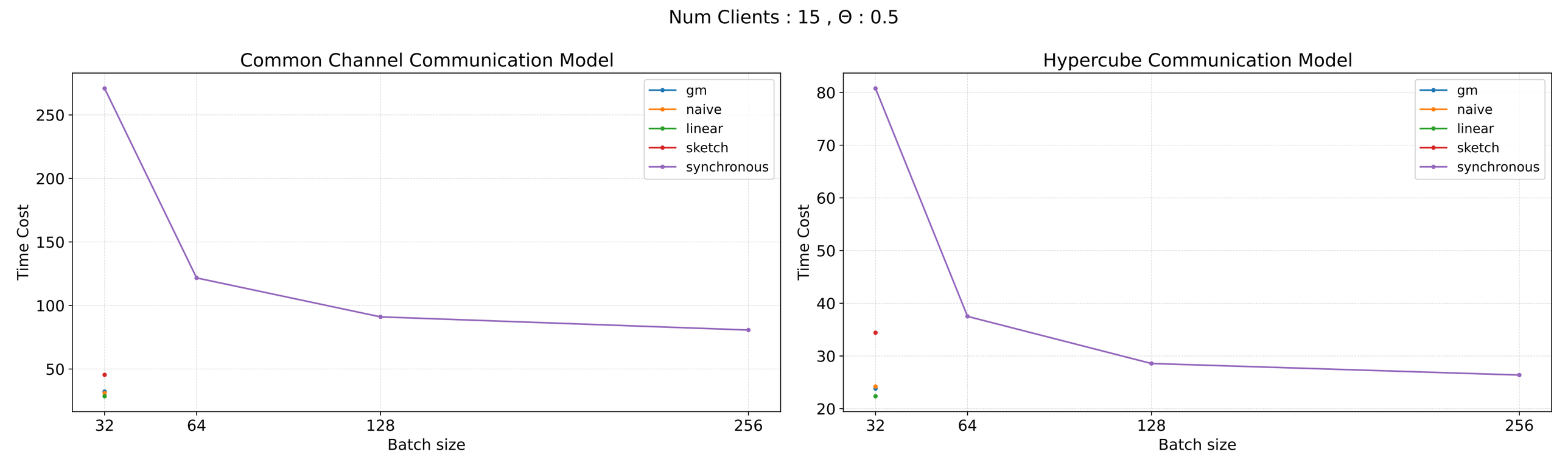
128
256

Num Clients : 10 , Θ : 15.0






Num Clients : 15 , Θ : 0.5
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
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100
150
200
250
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128
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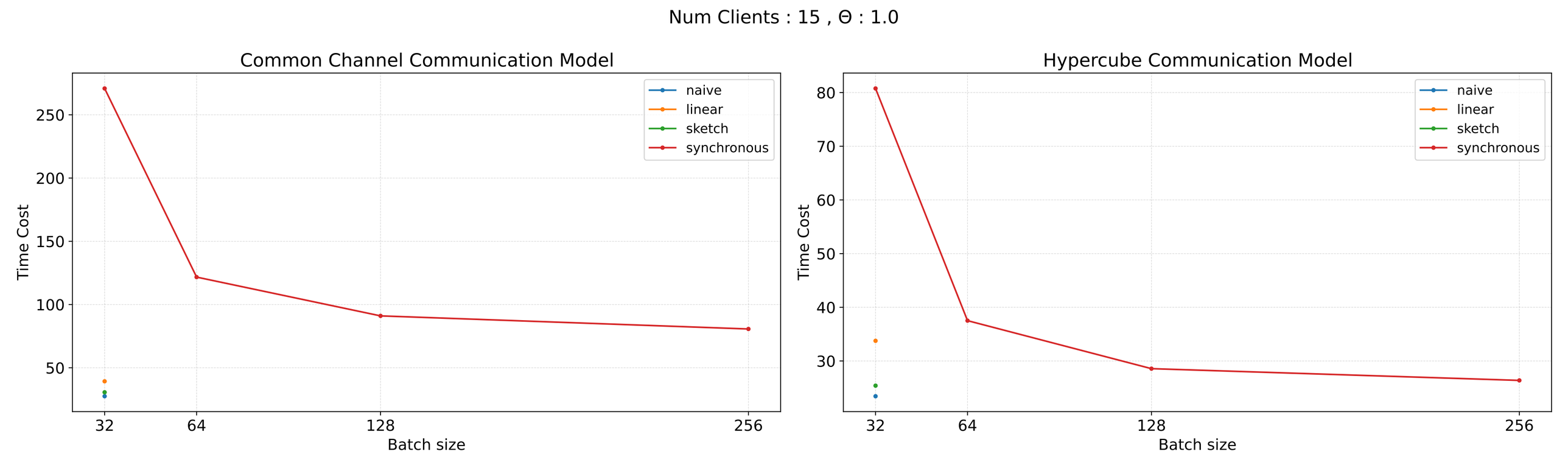
Num Clients : 15 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
naive
linear
sketch
synchronous
Time Cost
Batch size
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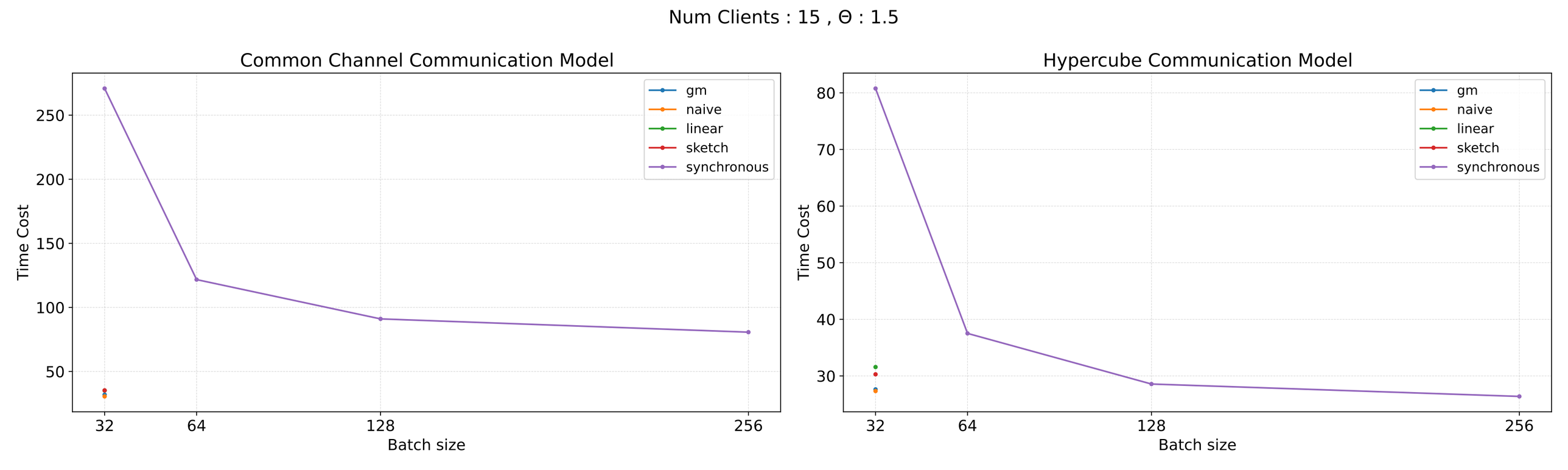
Num Clients : 15 , Θ : 1.5
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
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linear
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synchronous
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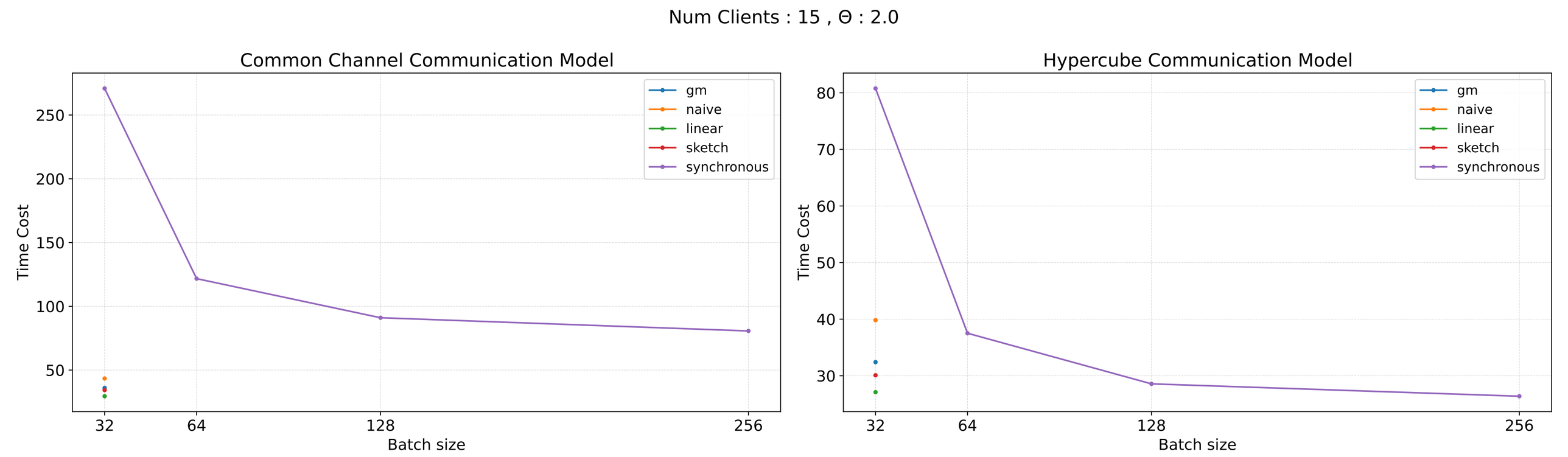
Num Clients : 15 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
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synchronous
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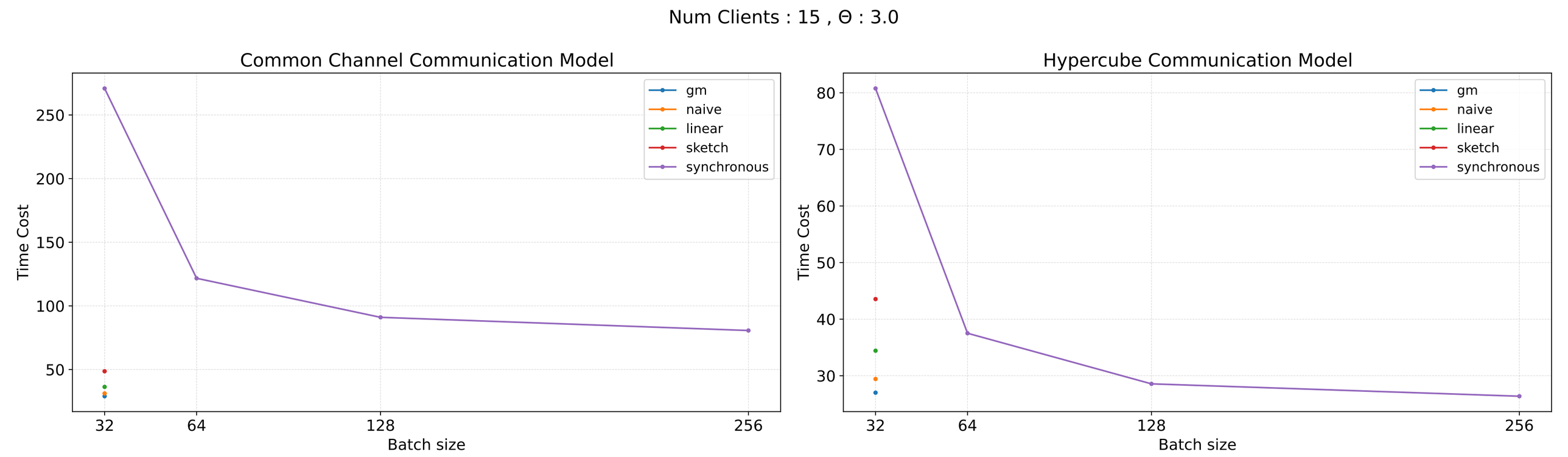
Num Clients : 15 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
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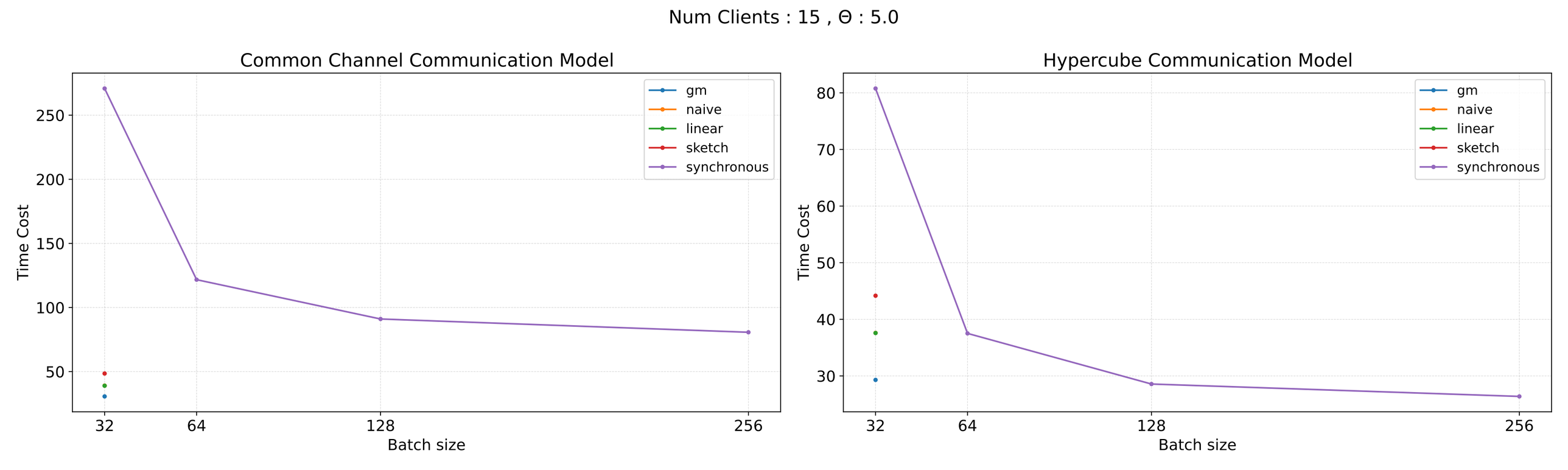
Num Clients : 15 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
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synchronous
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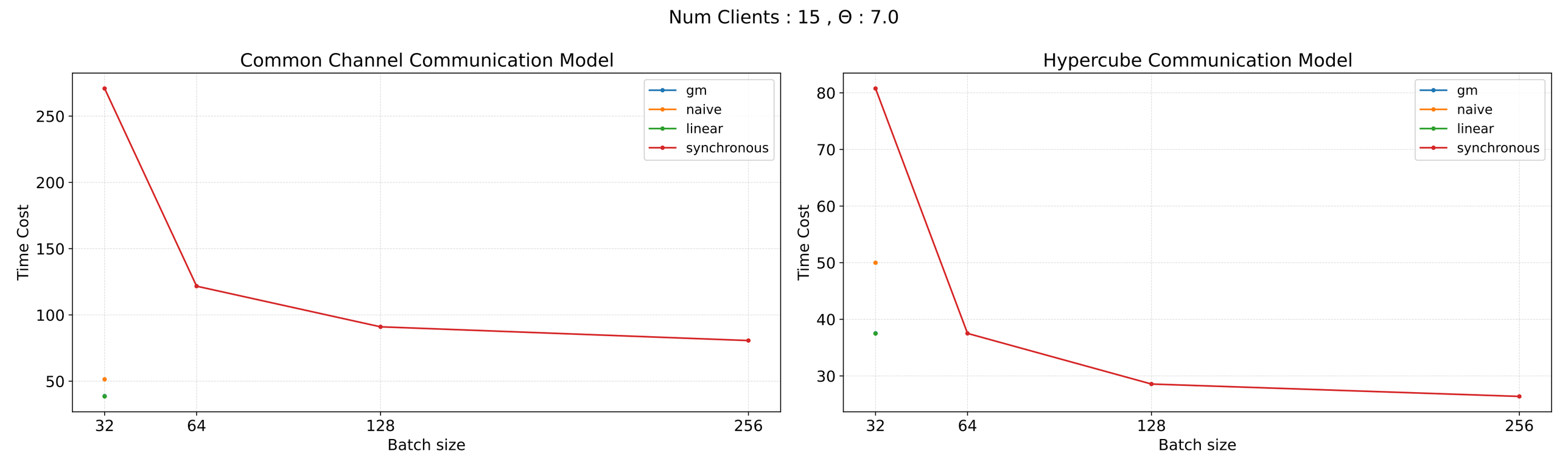
Num Clients : 15 , Θ : 7.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
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naive
linear
synchronous
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100
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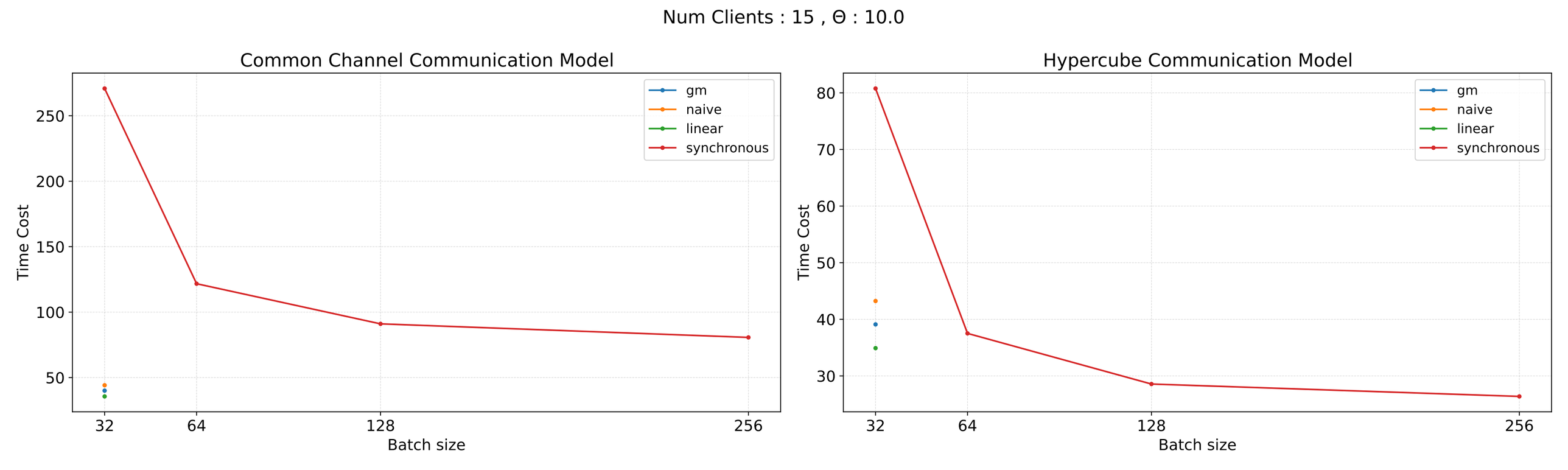
Num Clients : 15 , Θ : 10.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
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synchronous
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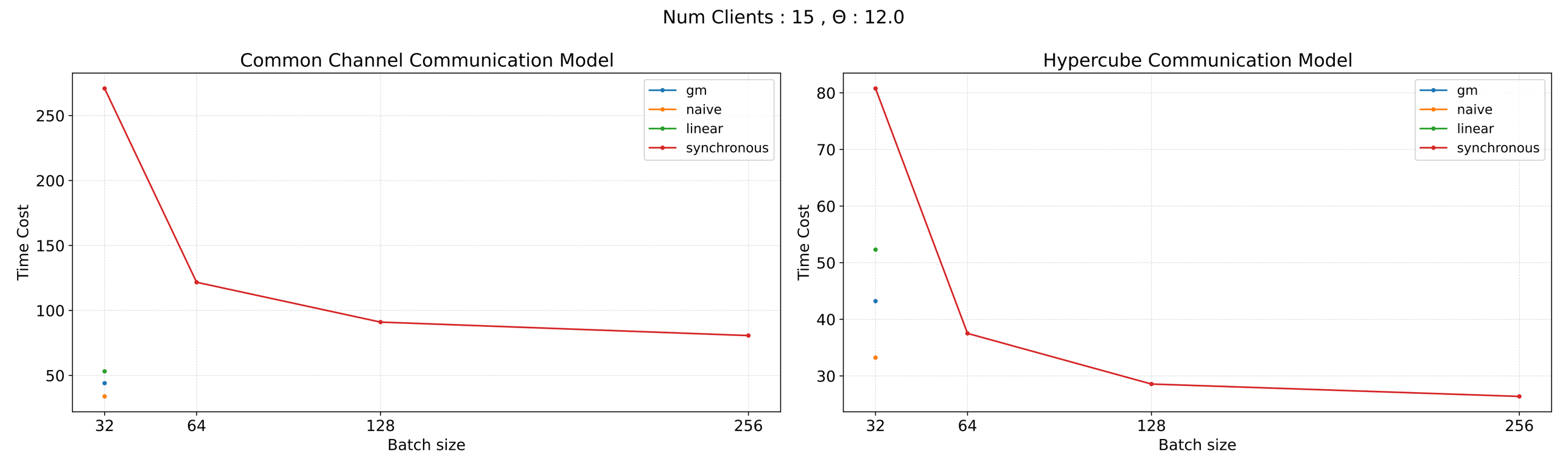
Num Clients : 15 , Θ : 12.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
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naive
linear
synchronous
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64
128
256
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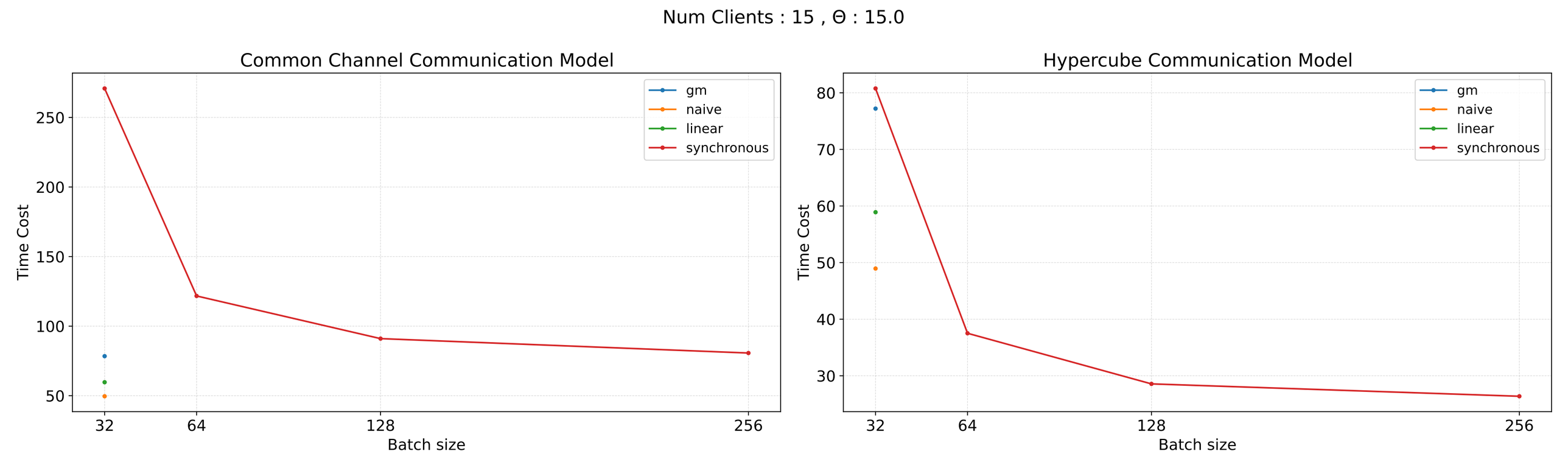
Num Clients : 15 , Θ : 15.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
50
100
150
200
250
30
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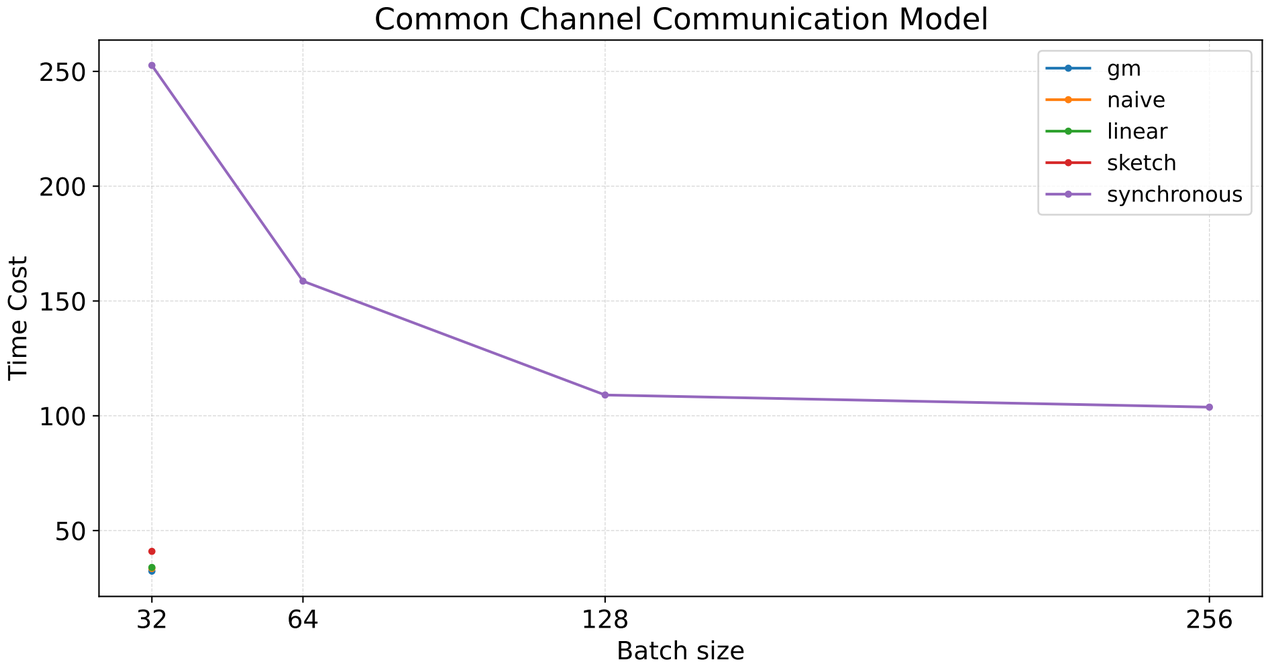
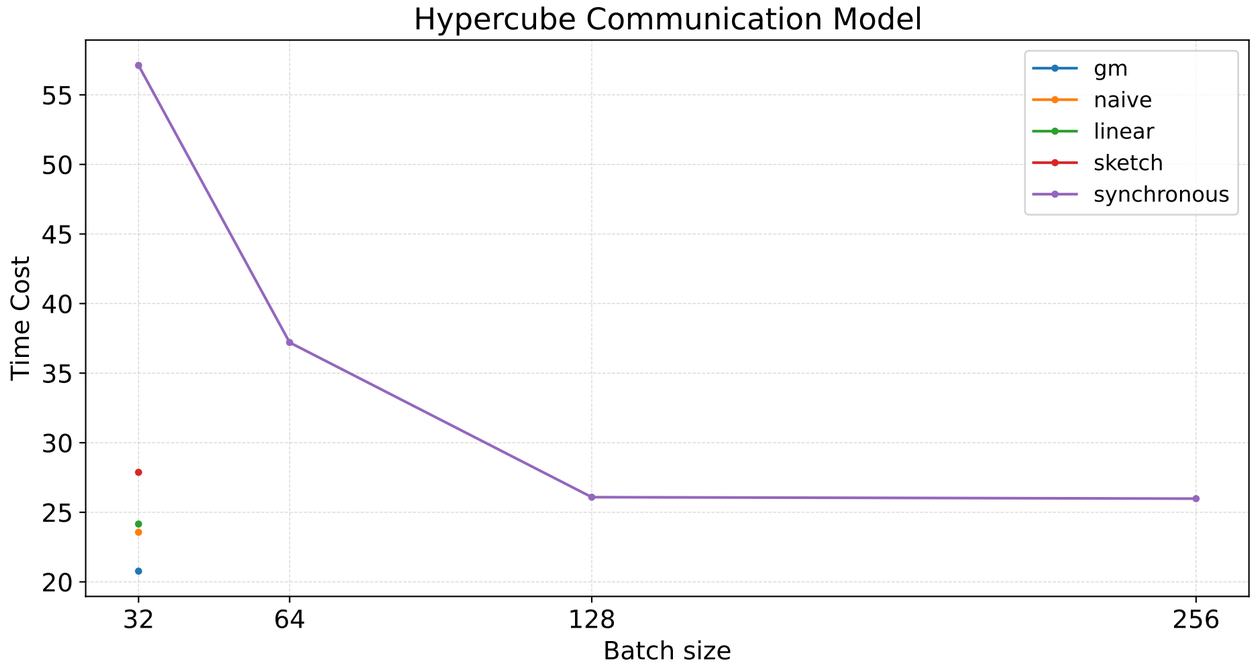
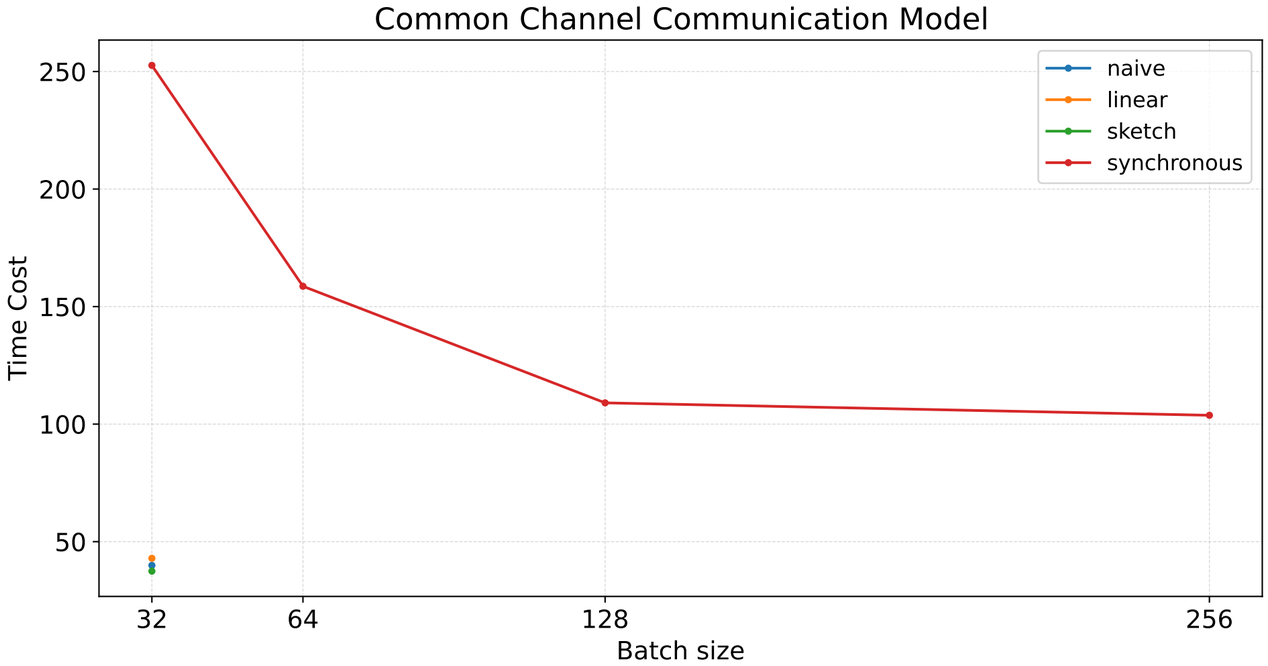
50
60
70
80
32
64
128
256

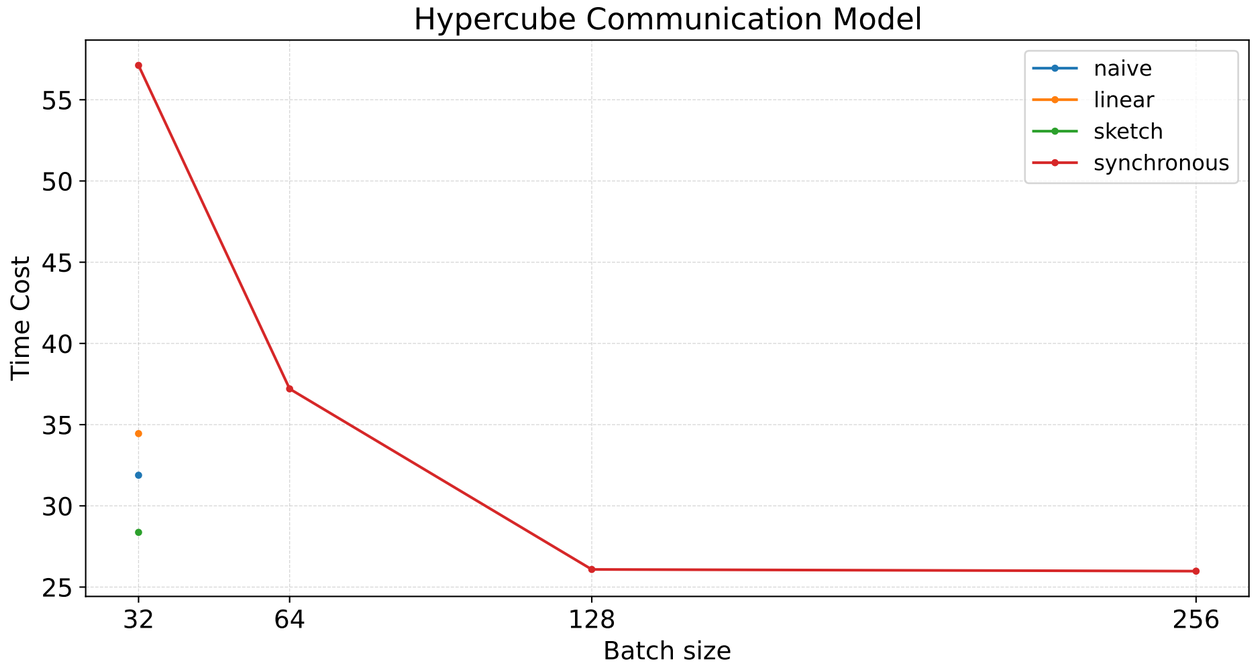
Num Clients : 20 , Θ : 0.5



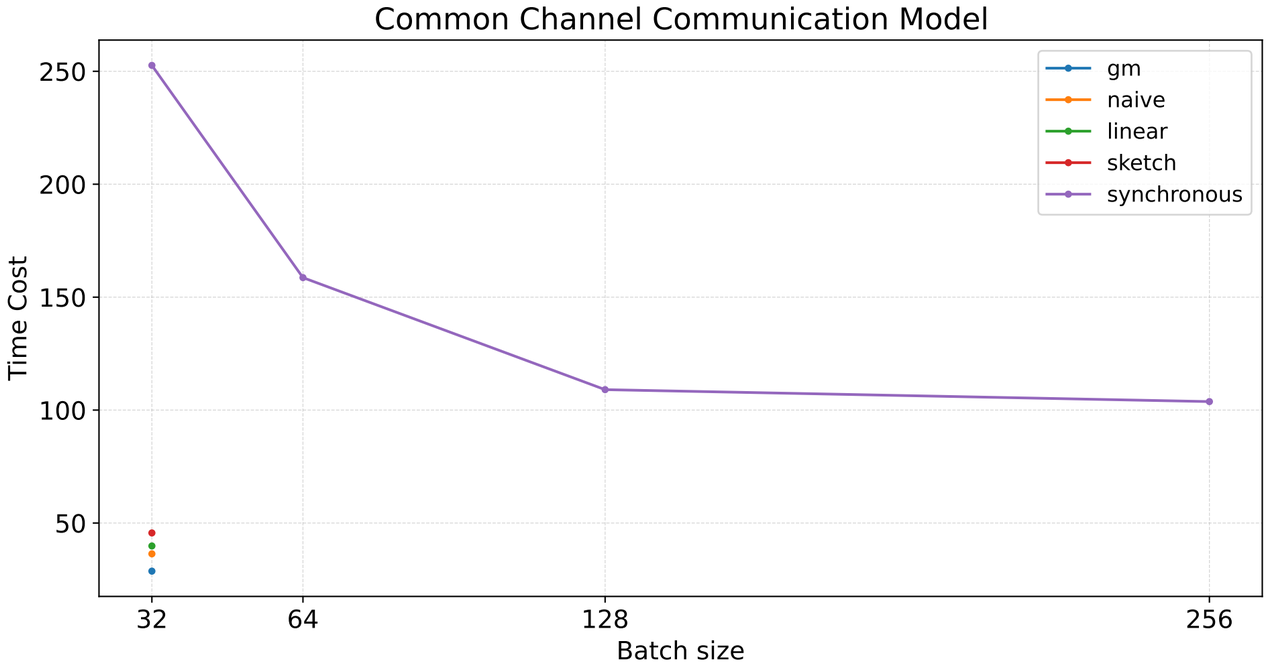


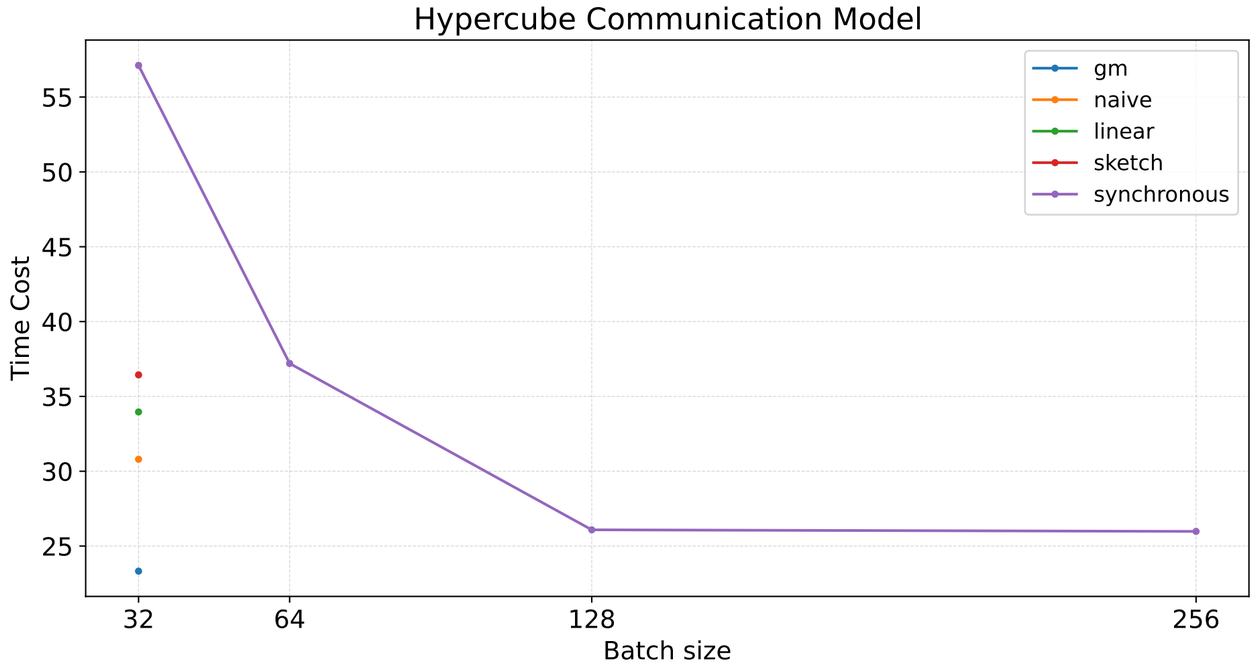
Num Clients : 20 , Θ : 1.0

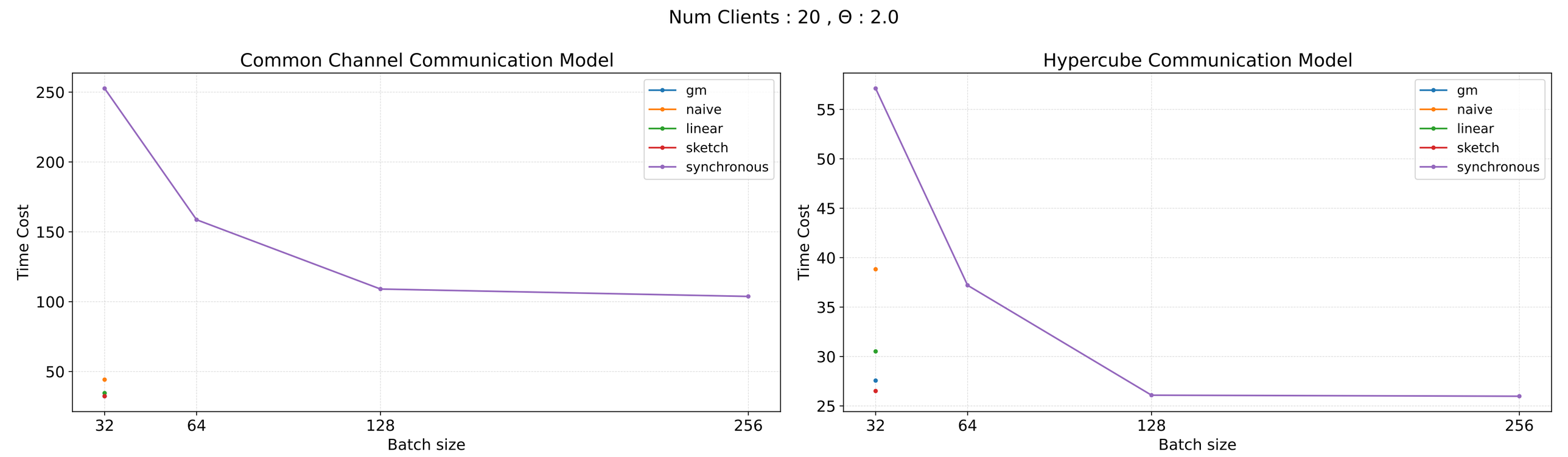


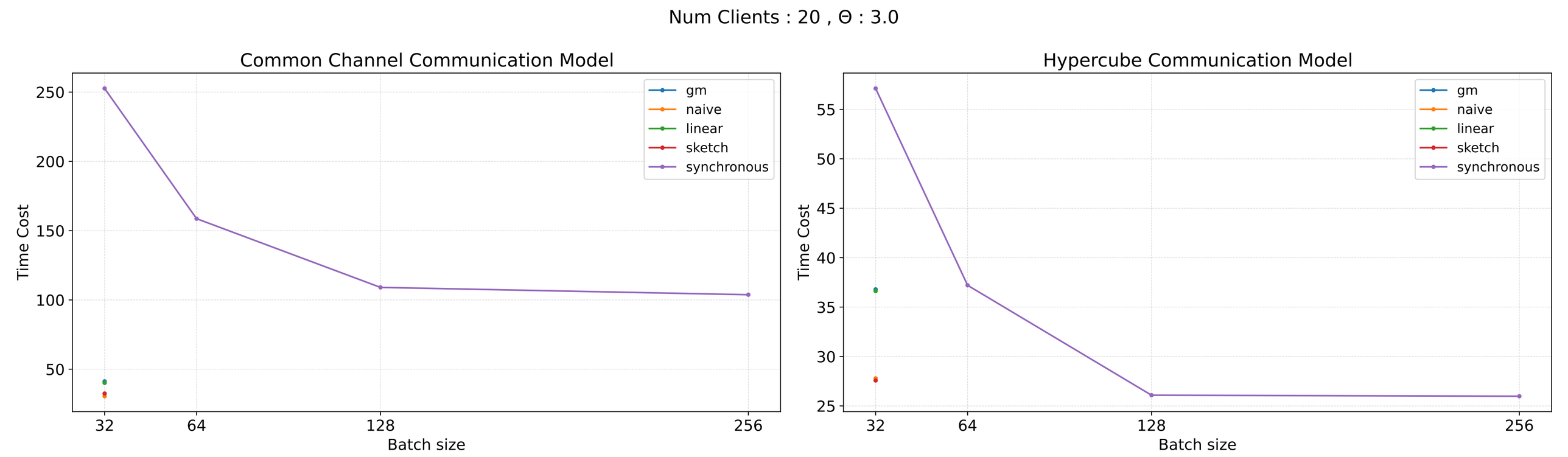


Num Clients : 20 , Θ : 1.5






Num Clients : 20 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
250
200
150
100
50
55
50
45
40
35
30
25
32
64
128
256


Num Clients : 20 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
250
200
150
100
50
55
50
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40
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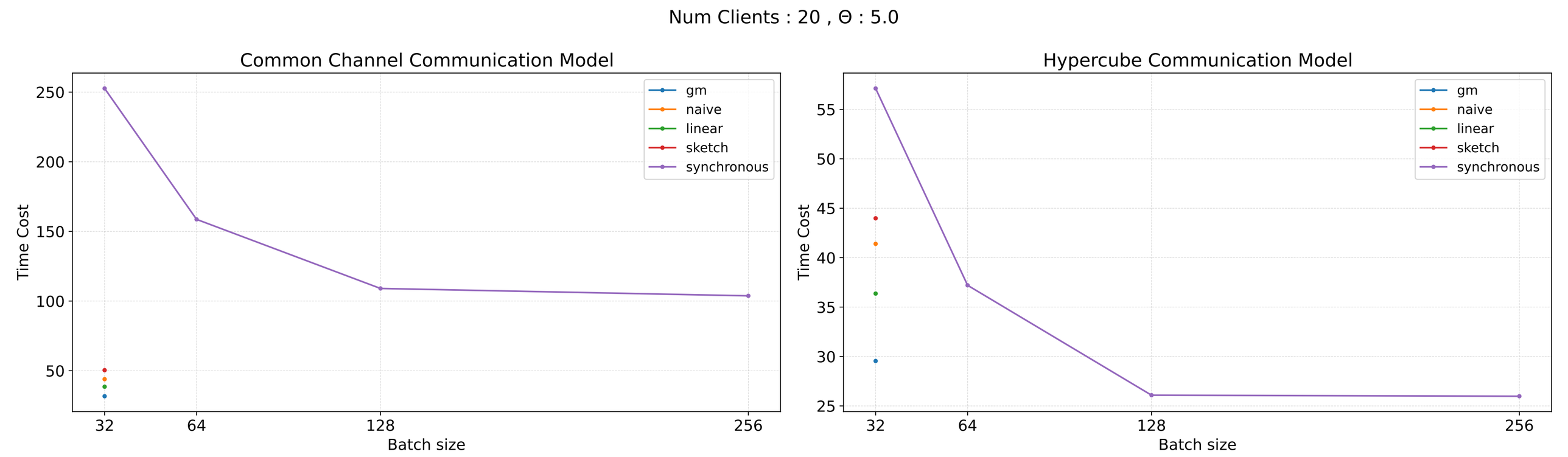
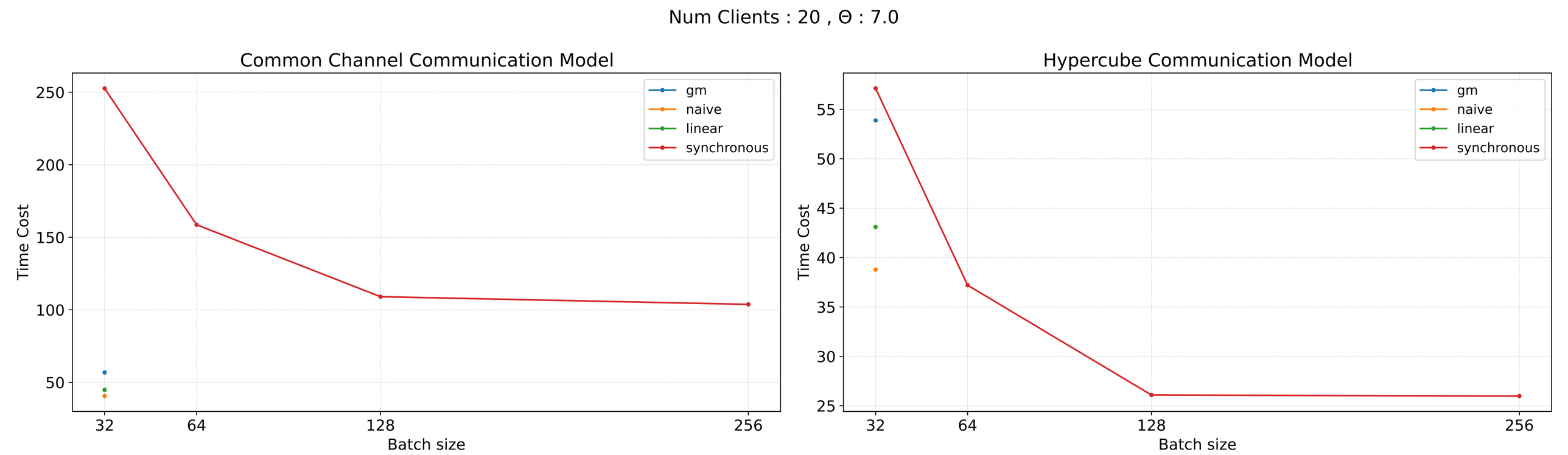
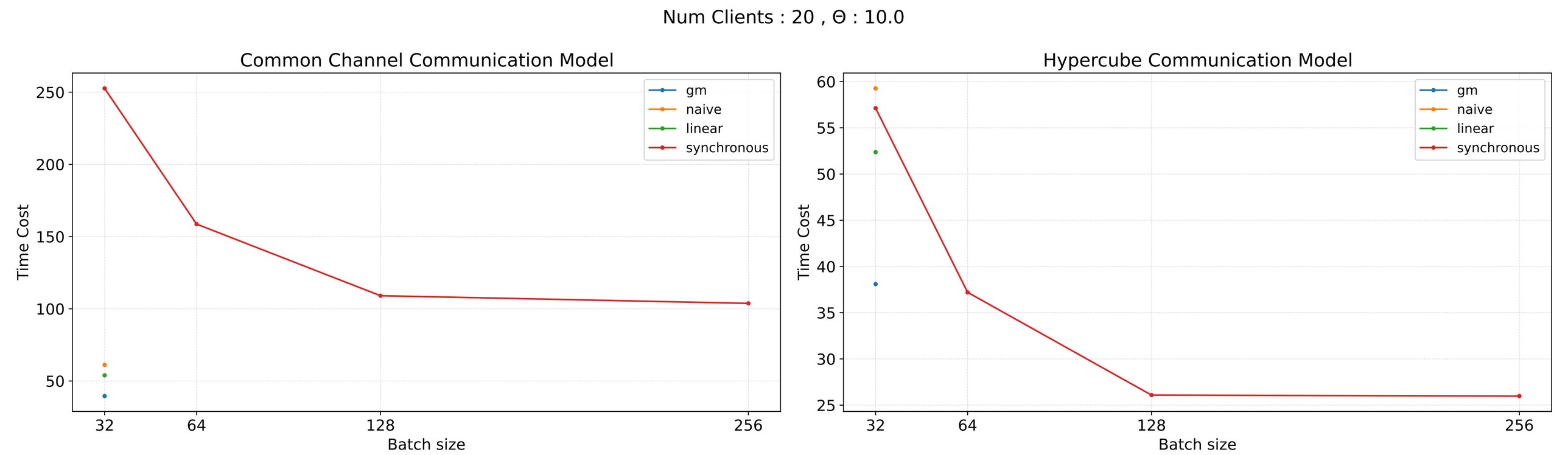
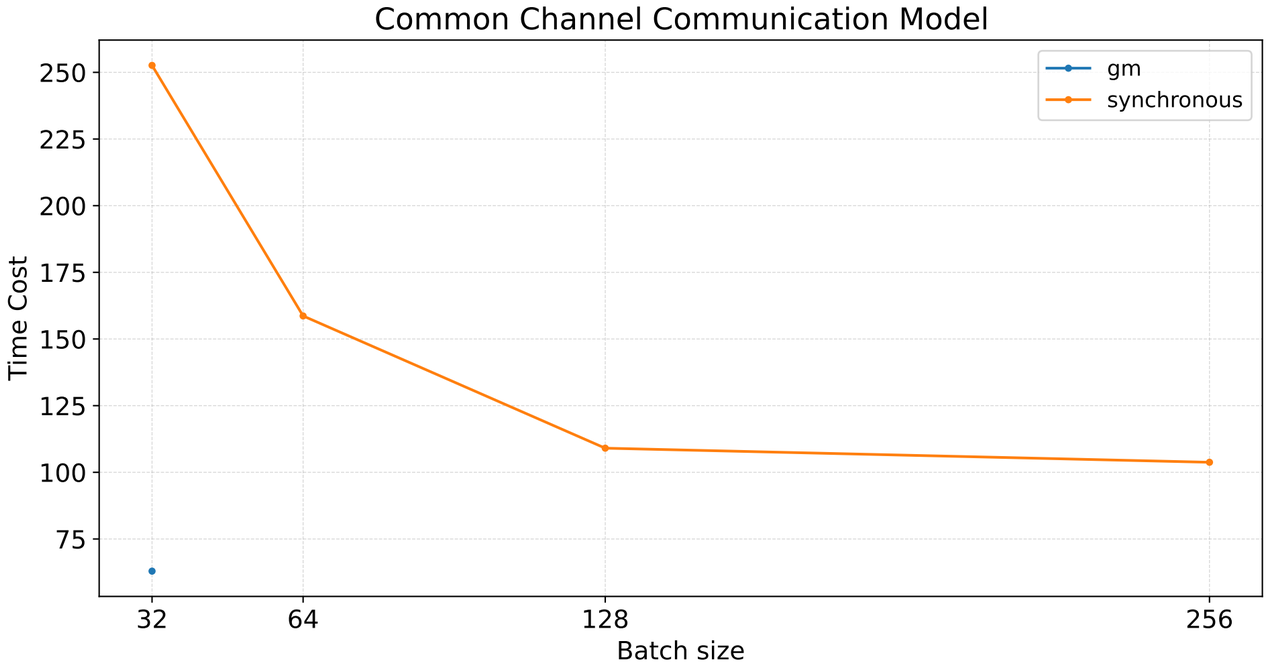
32
64
128
256

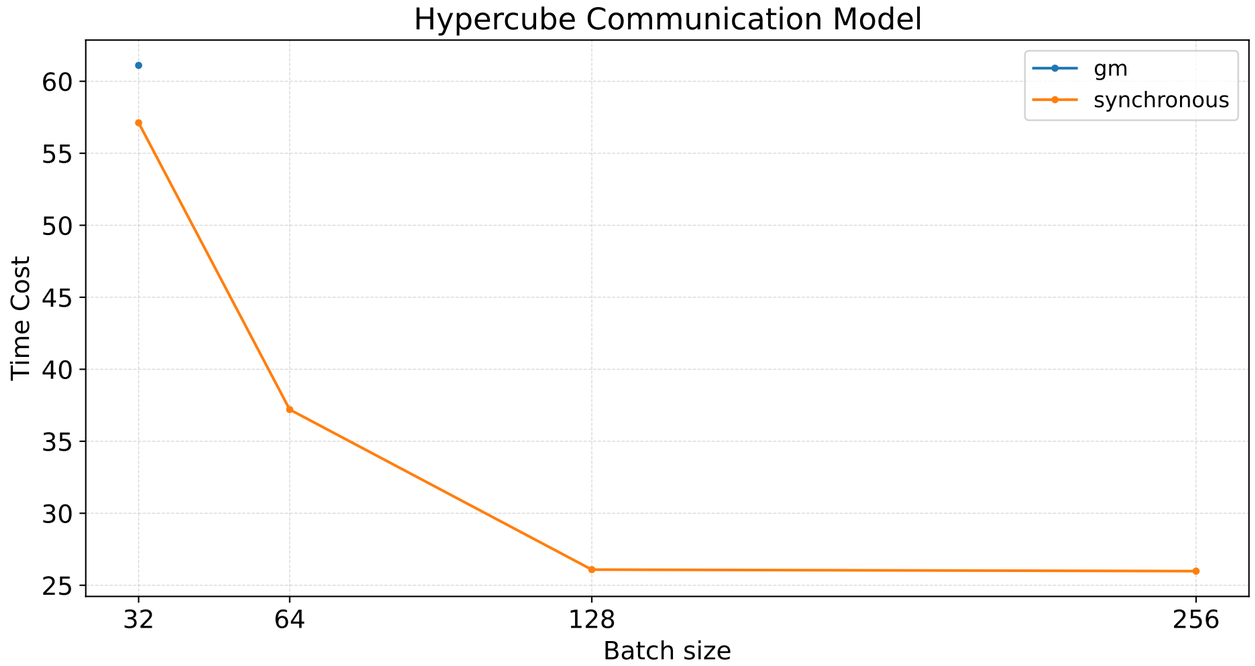

Num Clients : 20 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
250
200
150
100
50
55
50
45
40
35
30
25
32
64
128
256

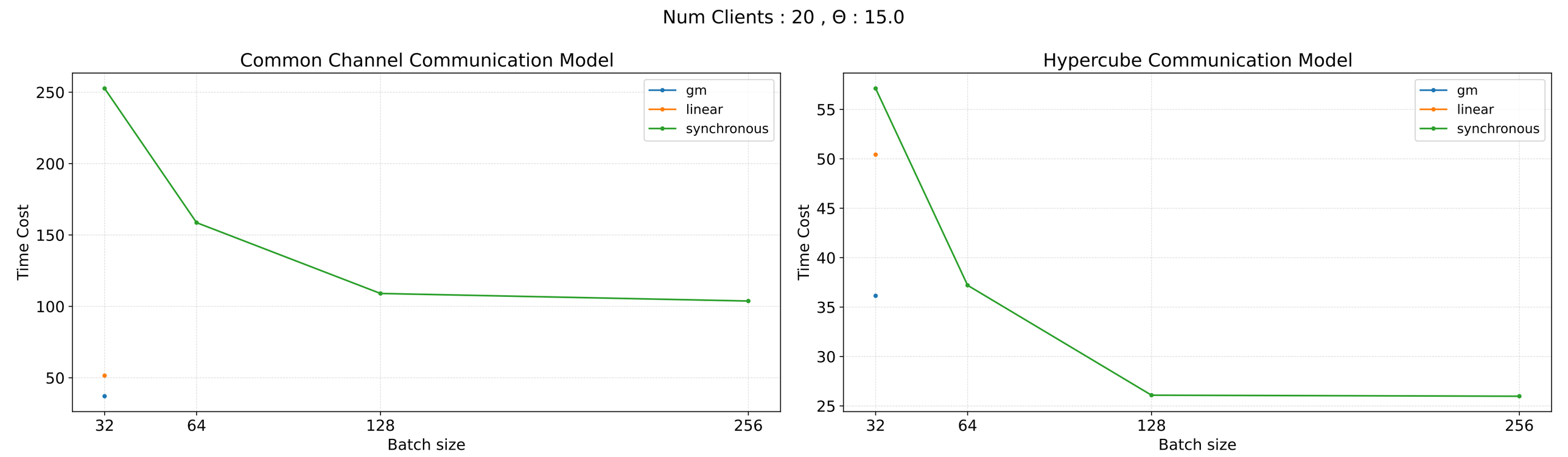

Num Clients : 20 , Θ : 7.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
250
200
150
100
50
55
50
45
40
35
30
25
32
64
128
256


Num Clients : 20 , Θ : 10.0
Common Channel Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
250
200
150
100
50
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
60
55
50
45
40
35
30
25
32
64
128
256

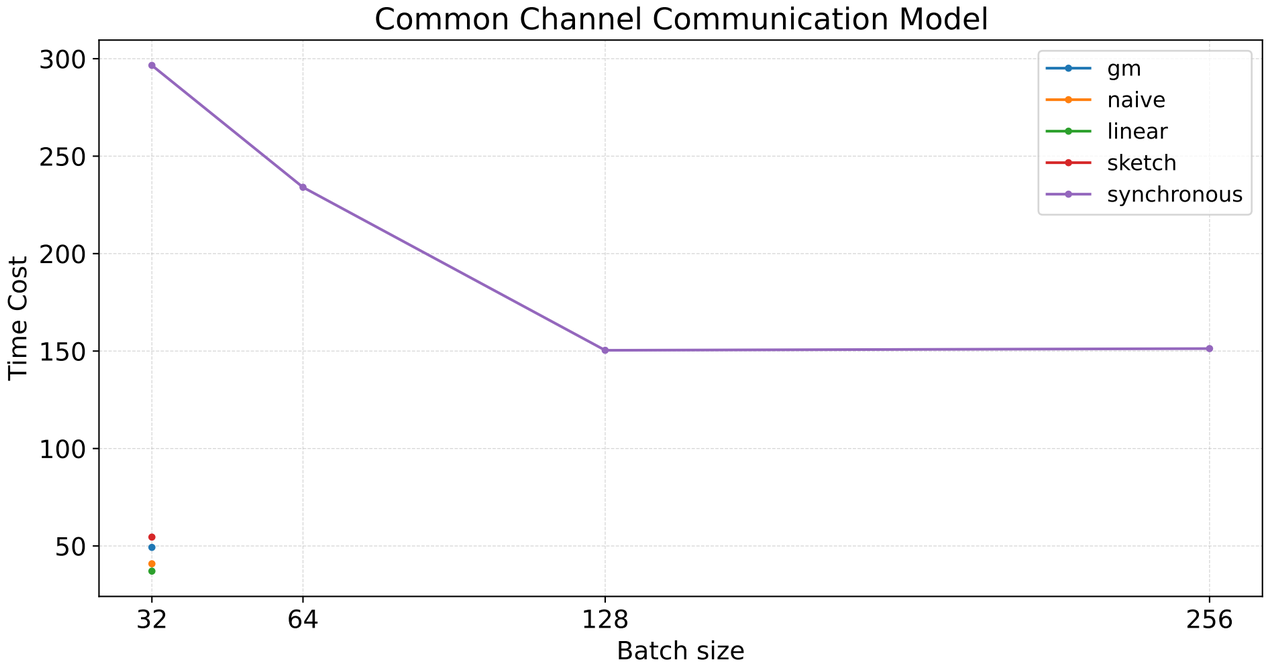
Num Clients : 20 , Θ : 12.0

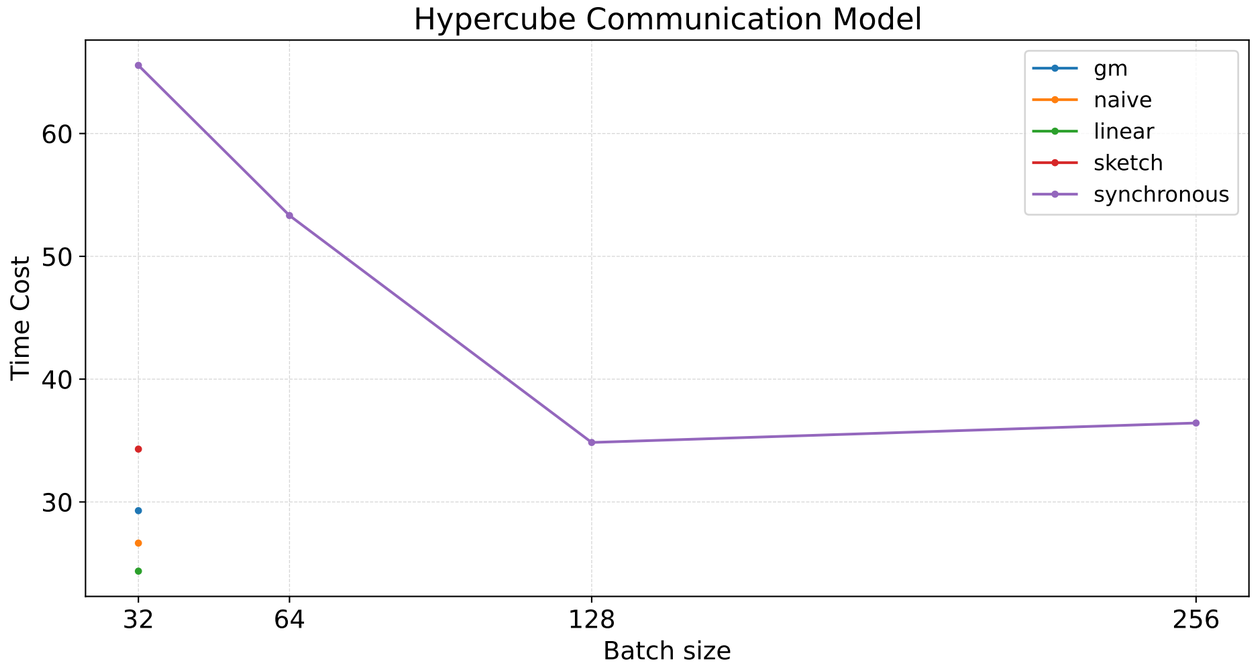




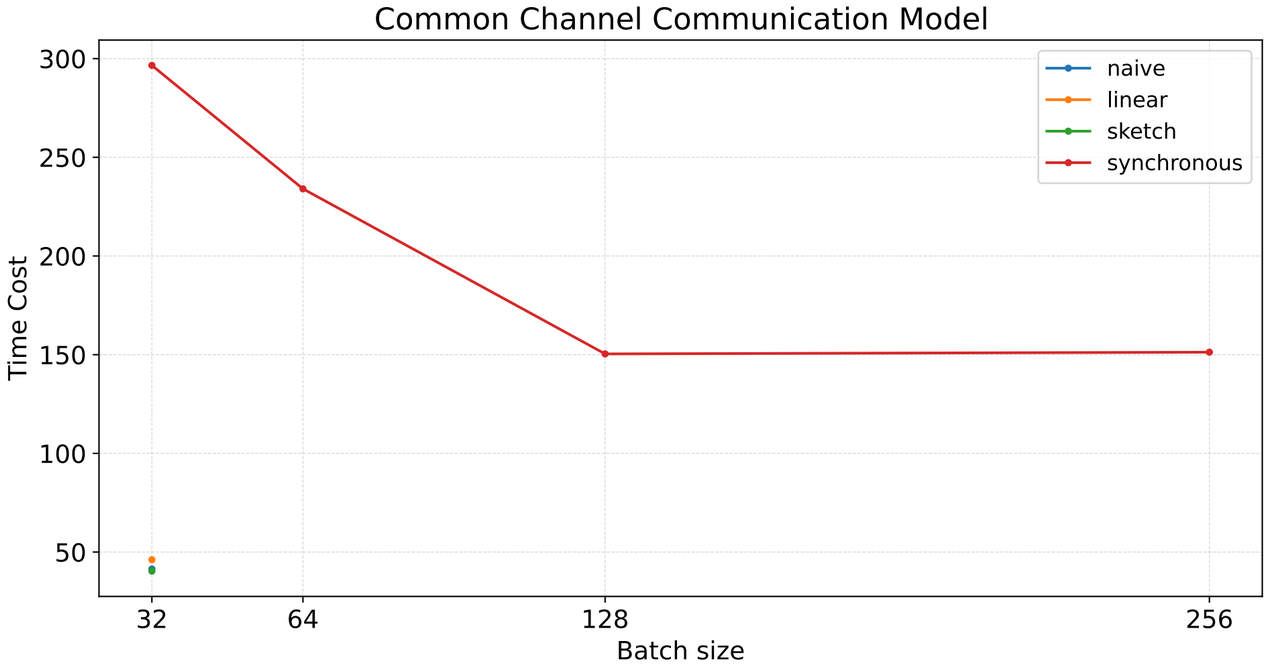

Num Clients : 20 , Θ : 15.0
Common Channel Communication Model
Time Cost
Batch size
gm
linear
synchronous
250
200
150
100
50
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
linear
synchronous
55
50
45
40
35
30
25
32
64
128
256

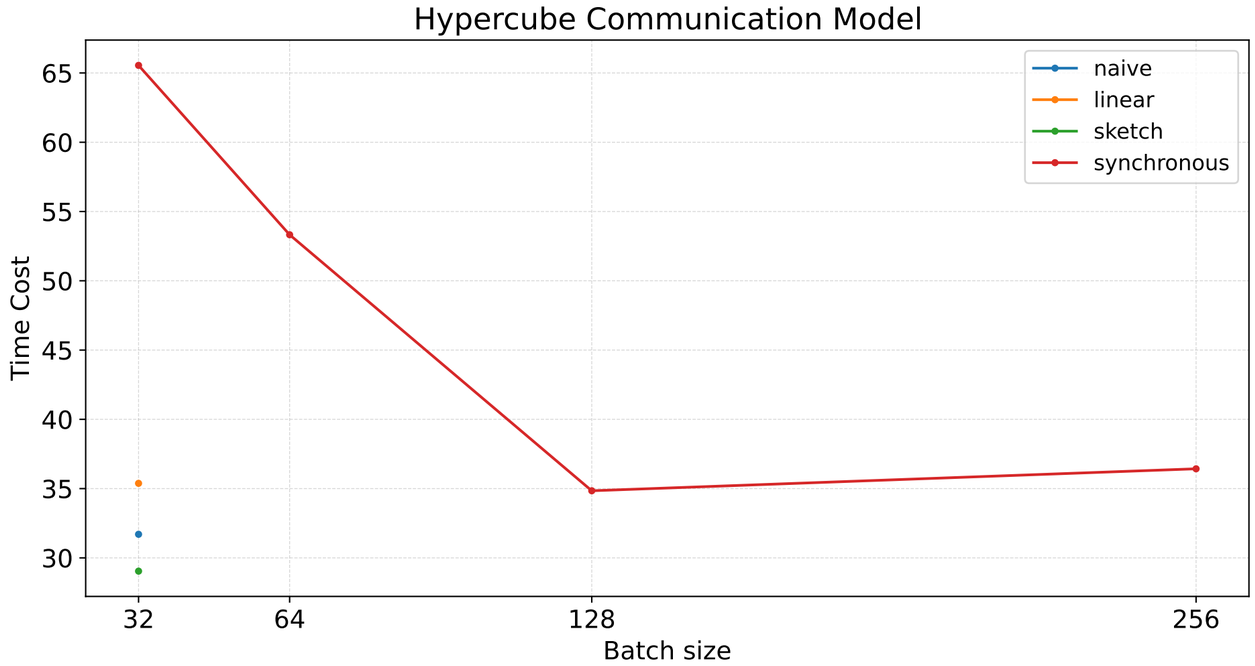
Num Clients : 25 , Θ : 0.5



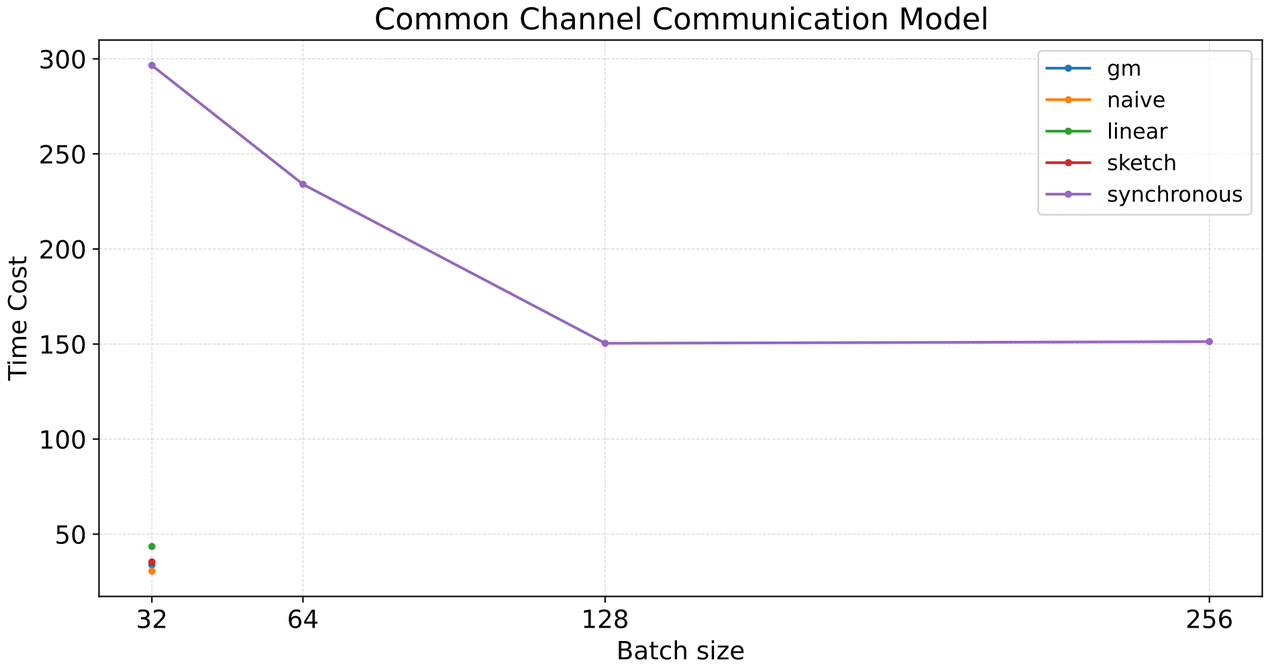


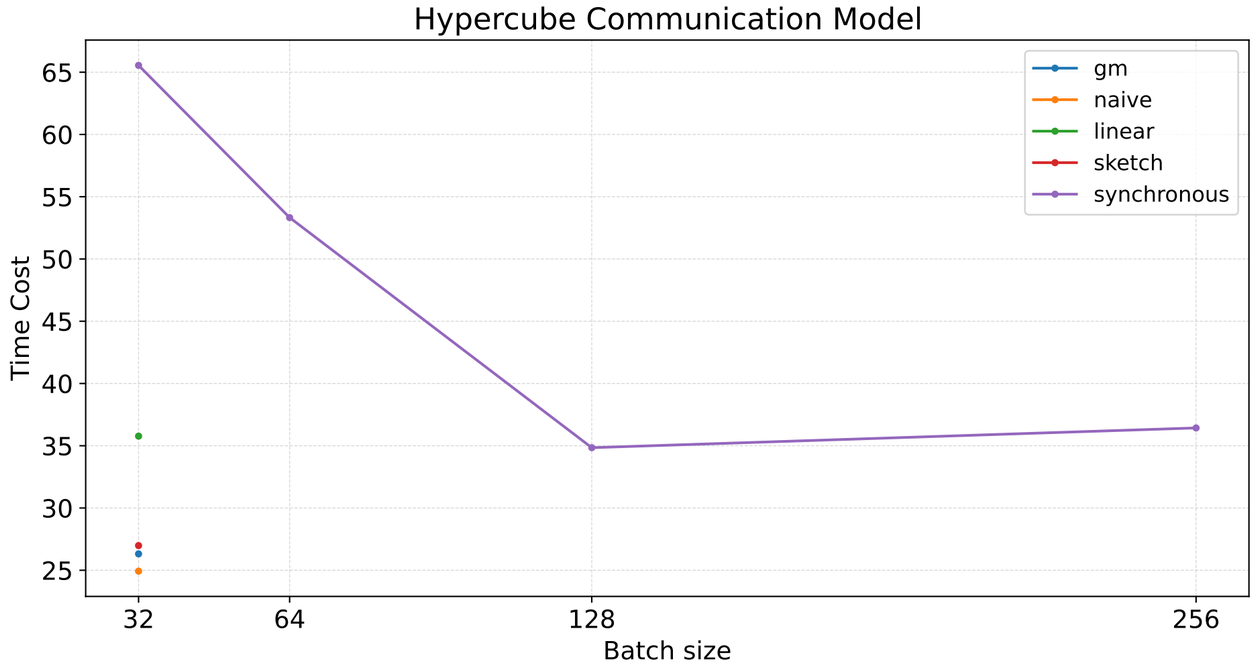
Num Clients : 25 , Θ : 1.0



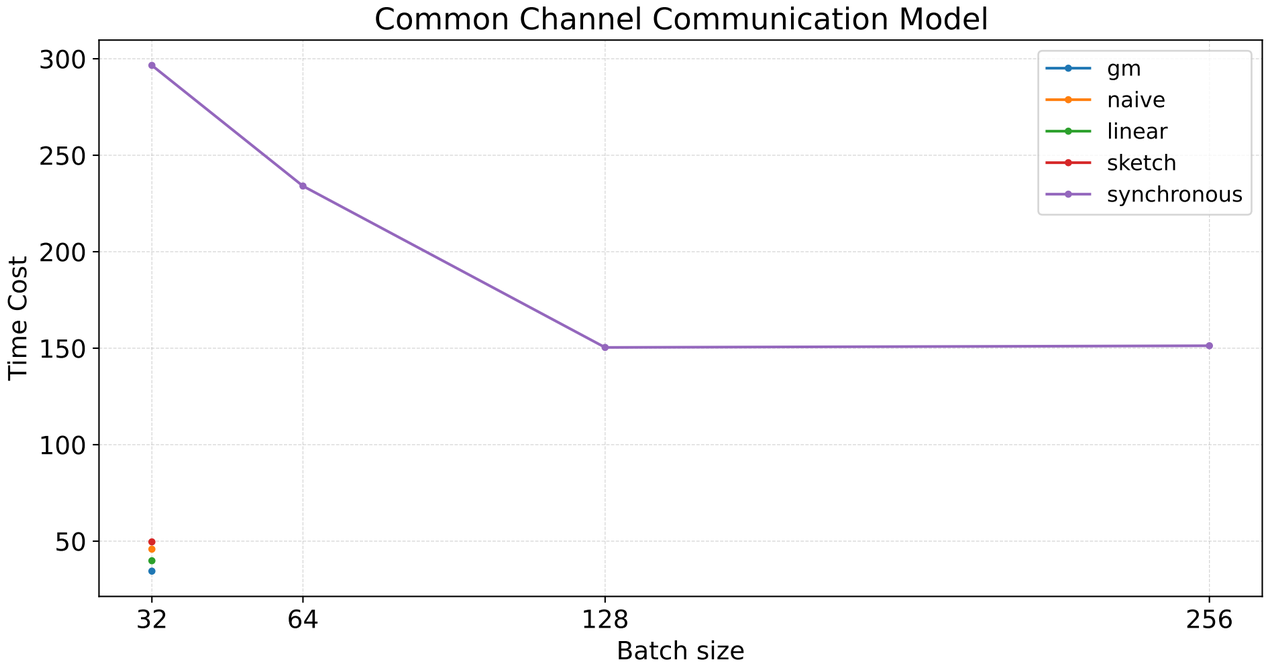


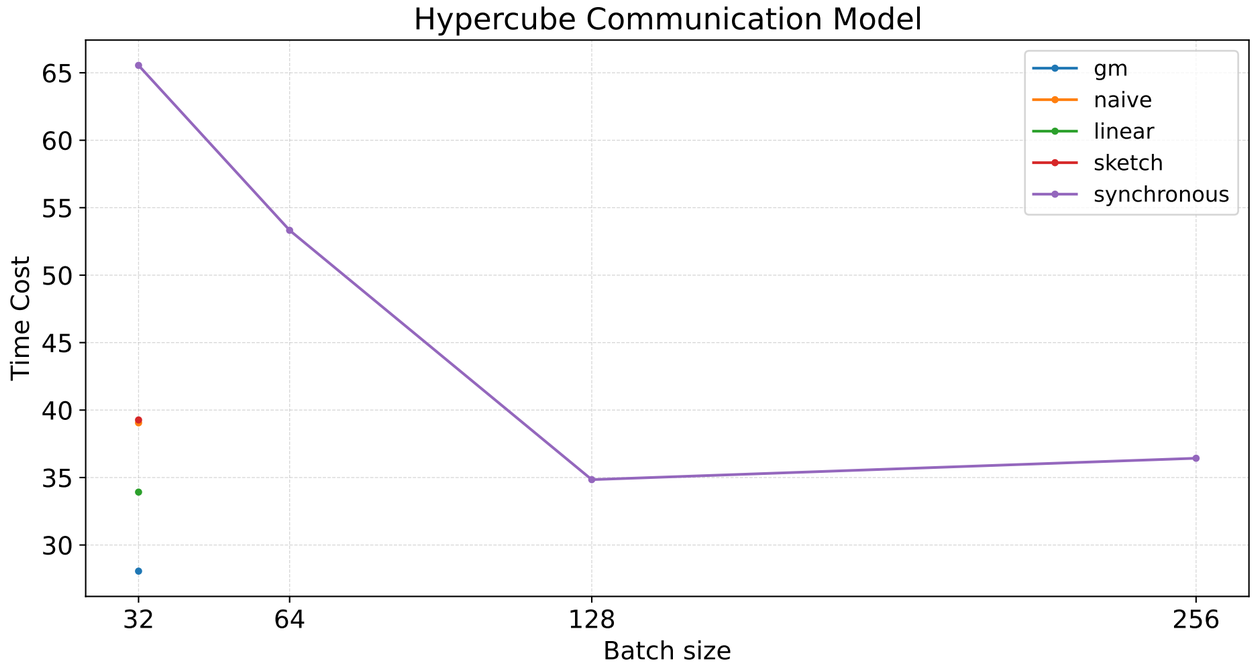
Num Clients : 25 , Θ : 1.5

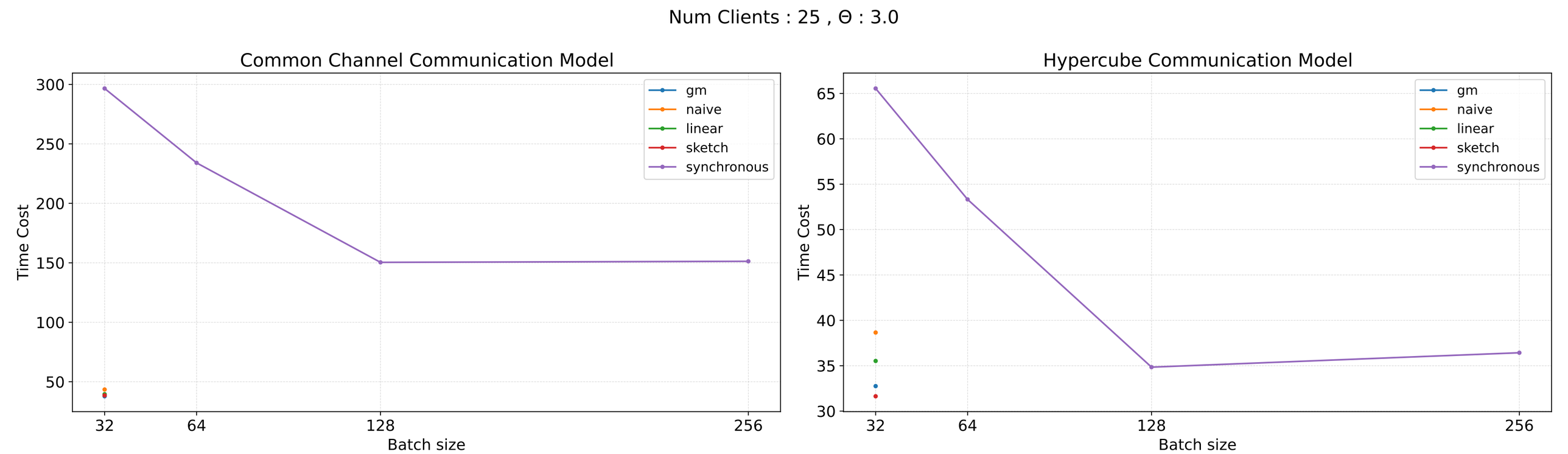




Num Clients : 25 , Θ : 2.0






Num Clients : 25 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
300
250
200
150
100
50
65
60
55
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45
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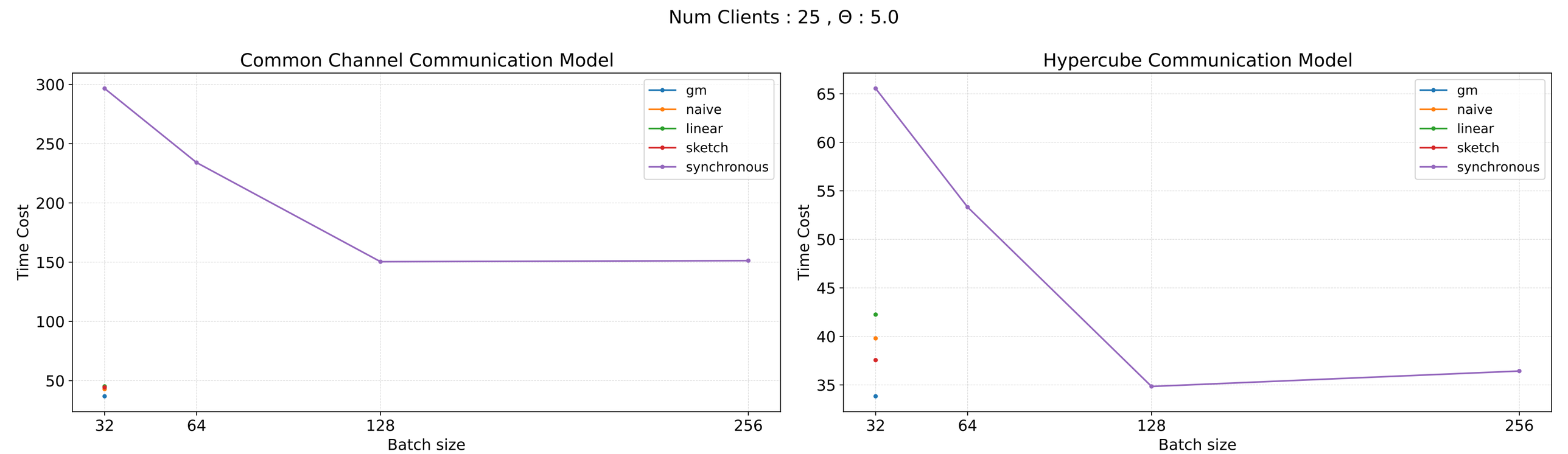
32
64
128
256


Num Clients : 25 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
300
250
200
150
100
50
65
60
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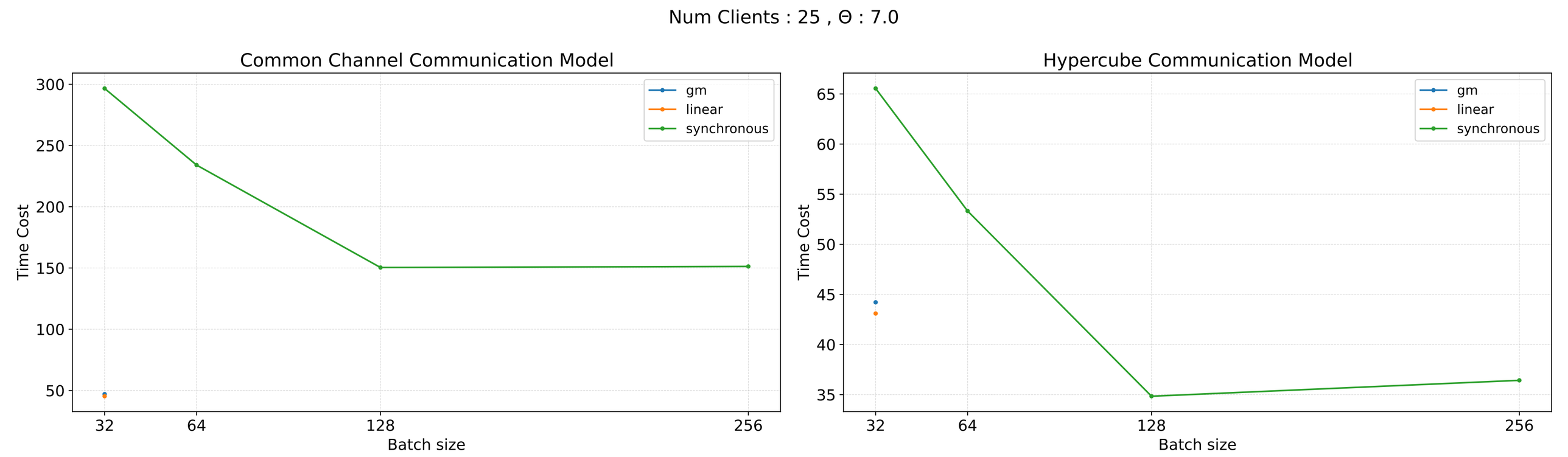
32
64
128
256


Num Clients : 25 , Θ : 7.0
Common Channel Communication Model
Time Cost
Batch size
gm
linear
synchronous
300
250
200
150
100
50
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
linear
synchronous
65
60
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50
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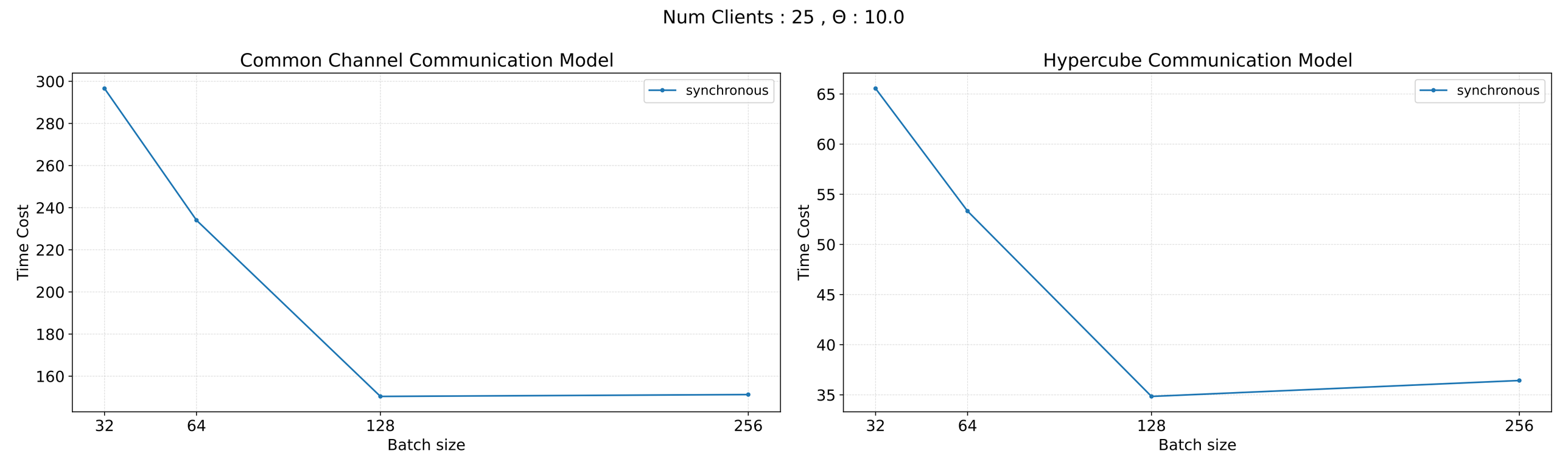
32
64
128
256


Num Clients : 25 , Θ : 10.0
Common Channel Communication Model
Time Cost
Batch size
synchronous
300
280
260
240
220
200
180
160
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
synchronous
65
60
55
50
45
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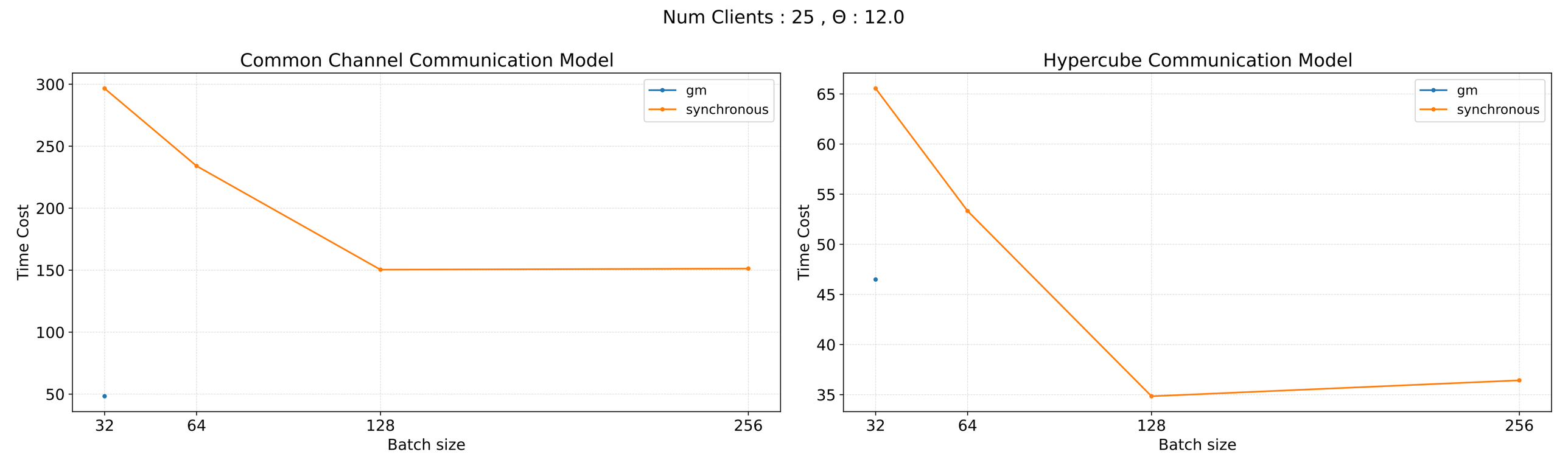
32
64
128
256


Num Clients : 25 , Θ : 12.0
Common Channel Communication Model
Time Cost
Batch size
gm
synchronous
300
250
200
150
100
50
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
synchronous
65
60
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50
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32
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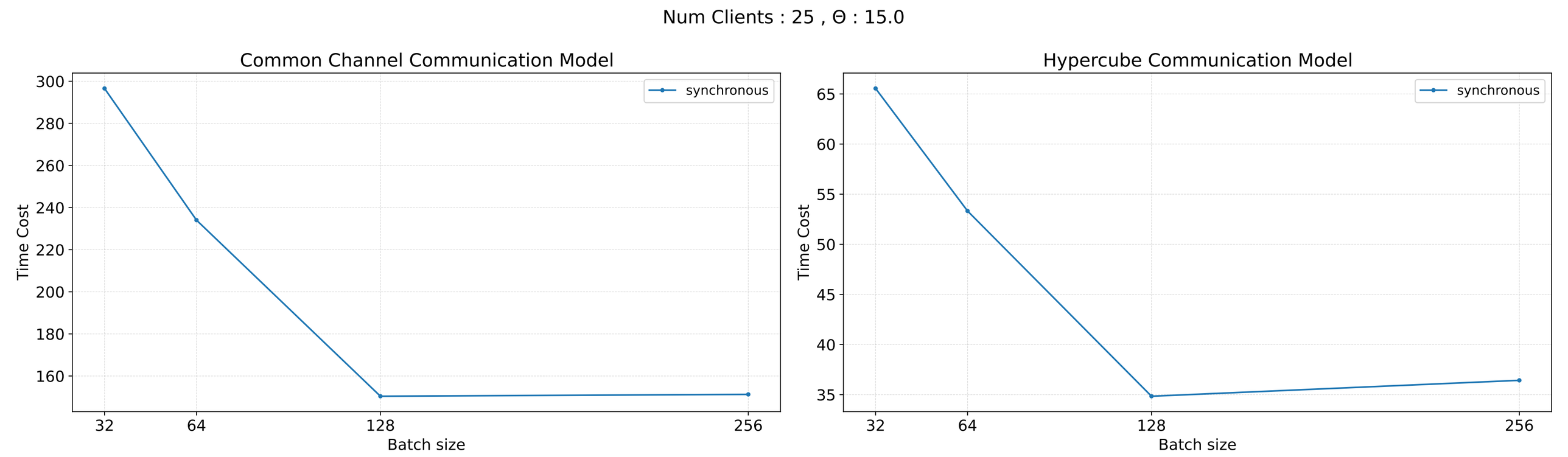
128
256


Num Clients : 25 , Θ : 15.0
Common Channel Communication Model
Time Cost
Batch size
synchronous
300
280
260
240
220
200
180
160
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
synchronous
65
60
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50
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32
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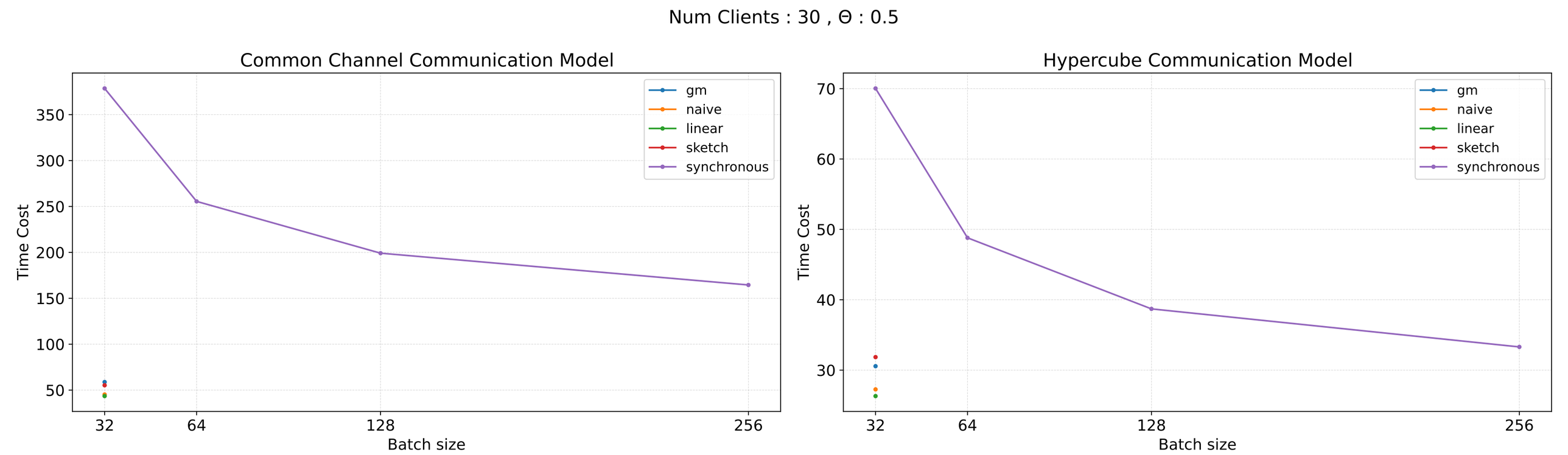
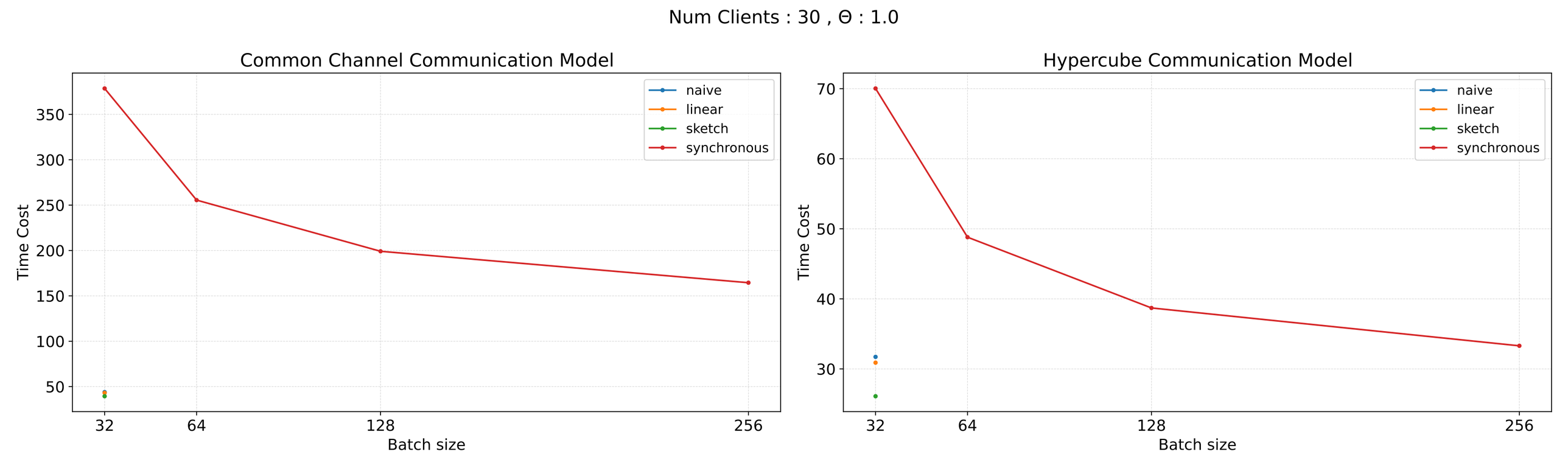
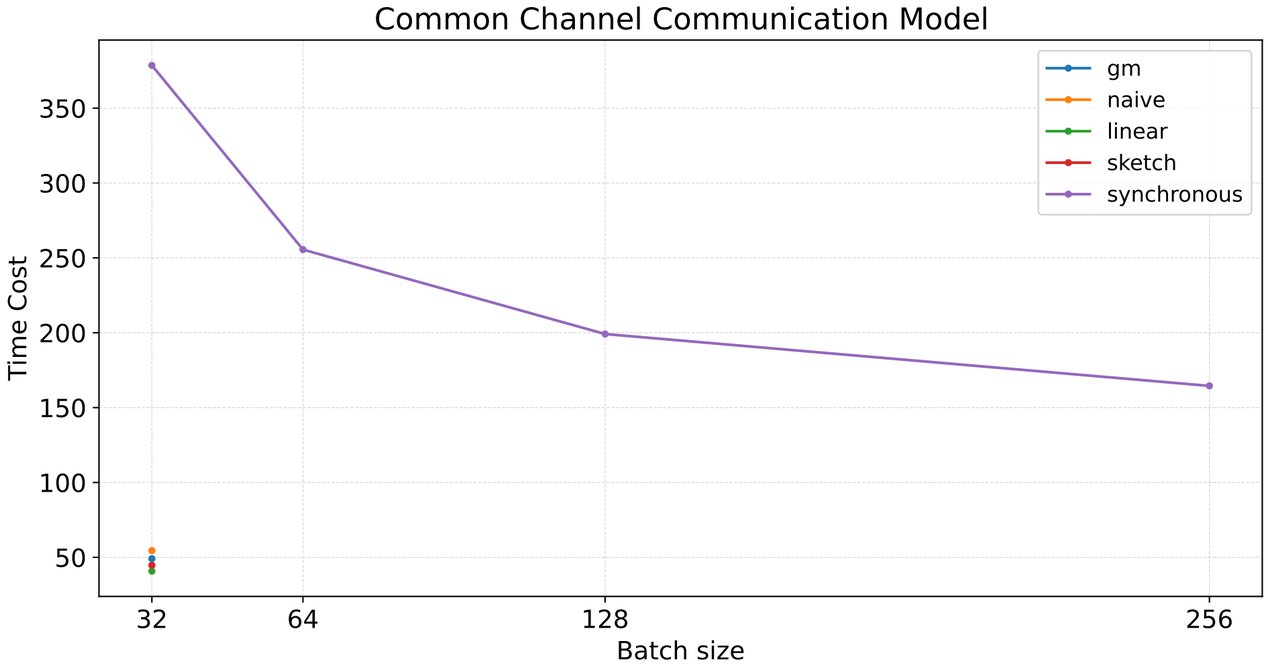
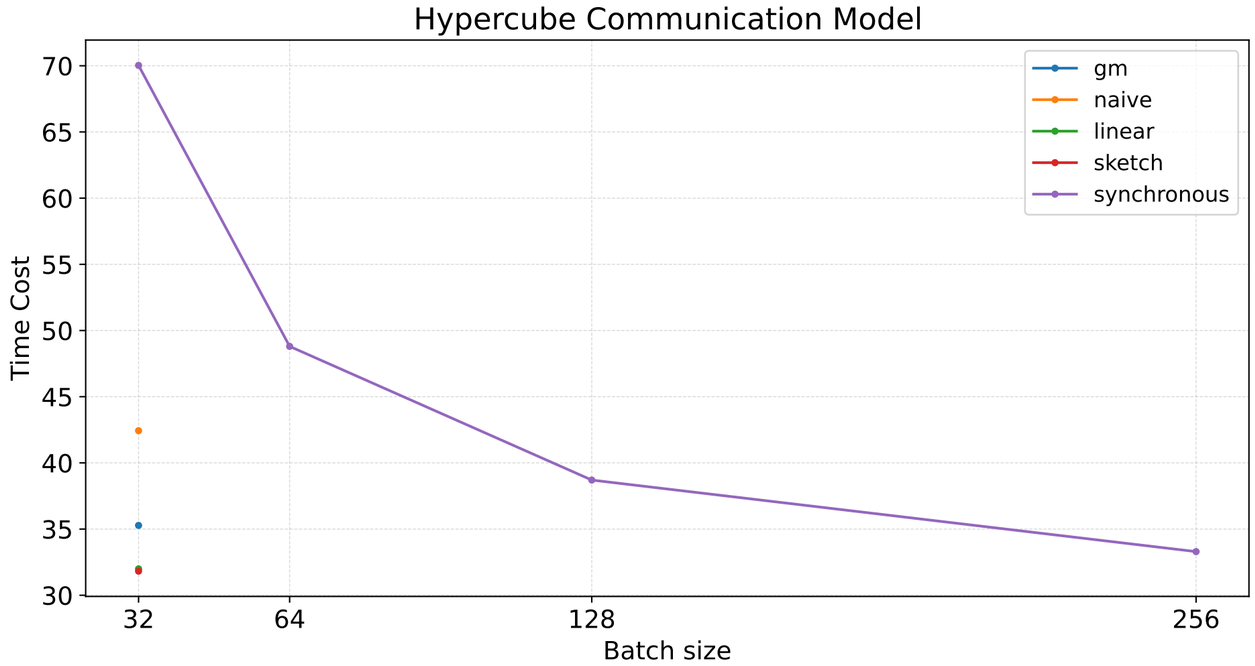
128
256

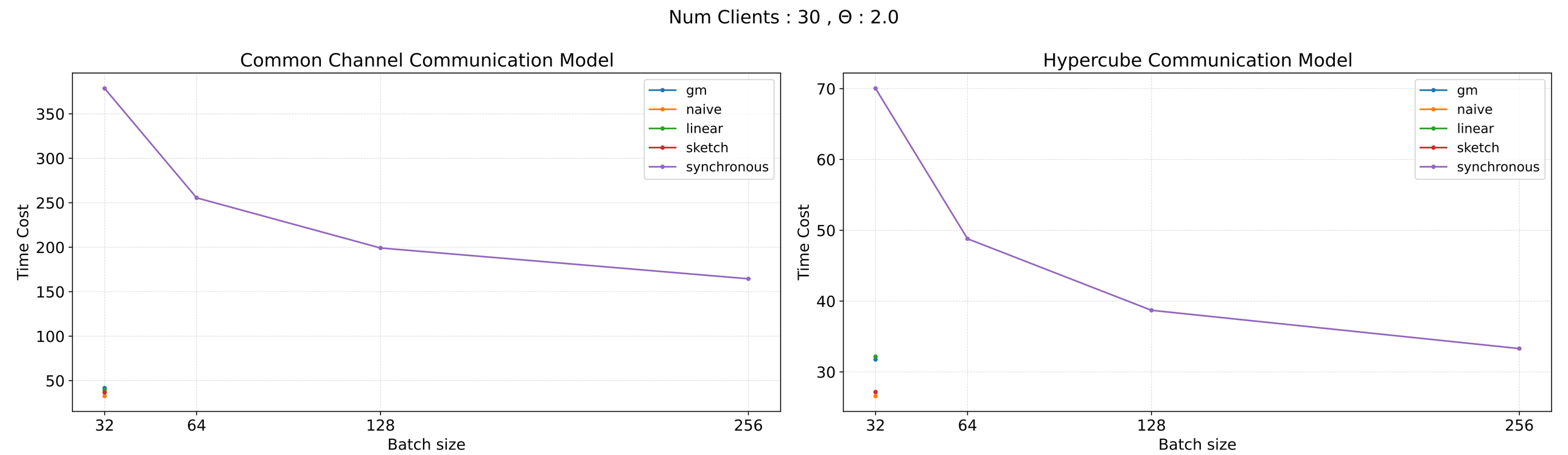

Num Clients : 30 , Θ : 0.5
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
350
300
250
200
150
100
50
70
60
50
40
30
32
64
128
256

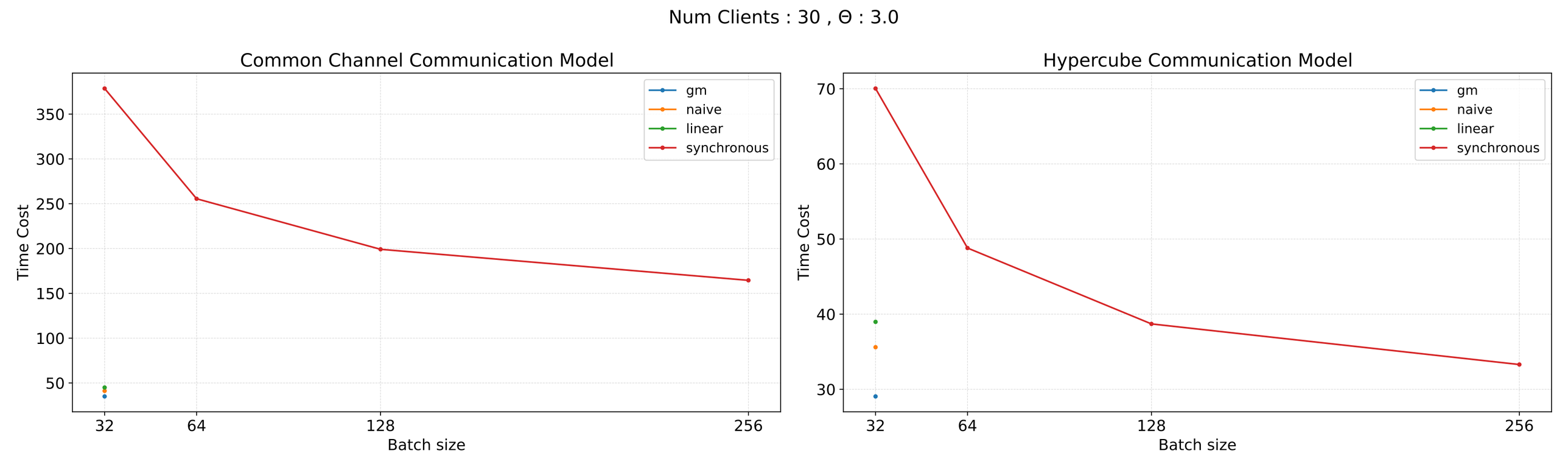

Num Clients : 30 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
naive
linear
sketch
synchronous
Time Cost
Batch size
50
100
150
200
250
300
350
30
40
50
60
70
32
64
128
256

Num Clients : 30 , Θ : 1.5






Num Clients : 30 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
50
100
150
200
250
300
350
30
40
50
60
70
32
64
128
256


Num Clients : 30 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
synchronous
350
300
250
200
150
100
50
70
60
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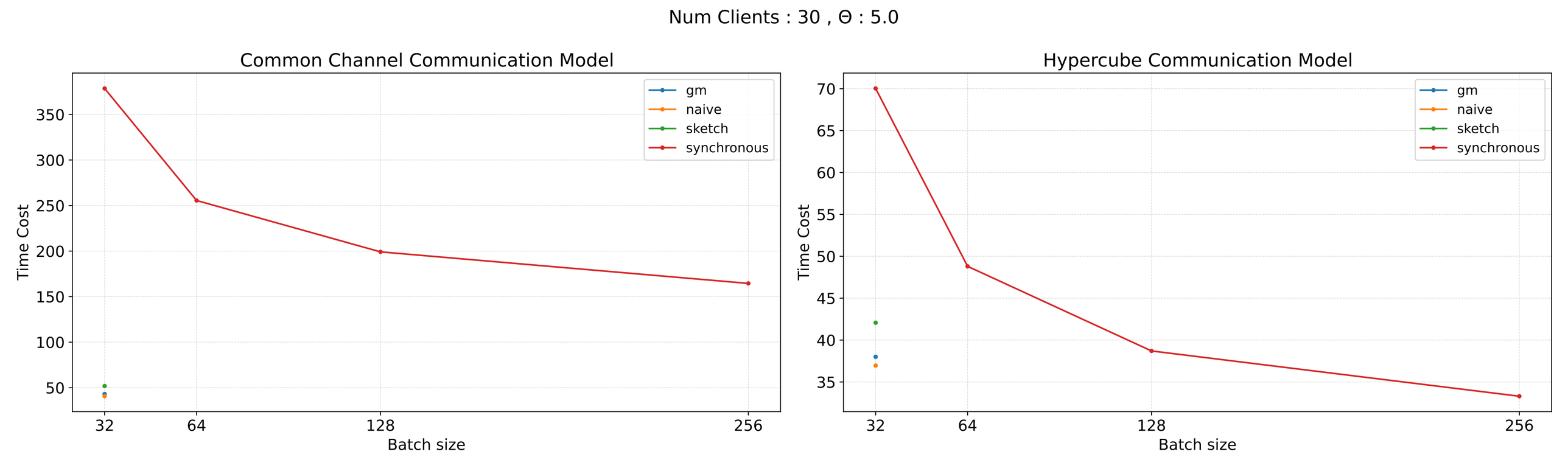
32
64
128
256


Num Clients : 30 , Θ : 5.0
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
sketch
synchronous
350
300
250
200
150
100
50
70
65
60
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50
45
40
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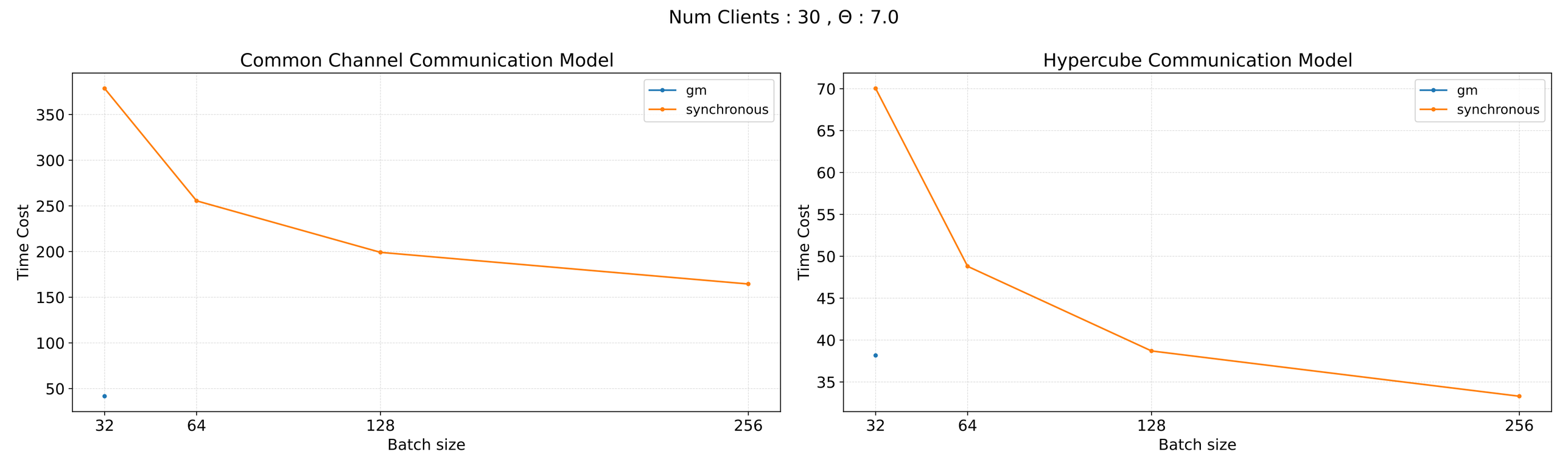
32
64
128
256


Num Clients : 30 , Θ : 7.0
Common Channel Communication Model
Time Cost
Batch size
gm
synchronous
350
300
250
200
150
100
50
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
gm
synchronous
70
65
60
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50
45
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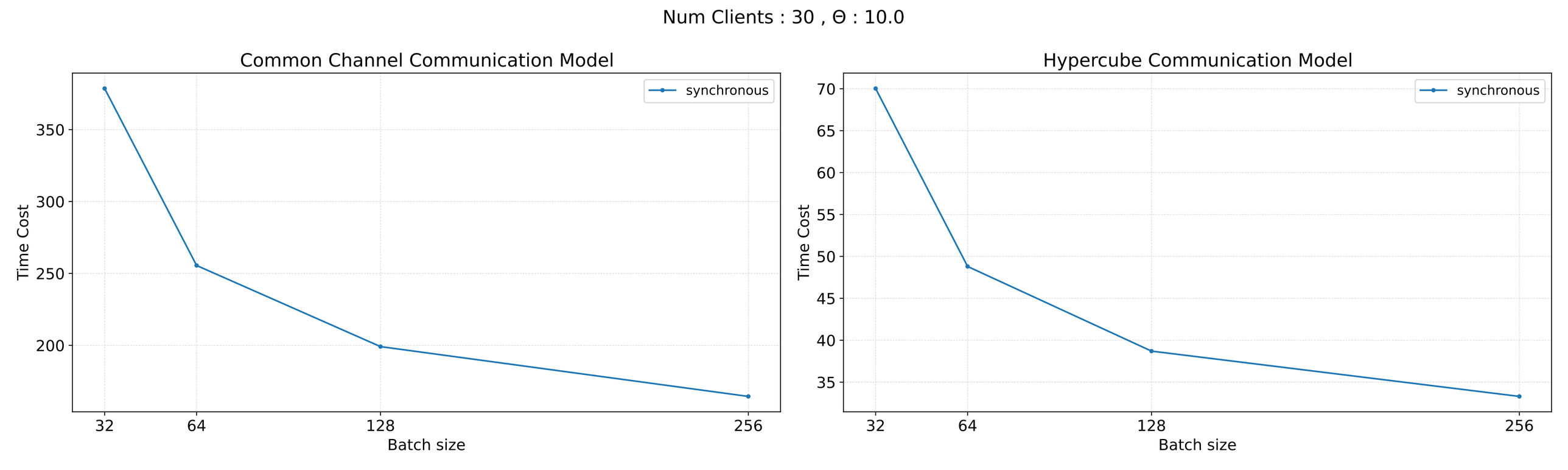
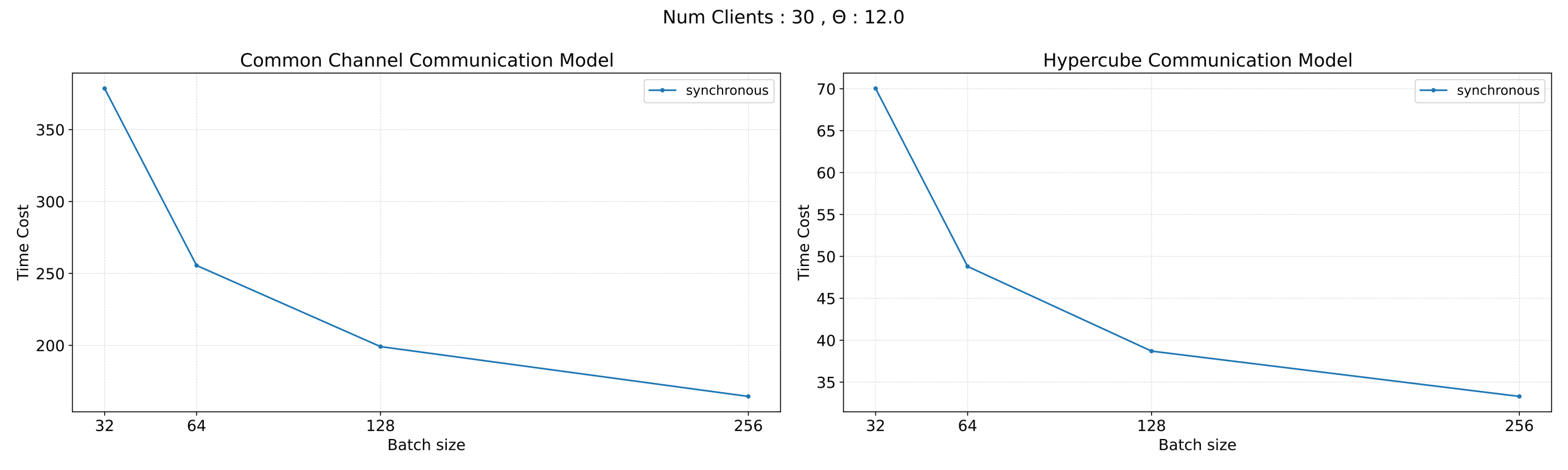
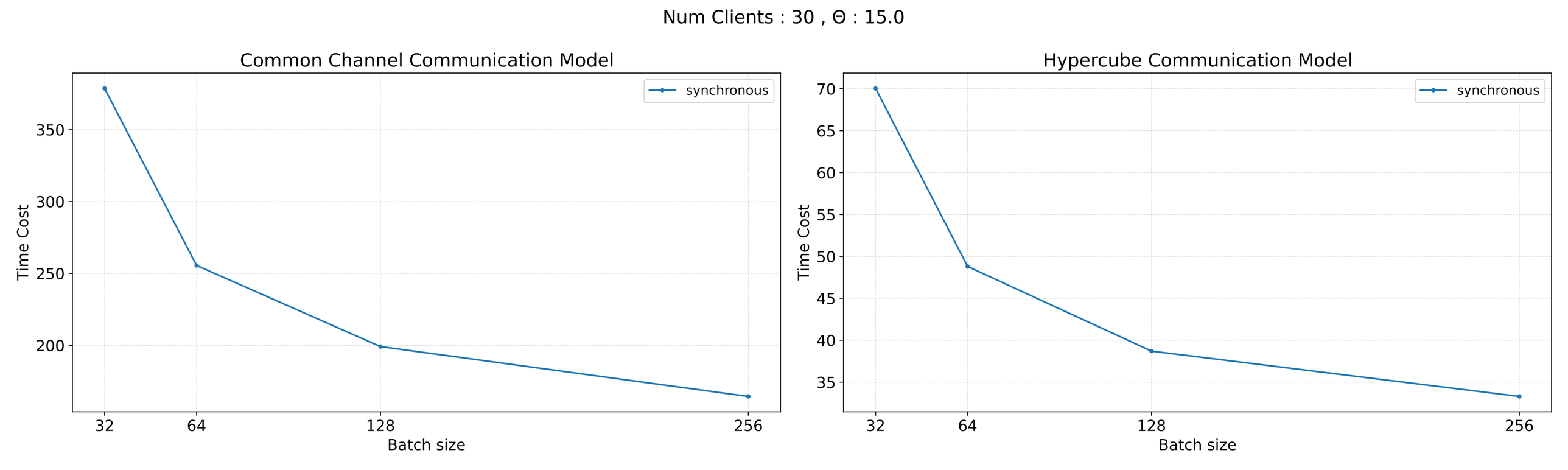
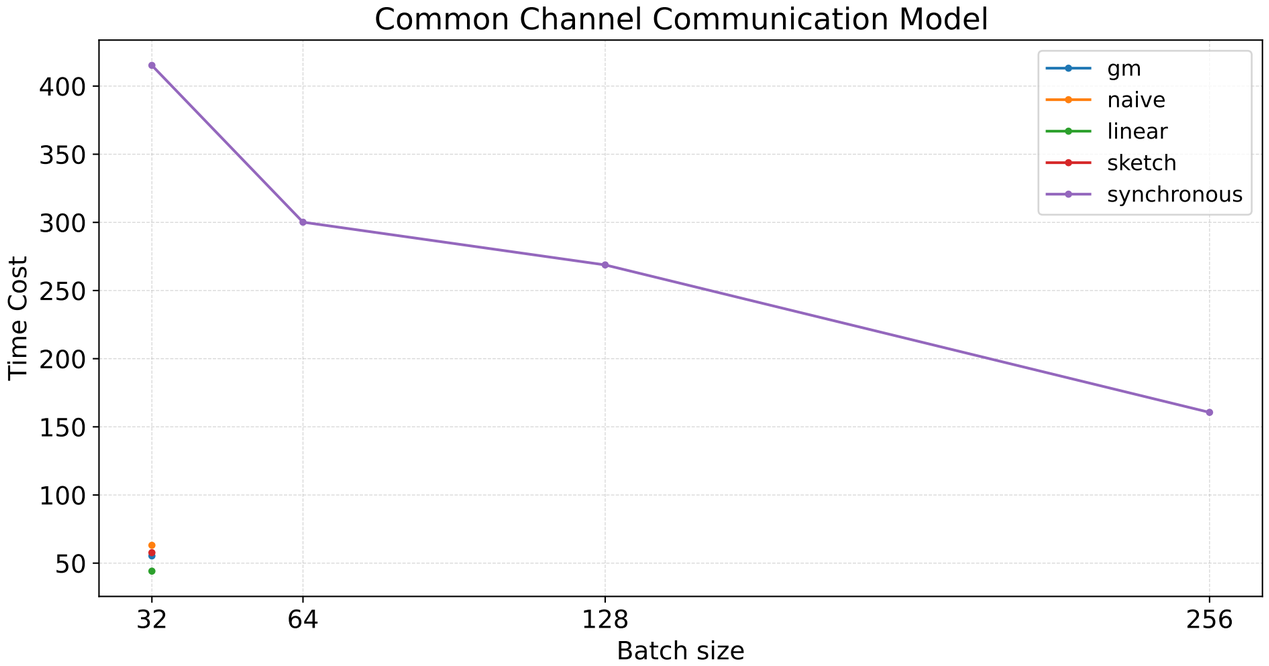
35
32
64
128
256

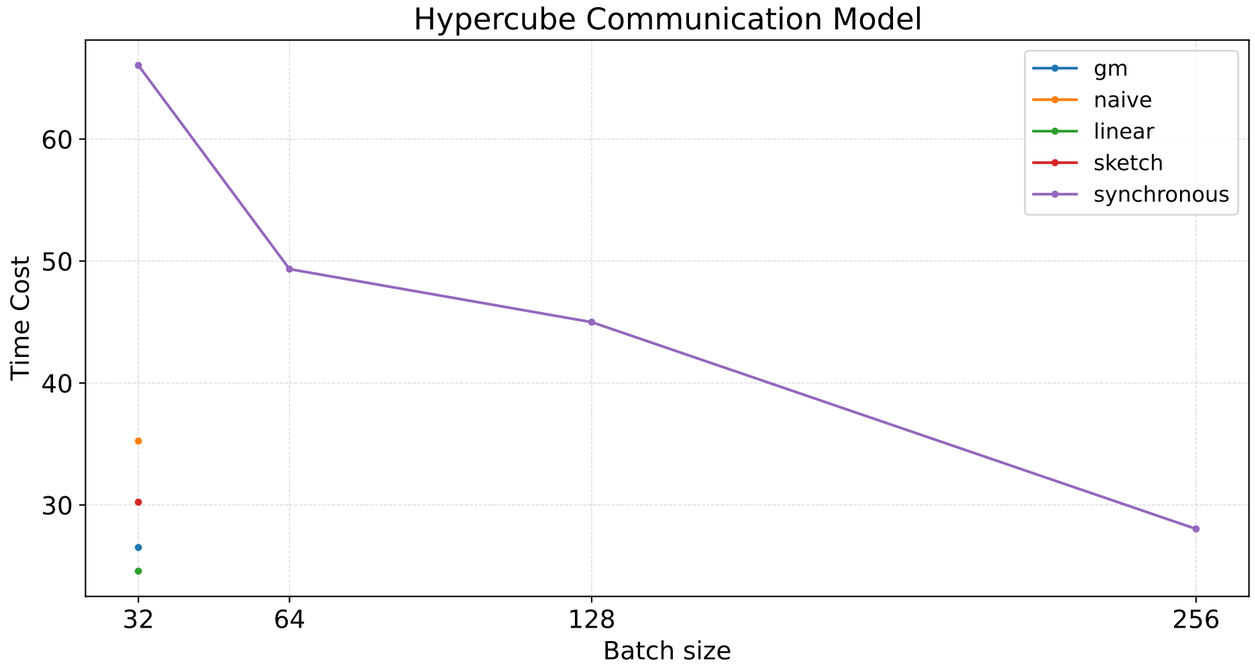

Num Clients : 30 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

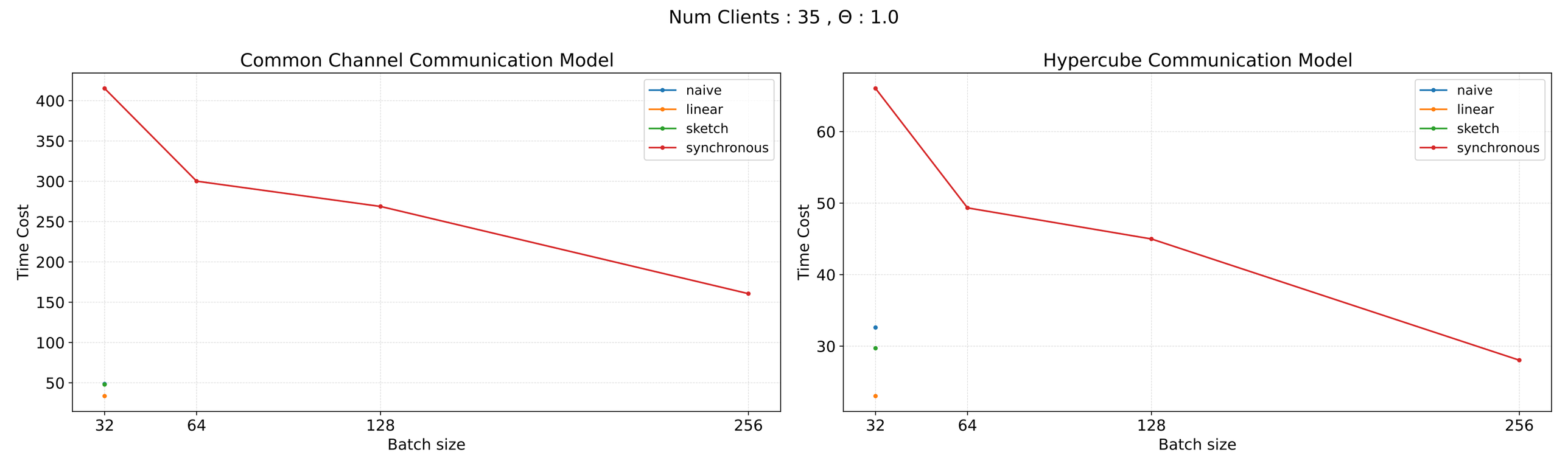

Num Clients : 30 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
70
65
60
55
50
45
40
35
32
64
128
256
Batch size


Num Clients : 30 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

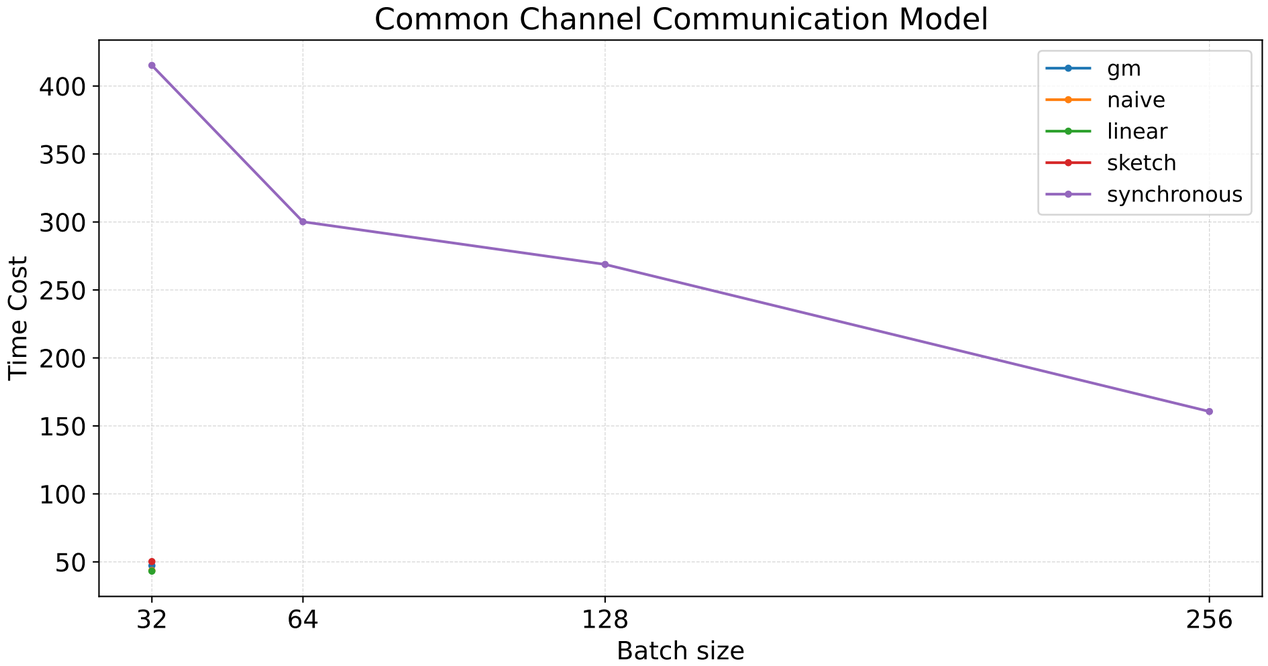
Num Clients : 35 , Θ : 0.5

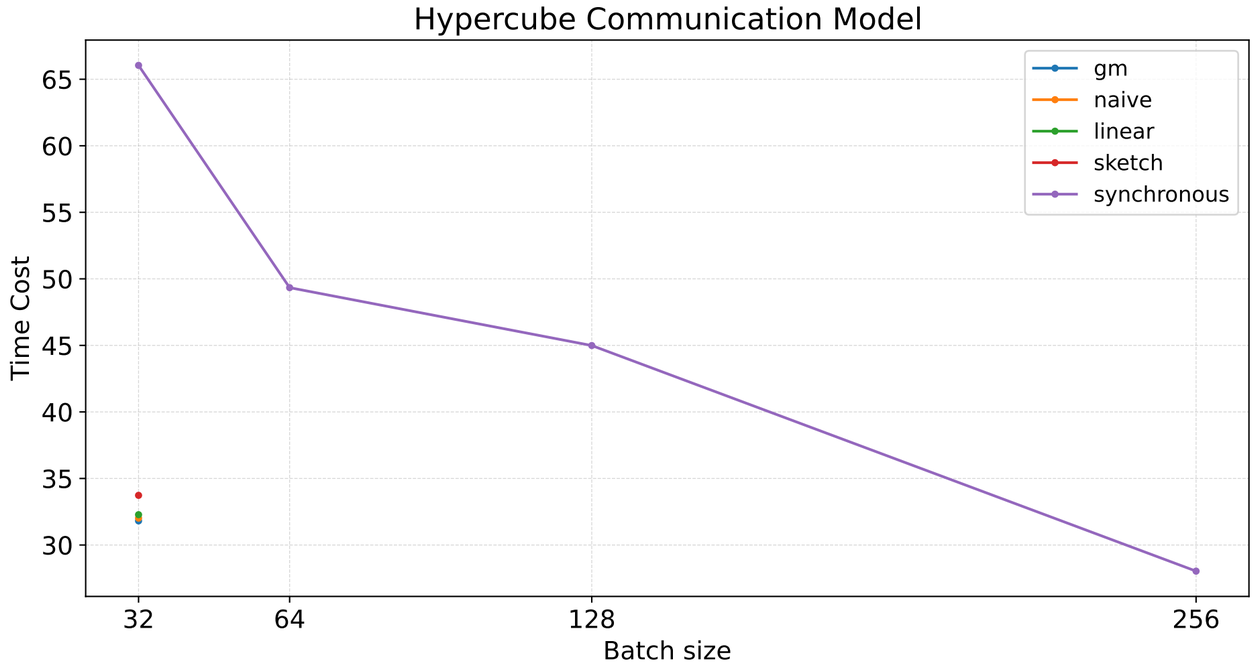


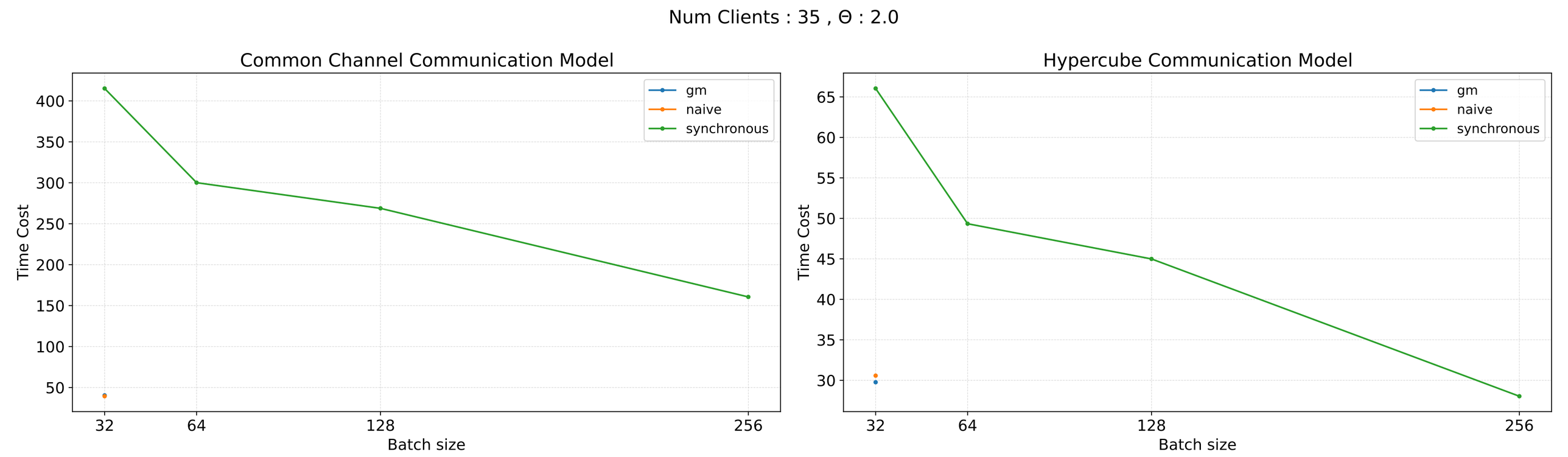


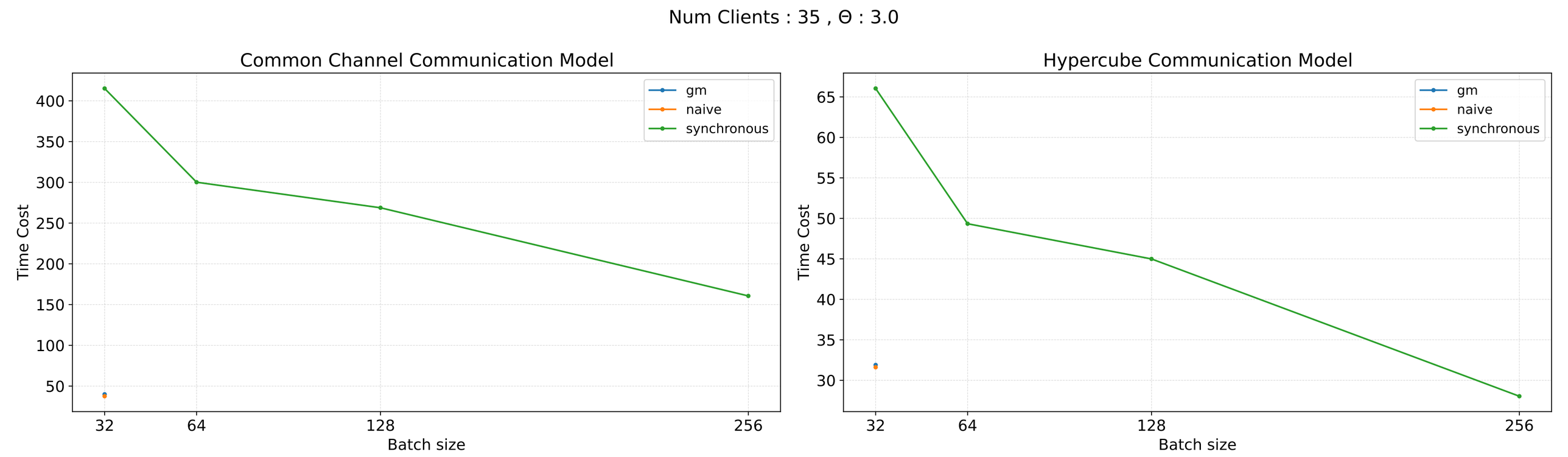

Num Clients : 35 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
naive
linear
sketch
synchronous
Time Cost
Batch size
400
350
300
250
200
150
100
50
60
50
40
30
32
64
128
256

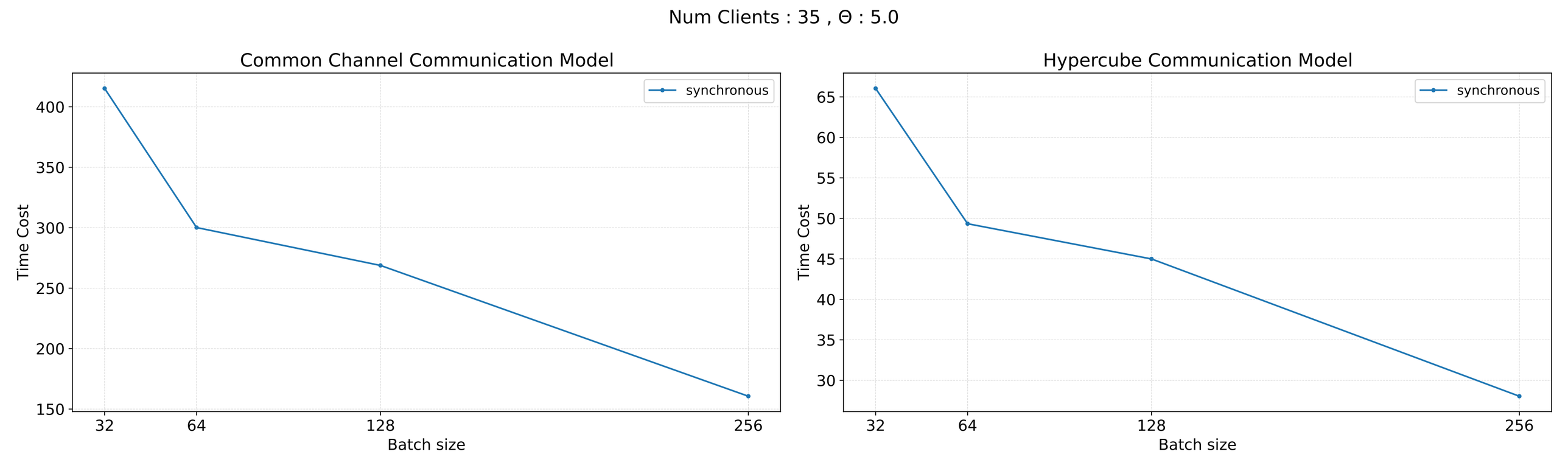
Num Clients : 35 , Θ : 1.5



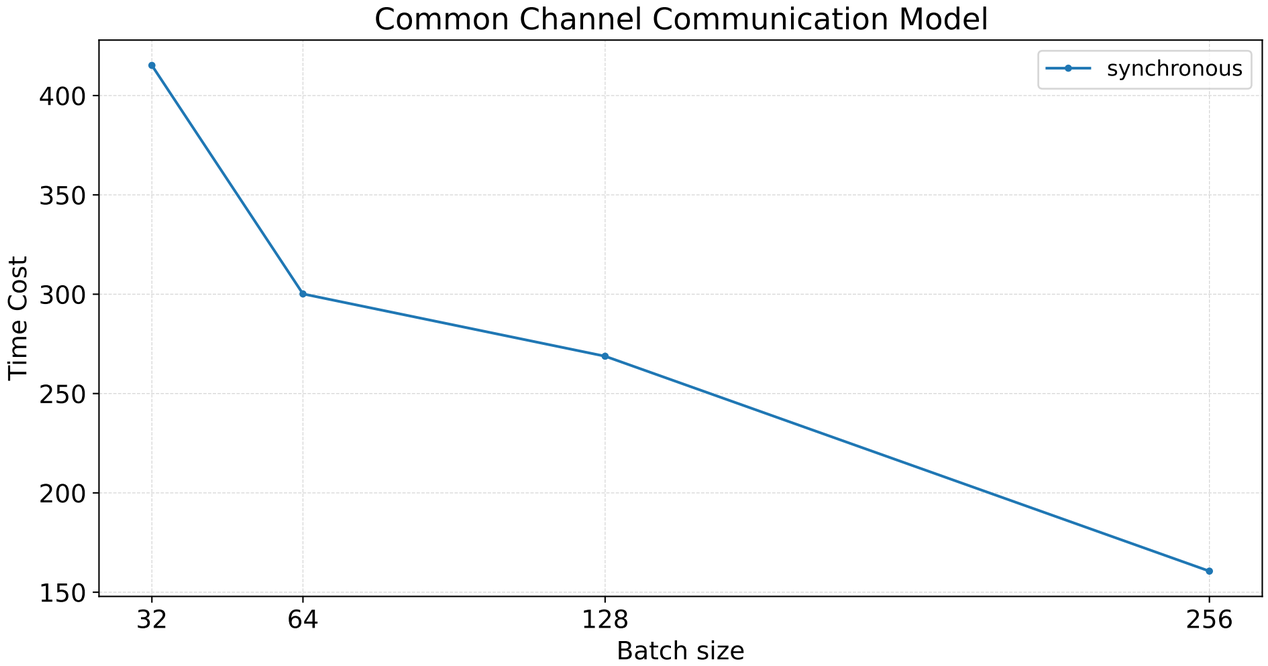


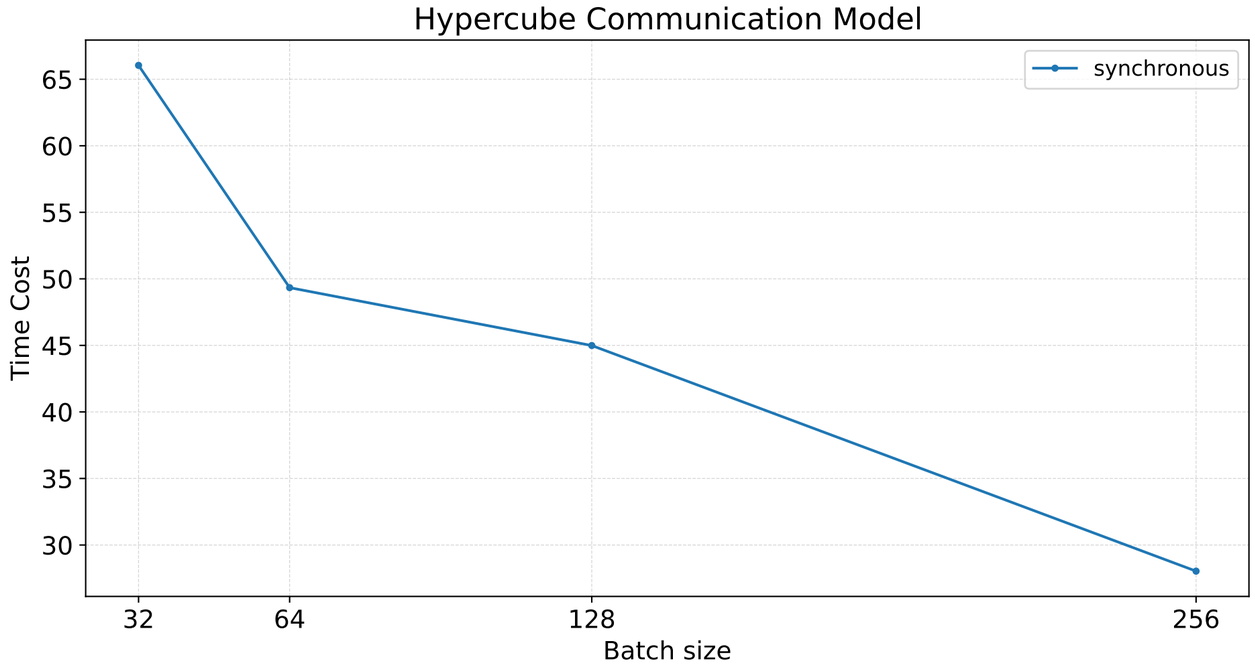

Num Clients : 35 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
gm
naive
synchronous
Time Cost
Batch size
400
350
300
250
200
150
100
50
65
60
55
50
45
40
35
30
32
64
128
256

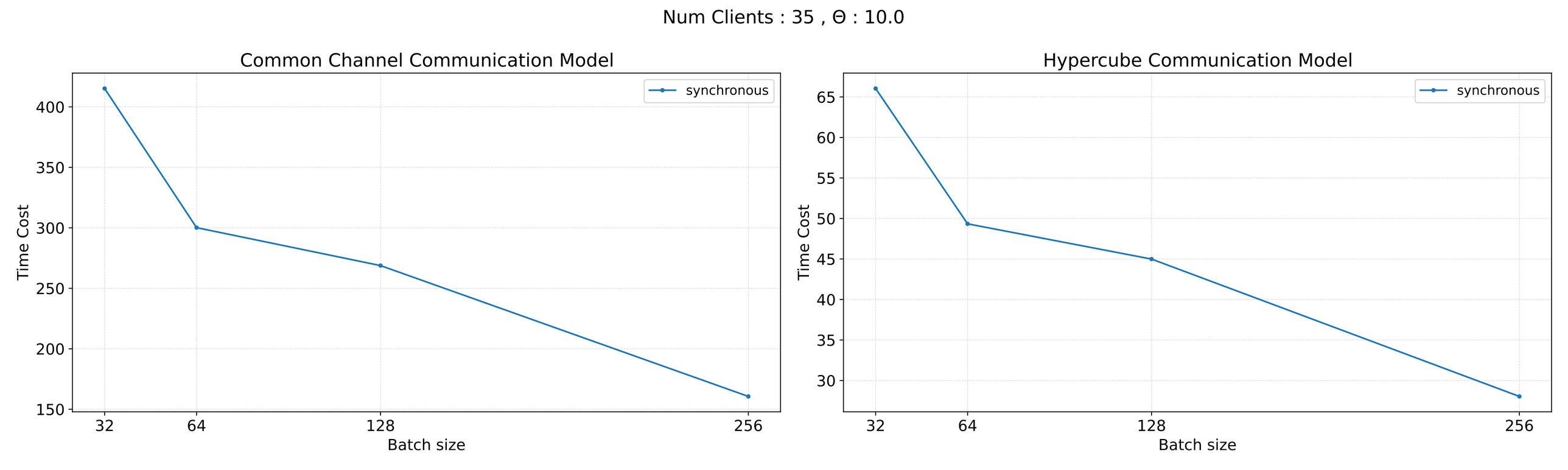

Num Clients : 35 , Θ : 3.0
Common Channel Communication Model
Hypercube Communication Model
gm
naive
synchronous
Time Cost
Batch size
400
350
300
250
200
150
100
50
65
60
55
50
45
40
35
30
32
64
128
256

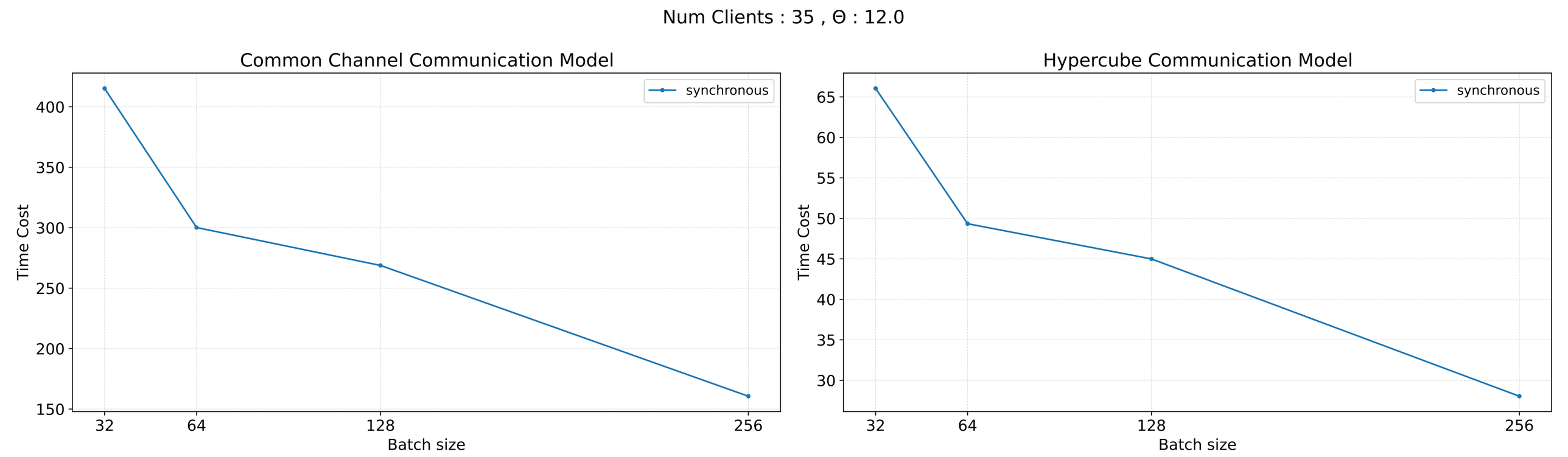

Num Clients : 35 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
400
350
300
250
200
150
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
65
60
55
50
45
40
35
30
32
64
128
256
Batch size

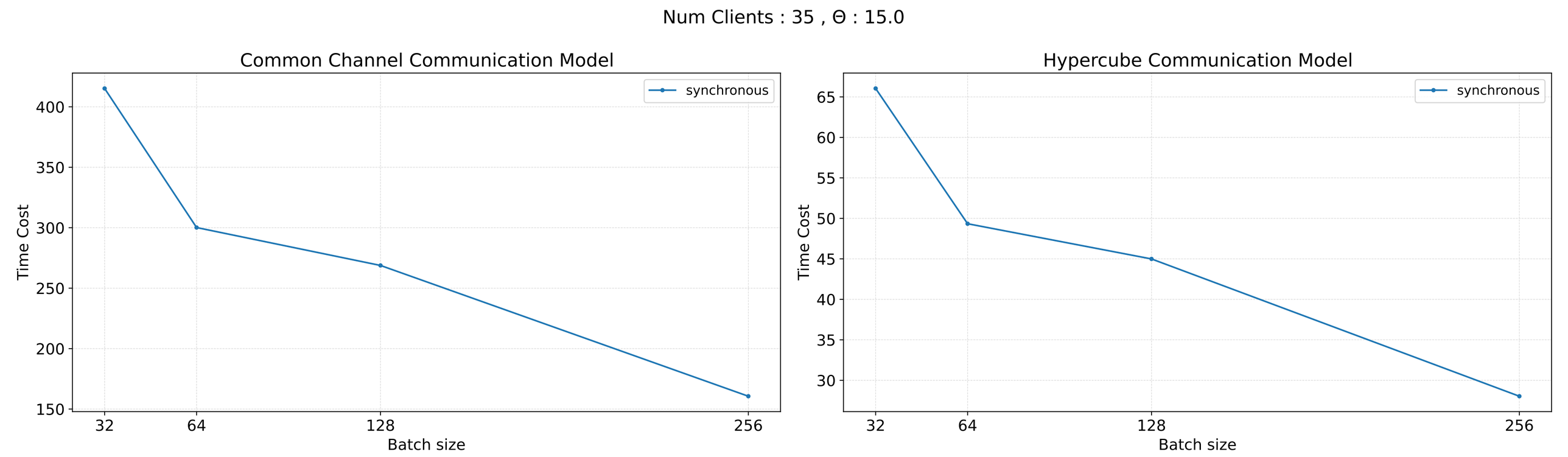
Num Clients : 35 , Θ : 7.0

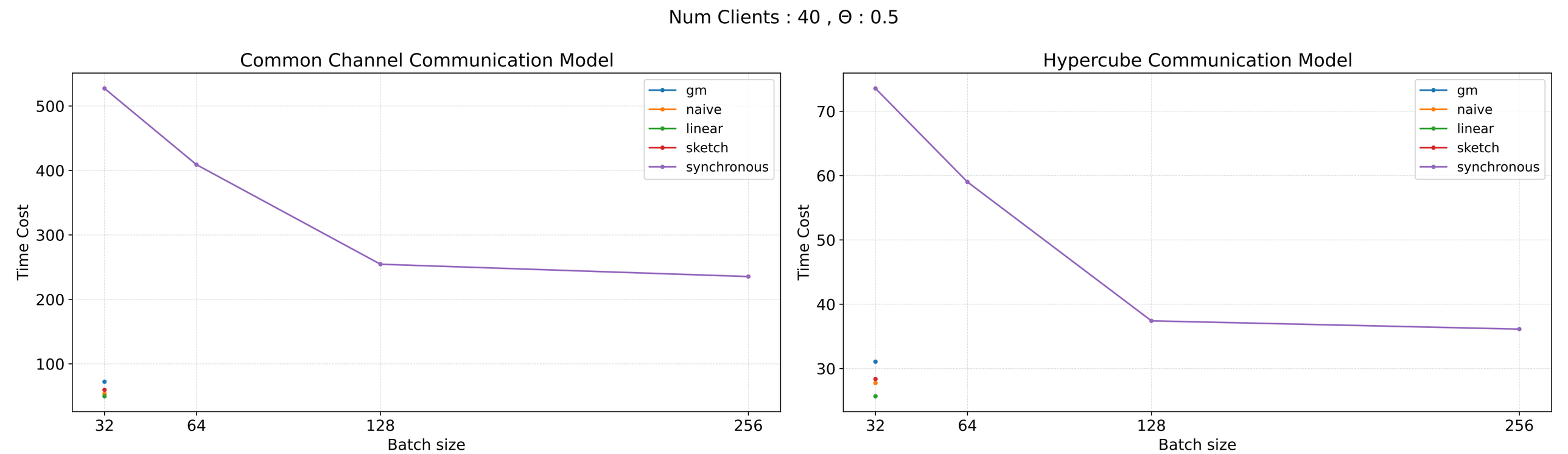


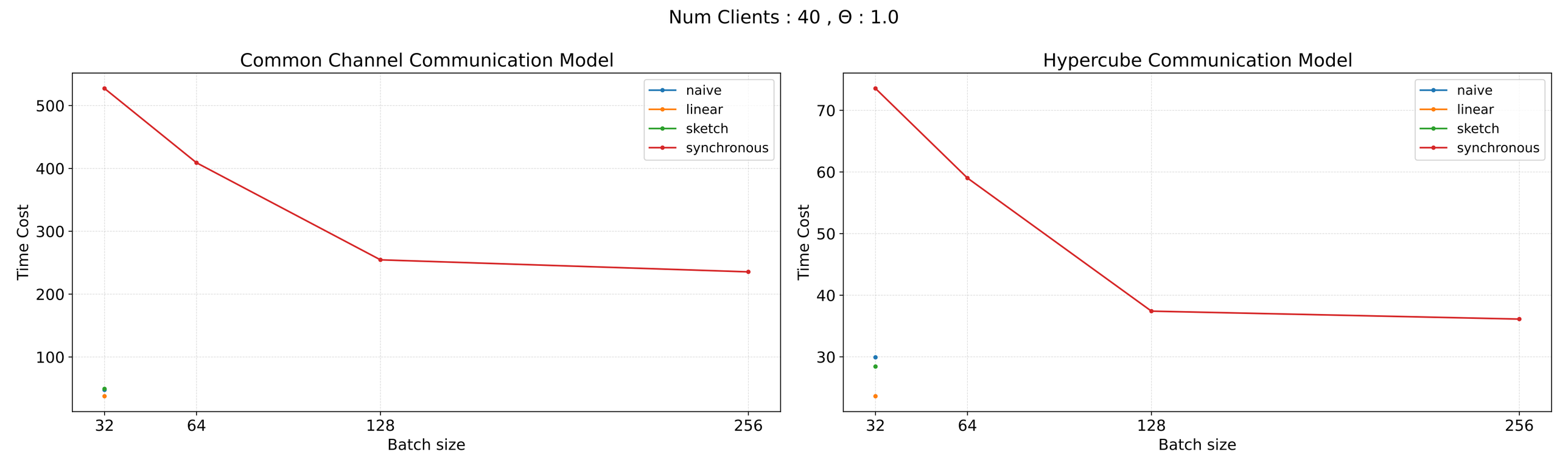


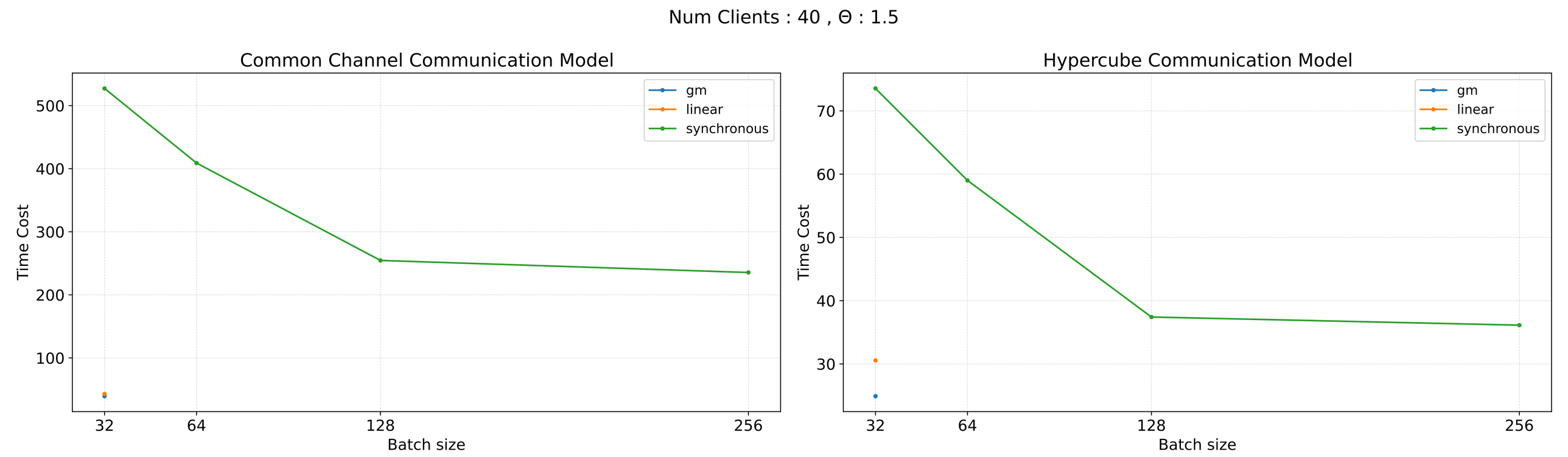

Num Clients : 35 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
400
350
300
250
200
150
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
65
60
55
50
45
40
35
30
32
64
128
256
Batch size


Num Clients : 35 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
400
350
300
250
200
150
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
65
60
55
50
45
40
35
30
32
64
128
256
Batch size

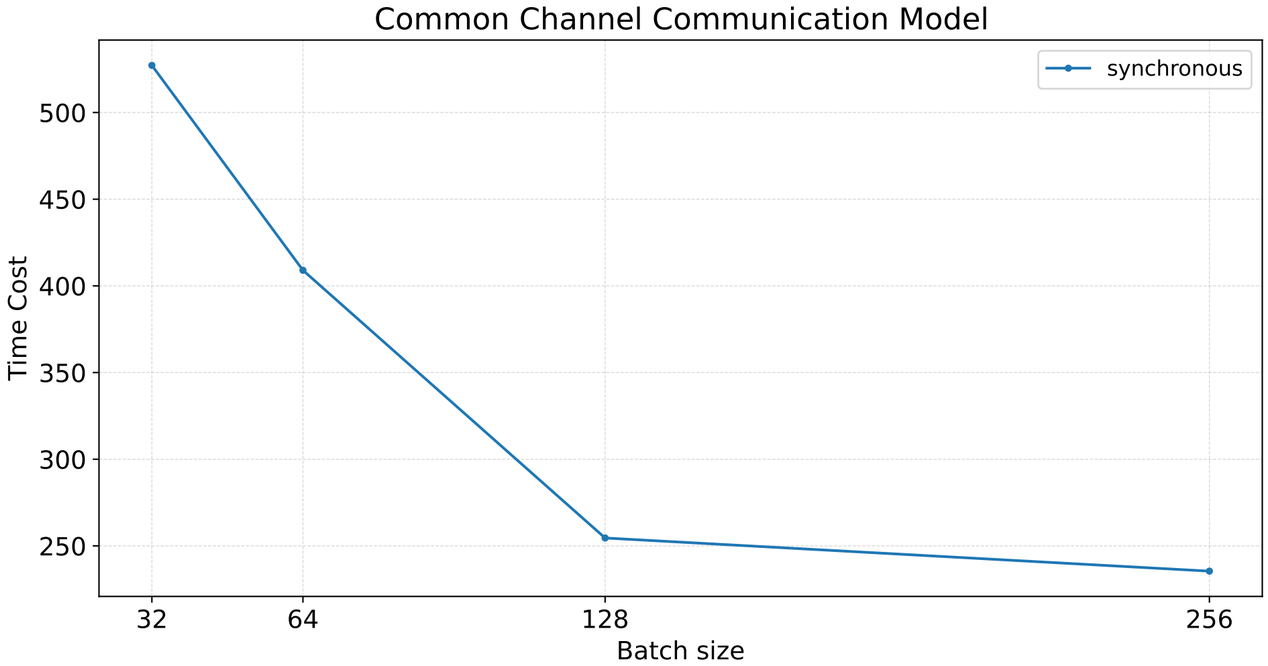

Num Clients : 35 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
400
350
300
250
200
150
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
65
60
55
50
45
40
35
30
32
64
128
256
Batch size

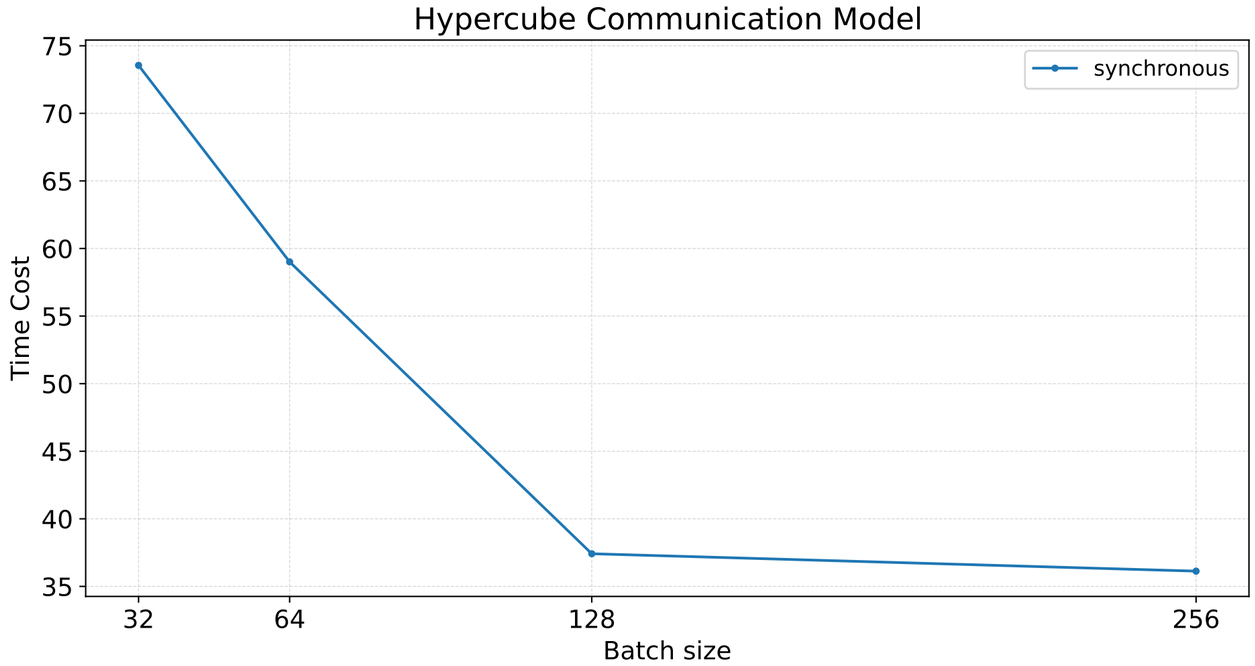

Num Clients : 40 , Θ : 0.5
Common Channel Communication Model
Hypercube Communication Model
Time Cost
Batch size
gm
naive
linear
sketch
synchronous
100
200
300
400
500
30
40
50
60
70
32
64
128
256

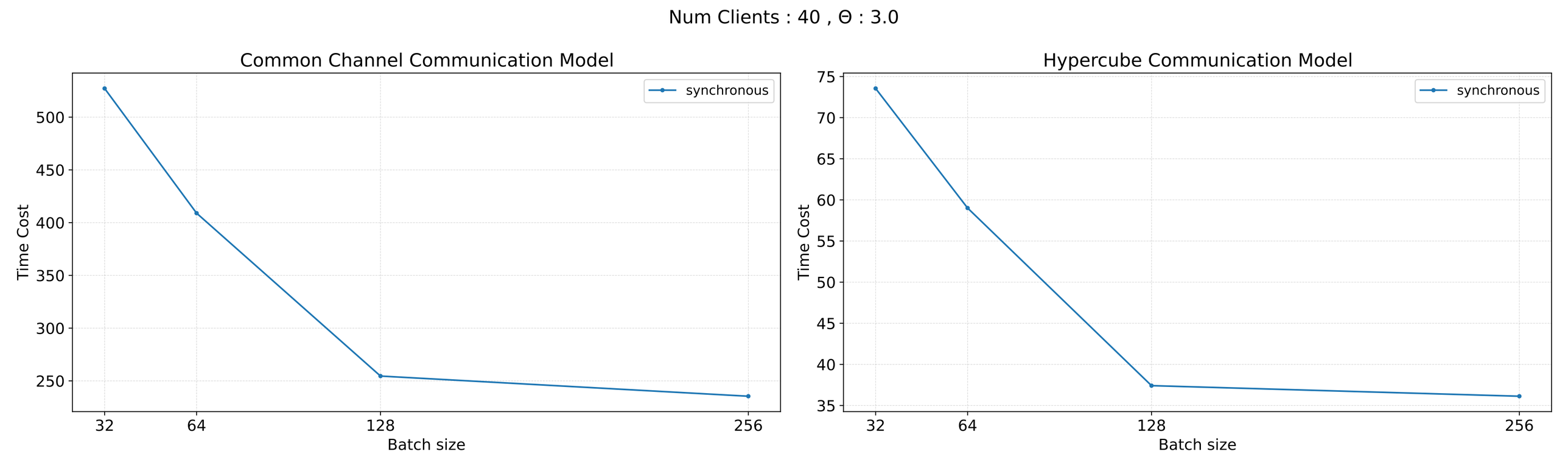

Num Clients : 40 , Θ : 1.0
Common Channel Communication Model
Hypercube Communication Model
naive
linear
sketch
synchronous
Time Cost
Batch size
100
200
300
400
500
30
40
50
60
70
32
64
128
256

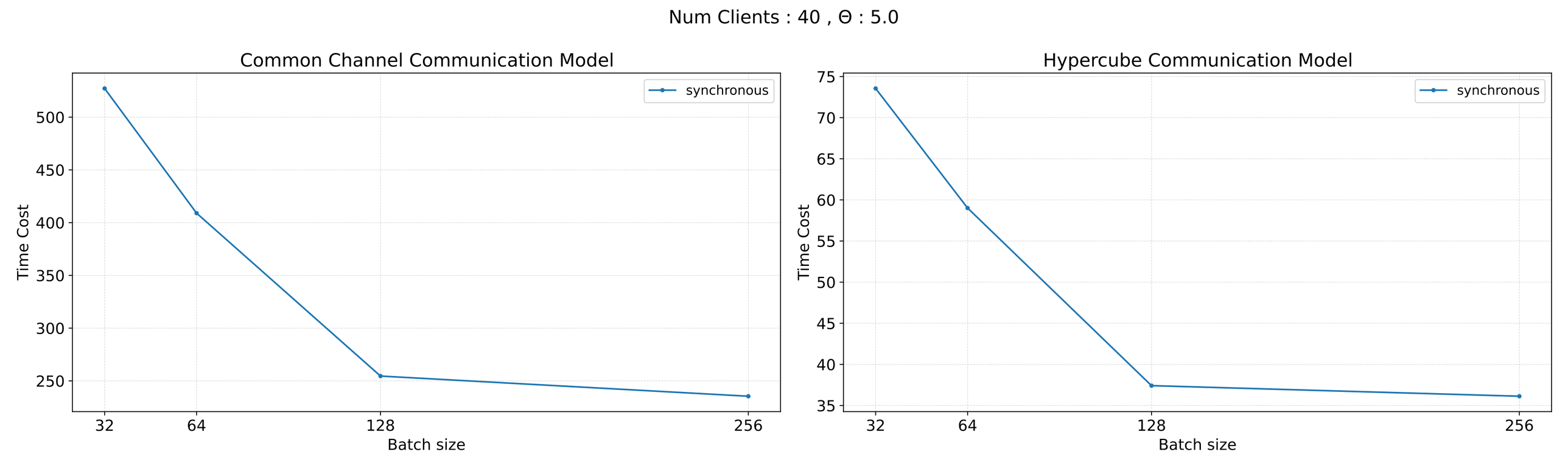

Num Clients : 40 , Θ : 1.5
Common Channel Communication Model
Hypercube Communication Model
gm
linear
synchronous
Time Cost
Batch size
100
200
300
400
500
30
40
50
60
70
32
64
128
256

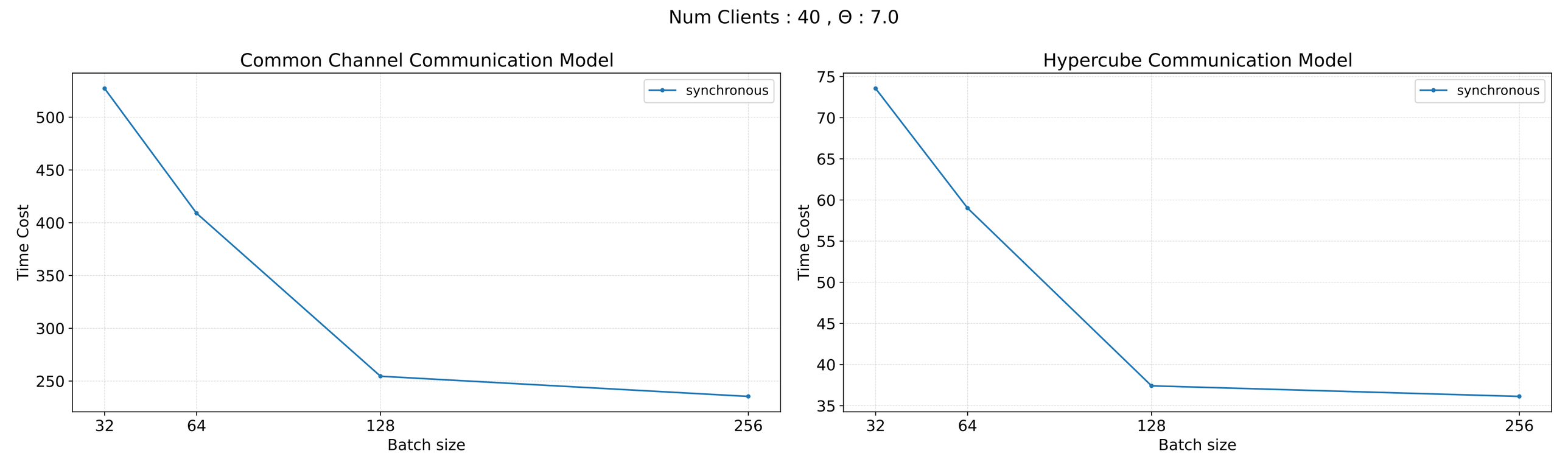
Num Clients : 40 , Θ : 2.0

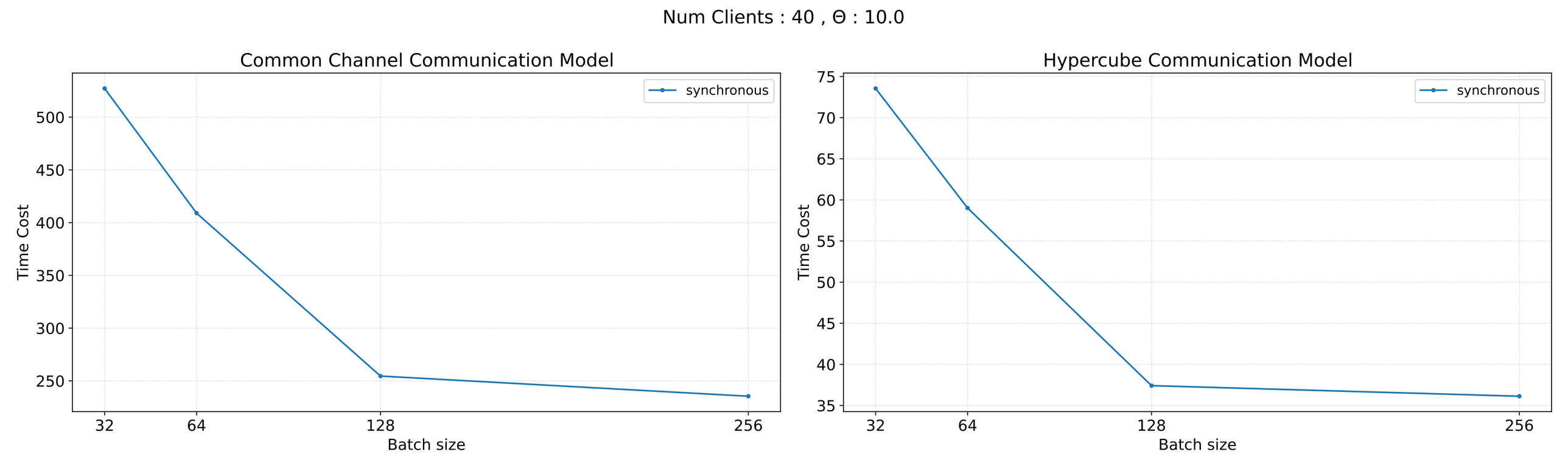


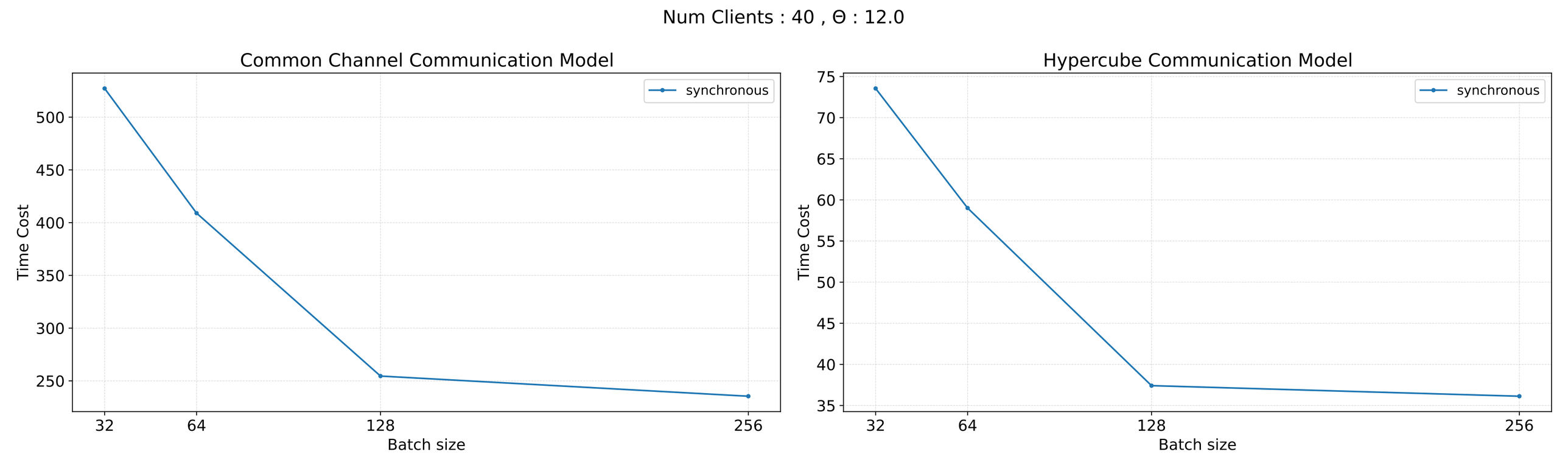


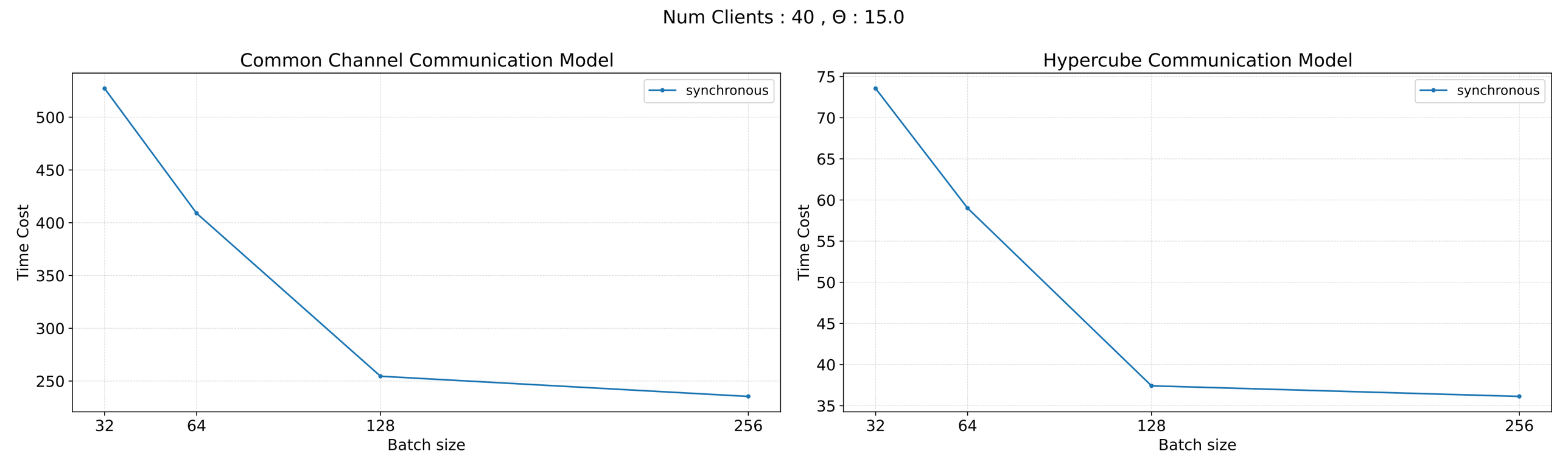

Num Clients : 40 , Θ : 3.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size


Num Clients : 40 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

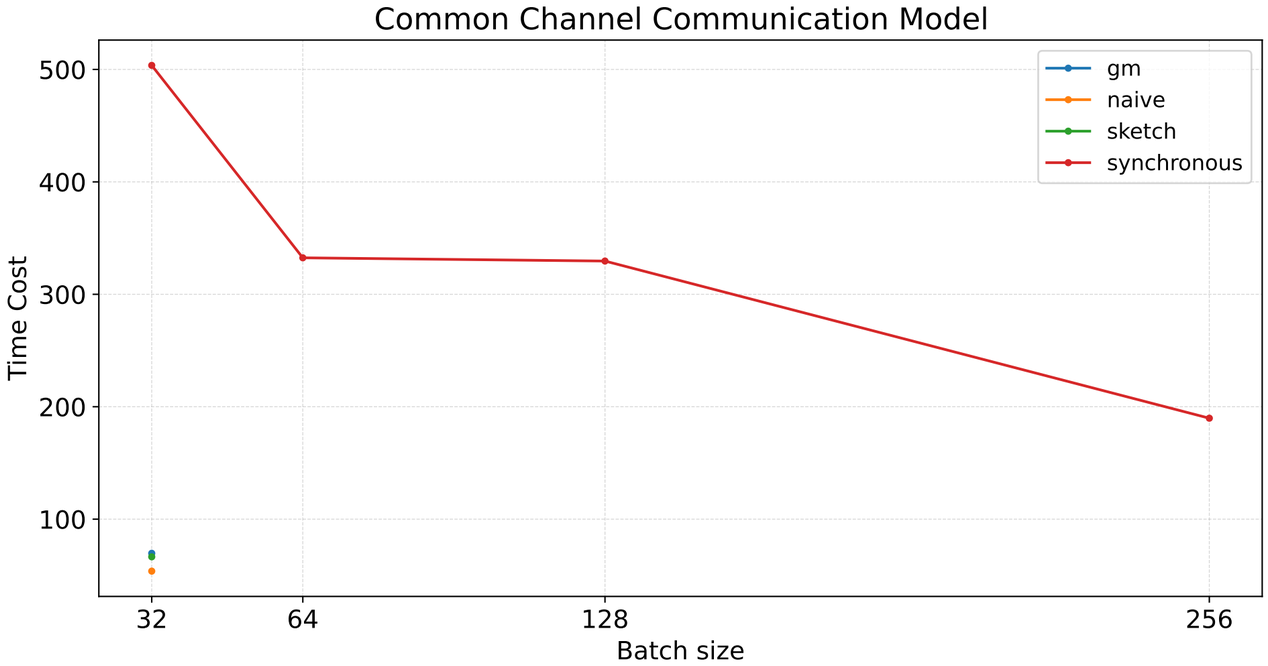

Num Clients : 40 , Θ : 7.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

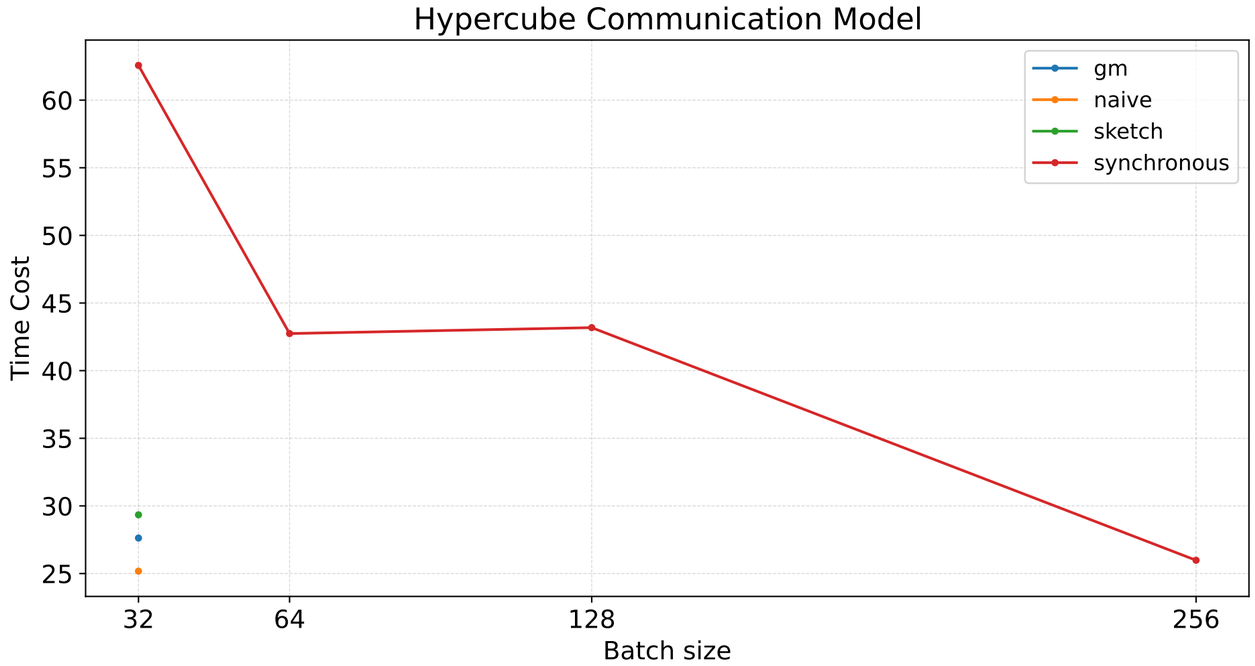

Num Clients : 40 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

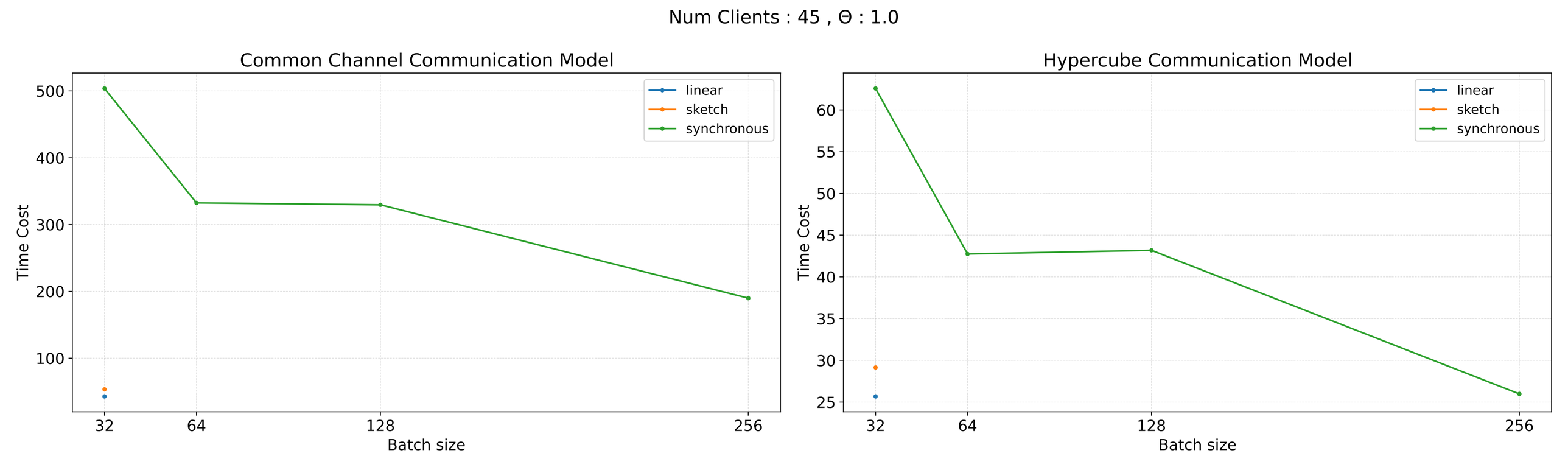

Num Clients : 40 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size


Num Clients : 40 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
75
70
65
60
55
50
45
40
35
32
64
128
256
Batch size

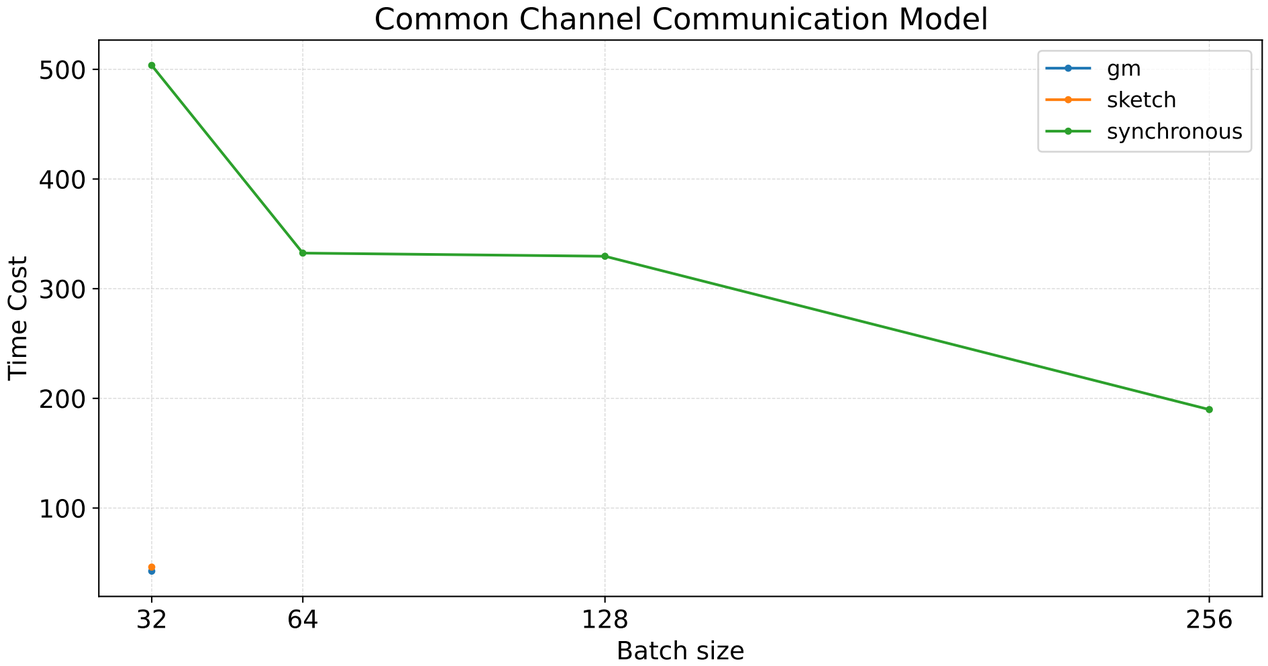
Num Clients : 45 , Θ : 0.5

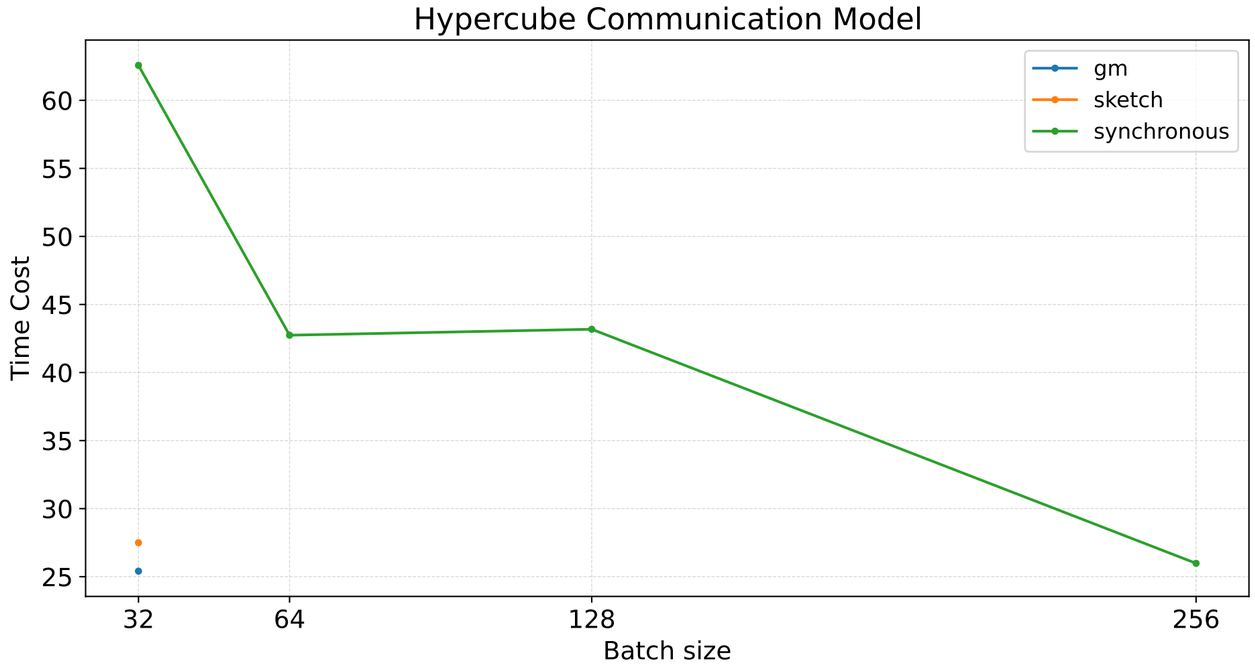


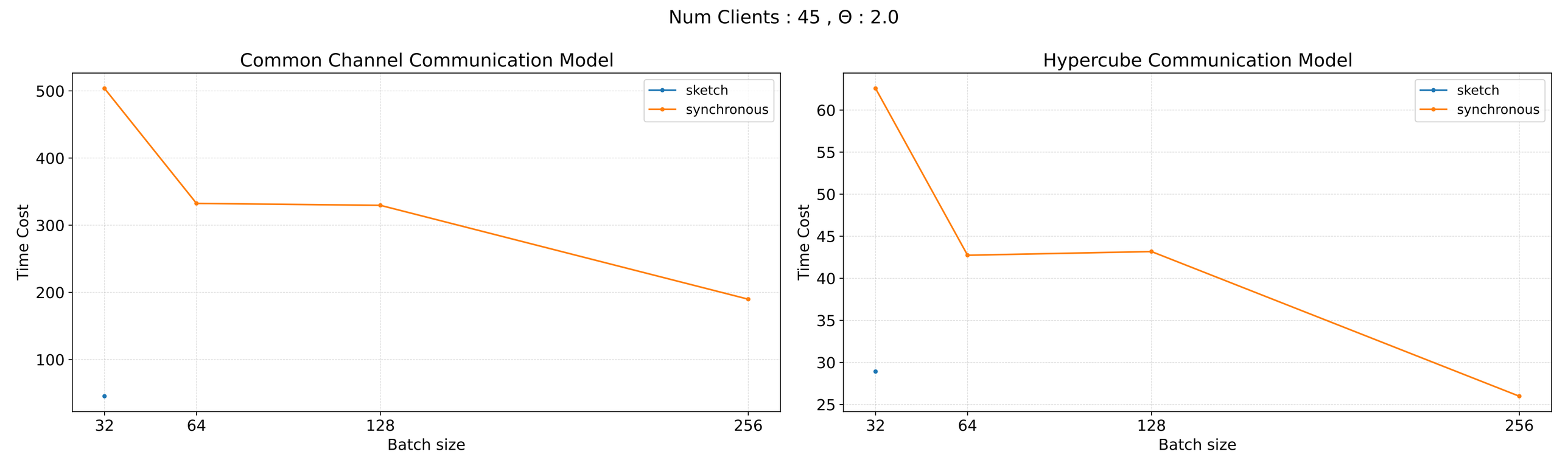


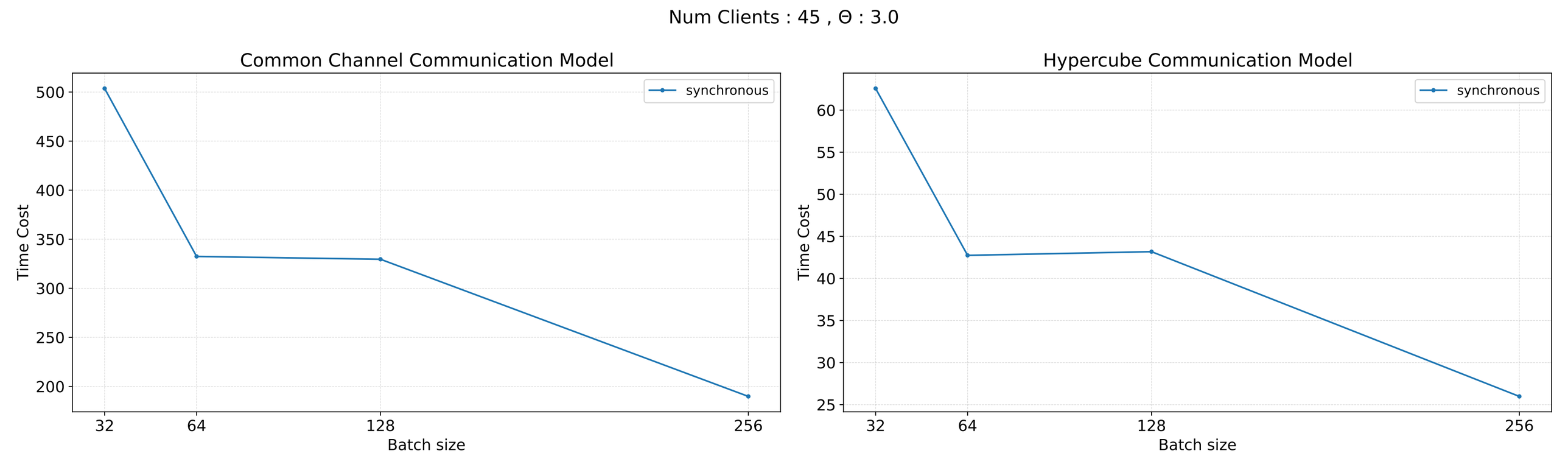

Num Clients : 45 , Θ : 1.0
Common Channel Communication Model
Time Cost
Batch size
linear
sketch
synchronous
500
400
300
200
100
32
64
128
256
Hypercube Communication Model
Time Cost
Batch size
linear
sketch
synchronous
60
55
50
45
40
35
30
25
32
64
128
256

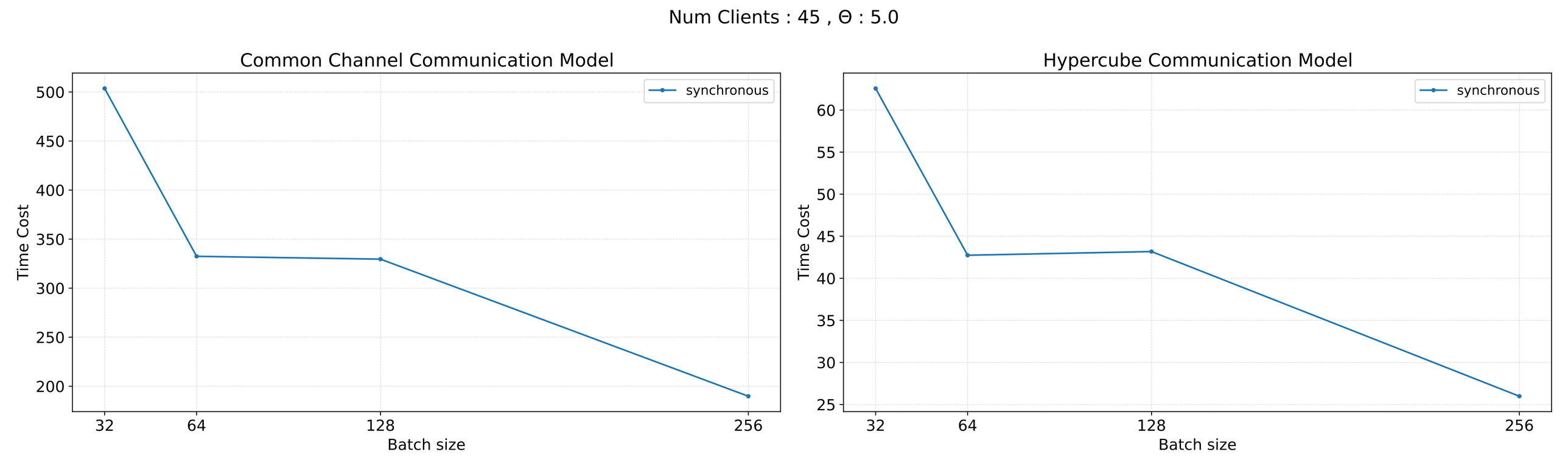
Num Clients : 45 , Θ : 1.5



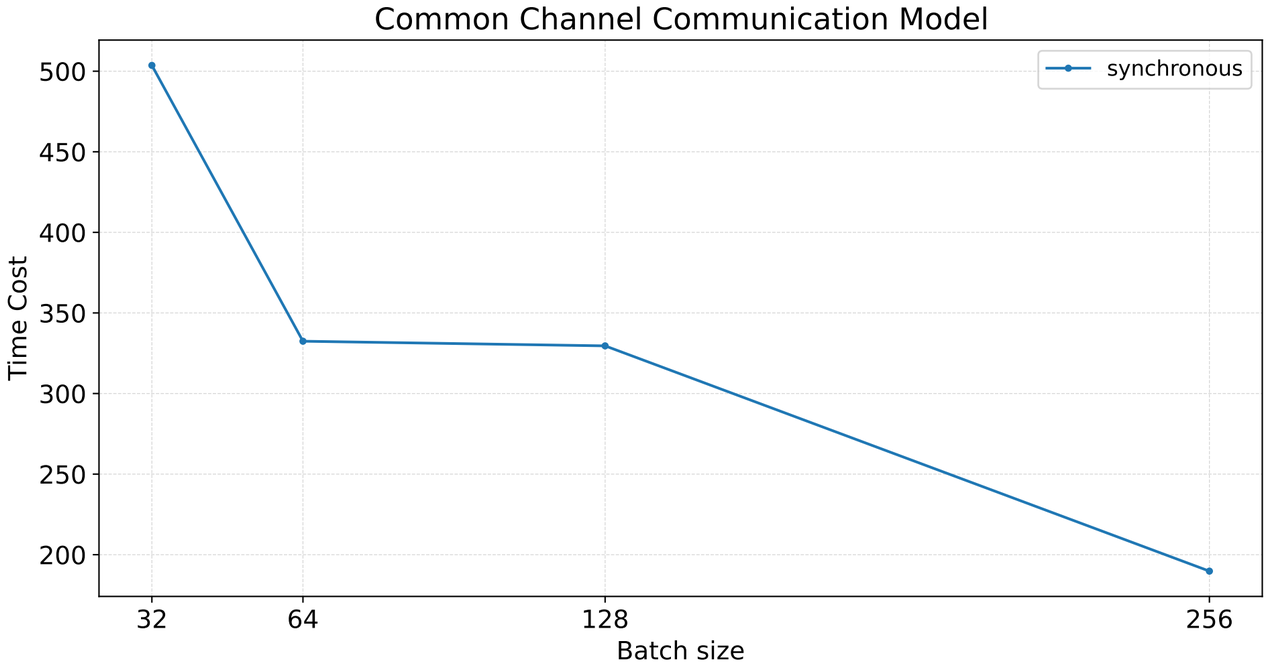


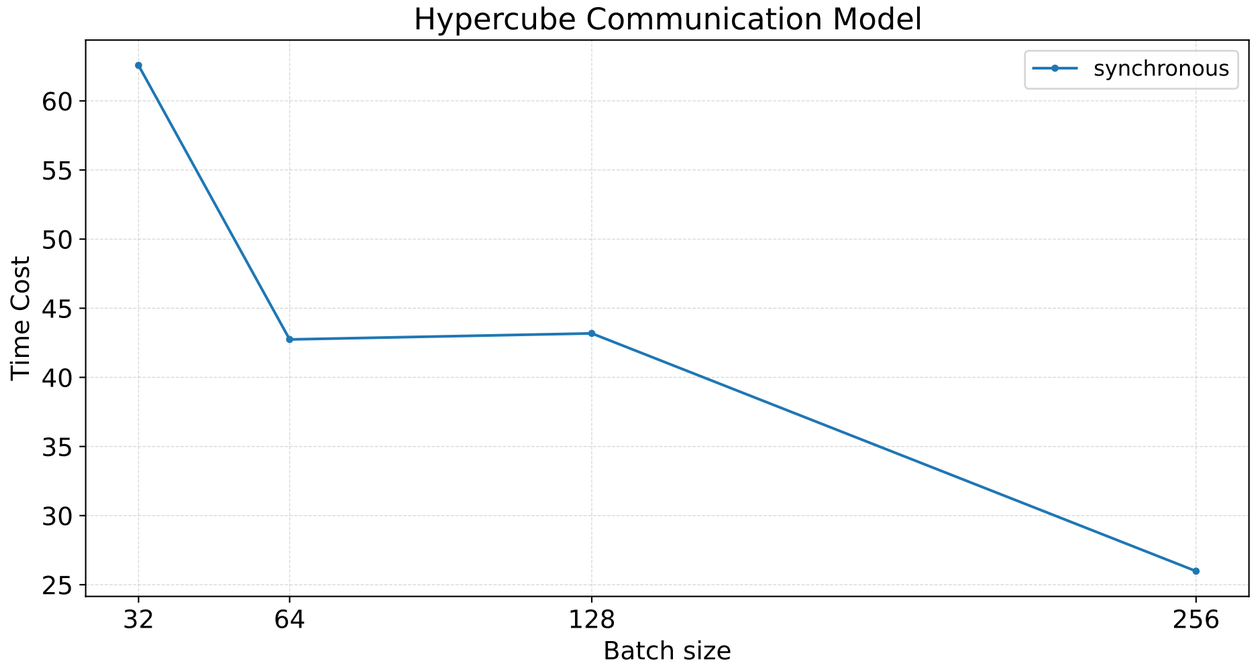

Num Clients : 45 , Θ : 2.0
Common Channel Communication Model
Hypercube Communication Model
sketch
synchronous
Time Cost
Batch size
500
400
300
200
100
60
55
50
45
40
35
30
25
32
64
128
256

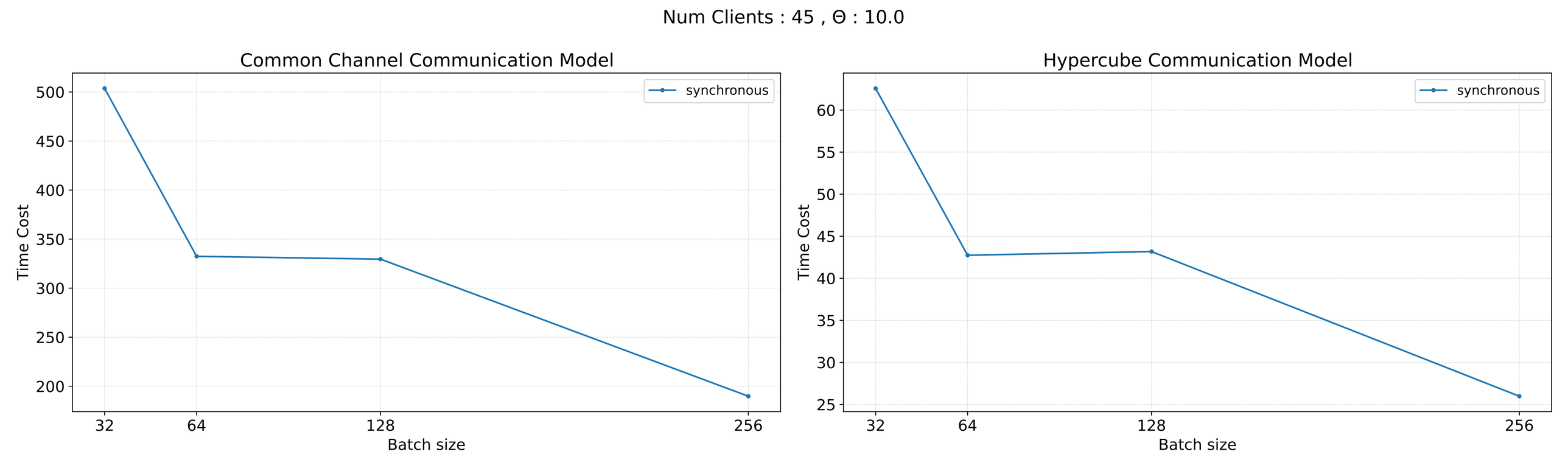

Num Clients : 45 , Θ : 3.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
60
55
50
45
40
35
30
25
32
64
128
256
Batch size

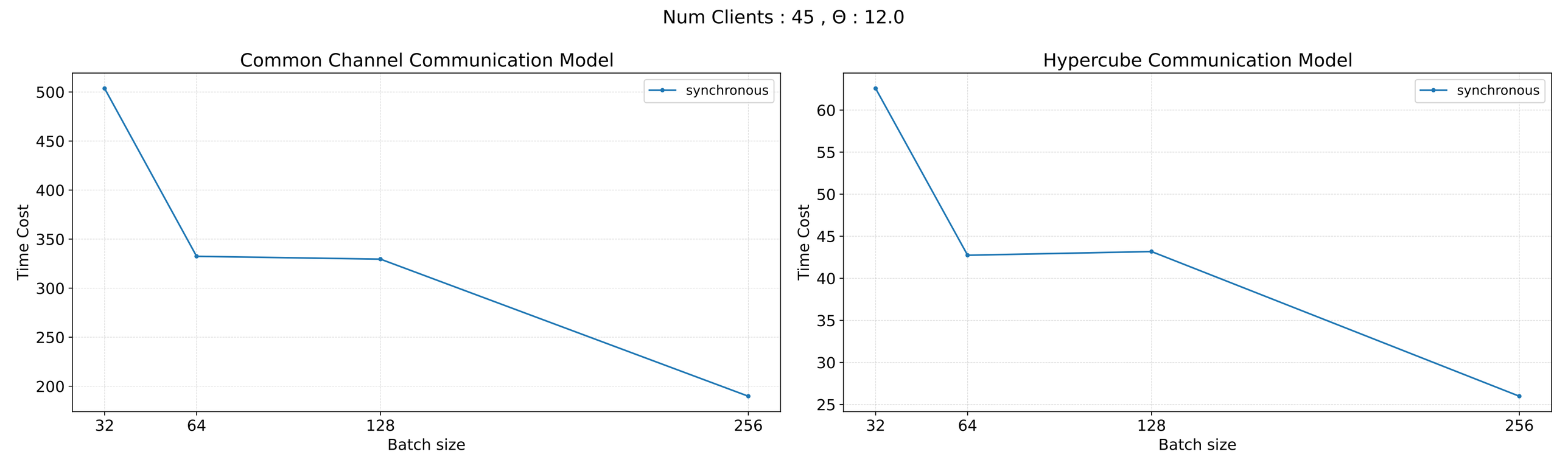

Num Clients : 45 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
60
55
50
45
40
35
30
25
32
64
128
256
Batch size

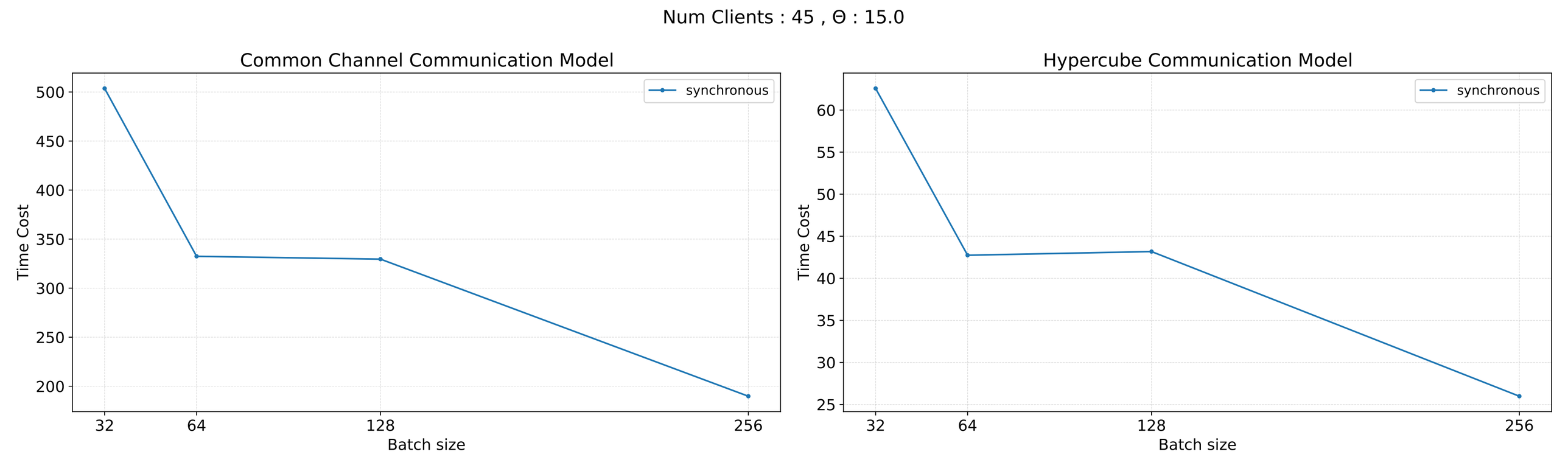
Num Clients : 45 , Θ : 7.0



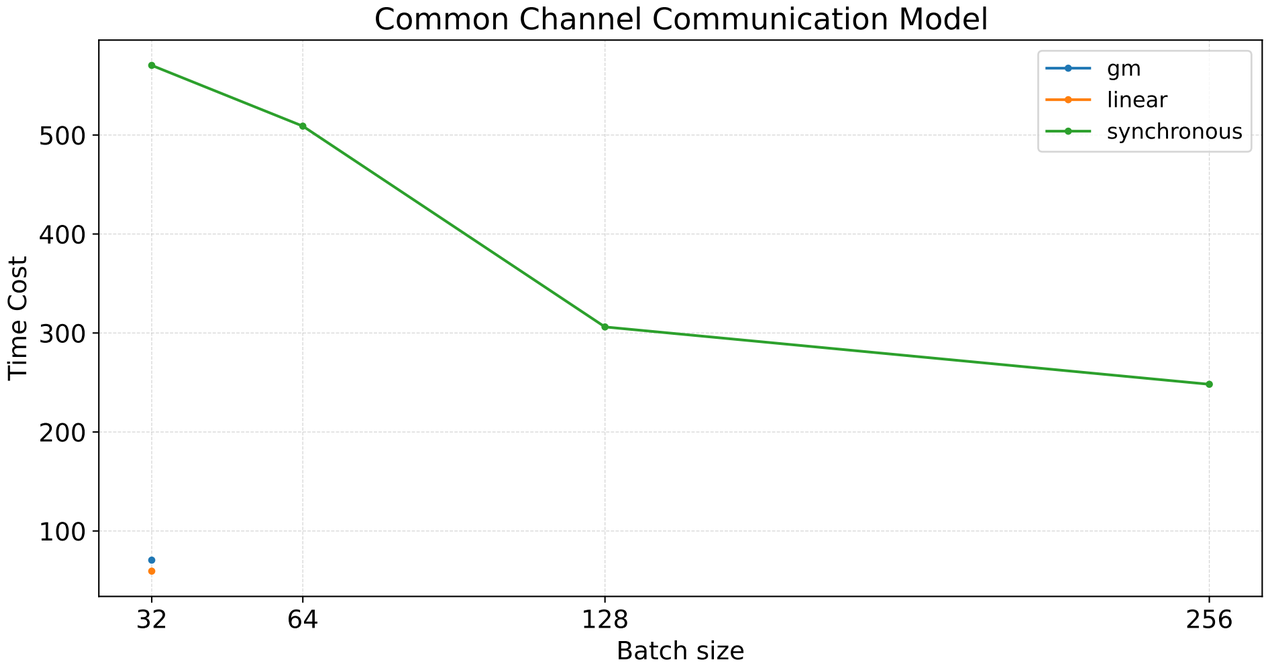


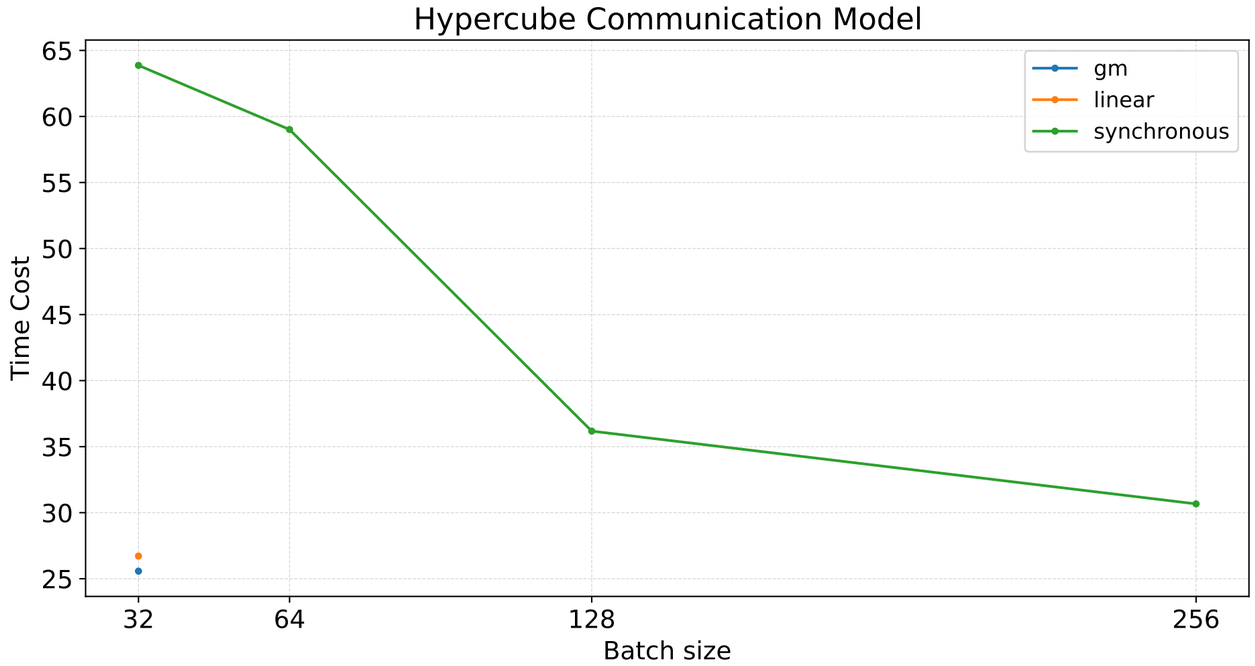

Num Clients : 45 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
60
55
50
45
40
35
30
25
32
64
128
256
Batch size


Num Clients : 45 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
60
55
50
45
40
35
30
25
32
64
128
256
Batch size

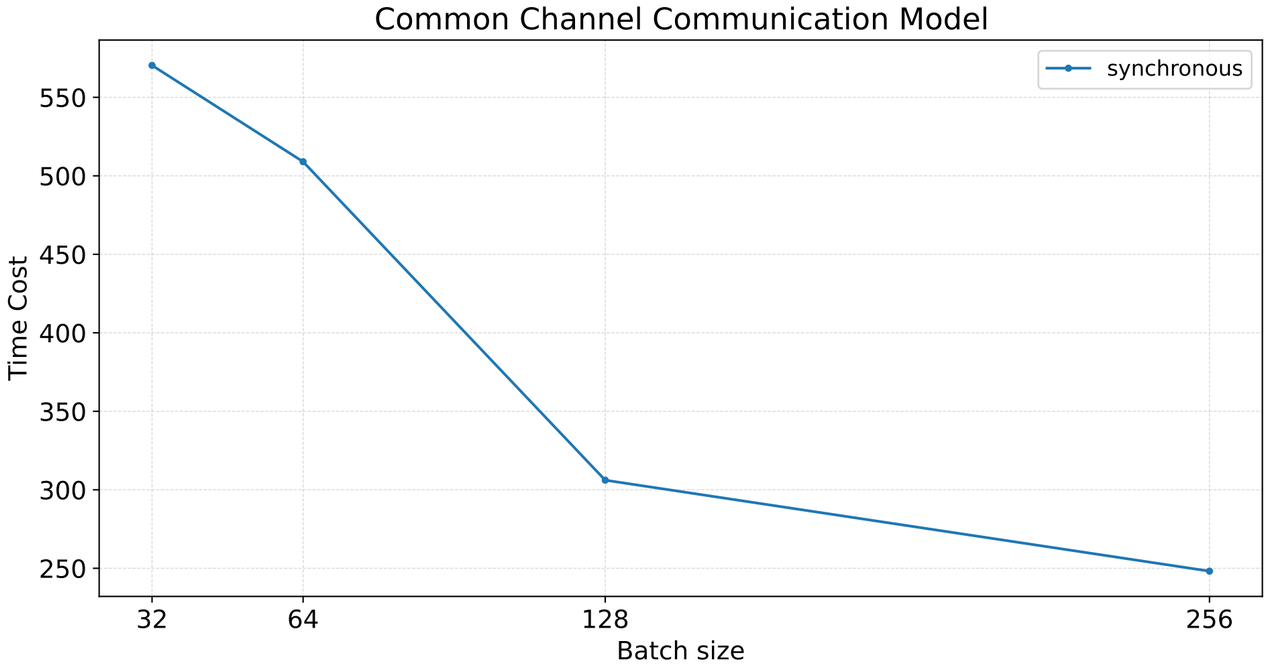

Num Clients : 45 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
500
450
400
350
300
250
200
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
60
55
50
45
40
35
30
25
32
64
128
256
Batch size

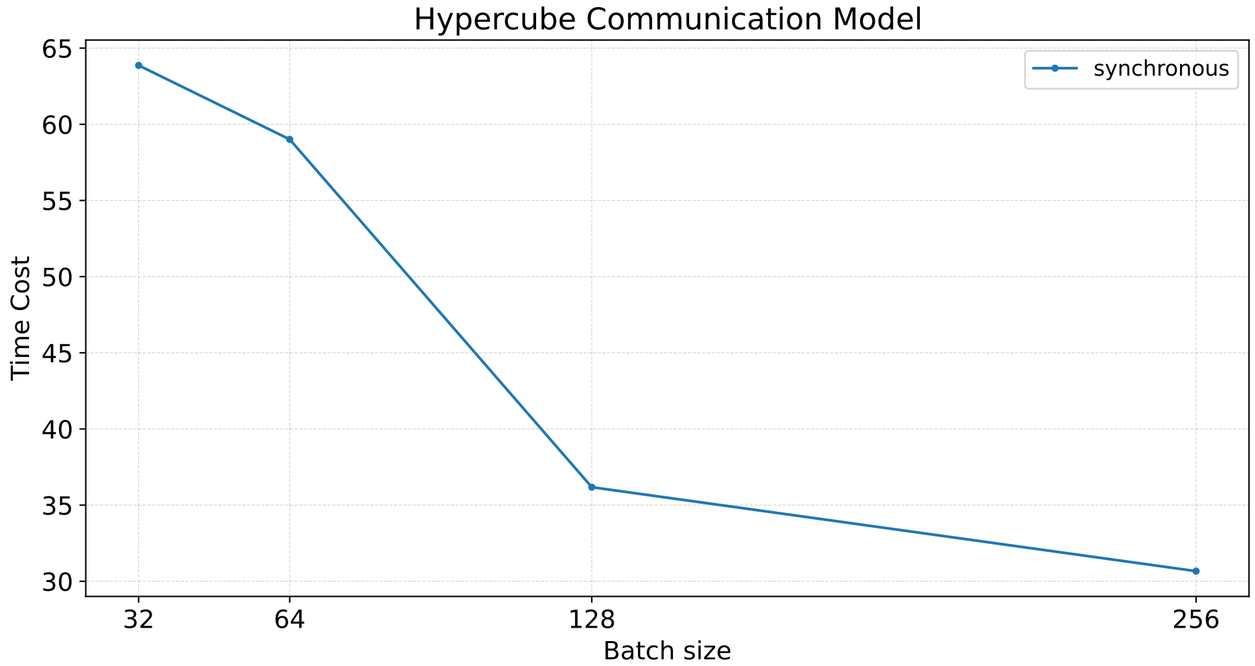
Num Clients : 50 , Θ : 0.5

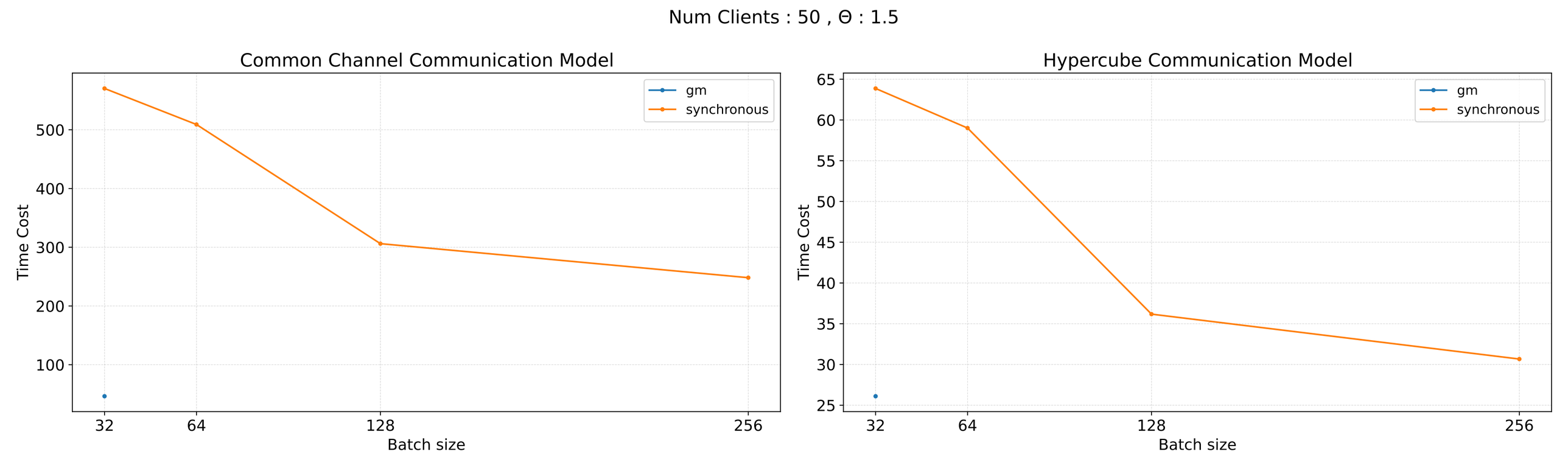




Num Clients : 50 , Θ : 1.0






Num Clients : 50 , Θ : 1.5
Common Channel Communication Model
Hypercube Communication Model
gm
synchronous
Time Cost
Batch size
100
200
300
400
500
25
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40
45
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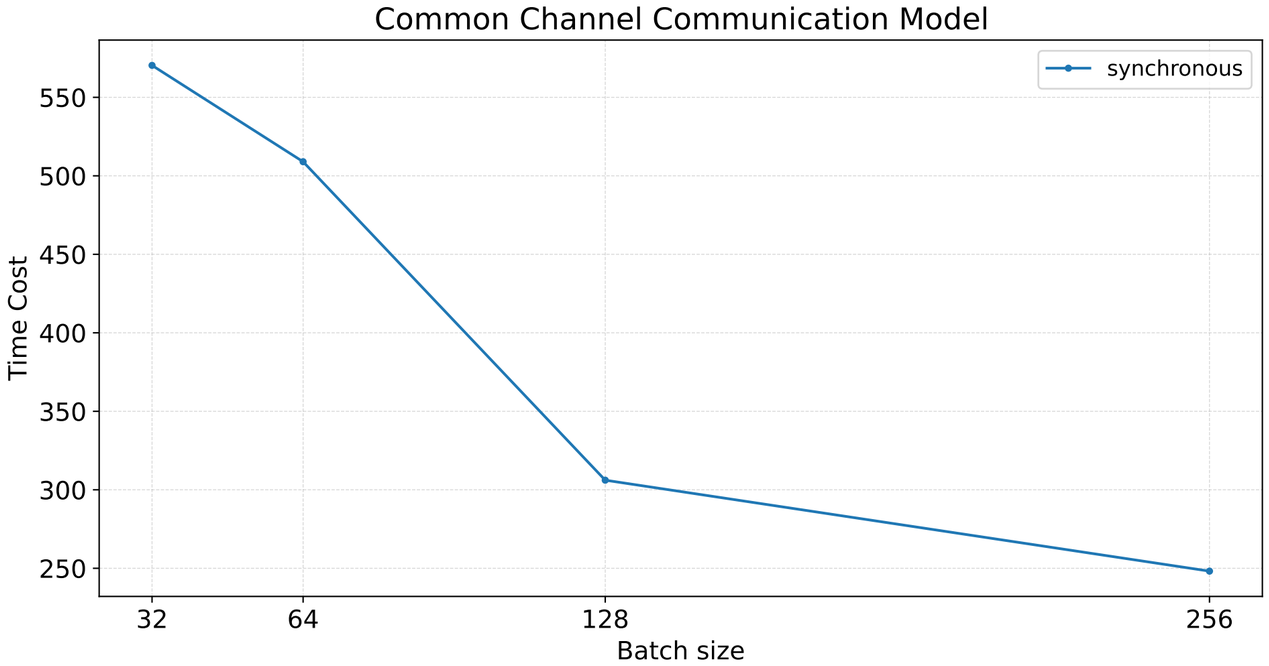
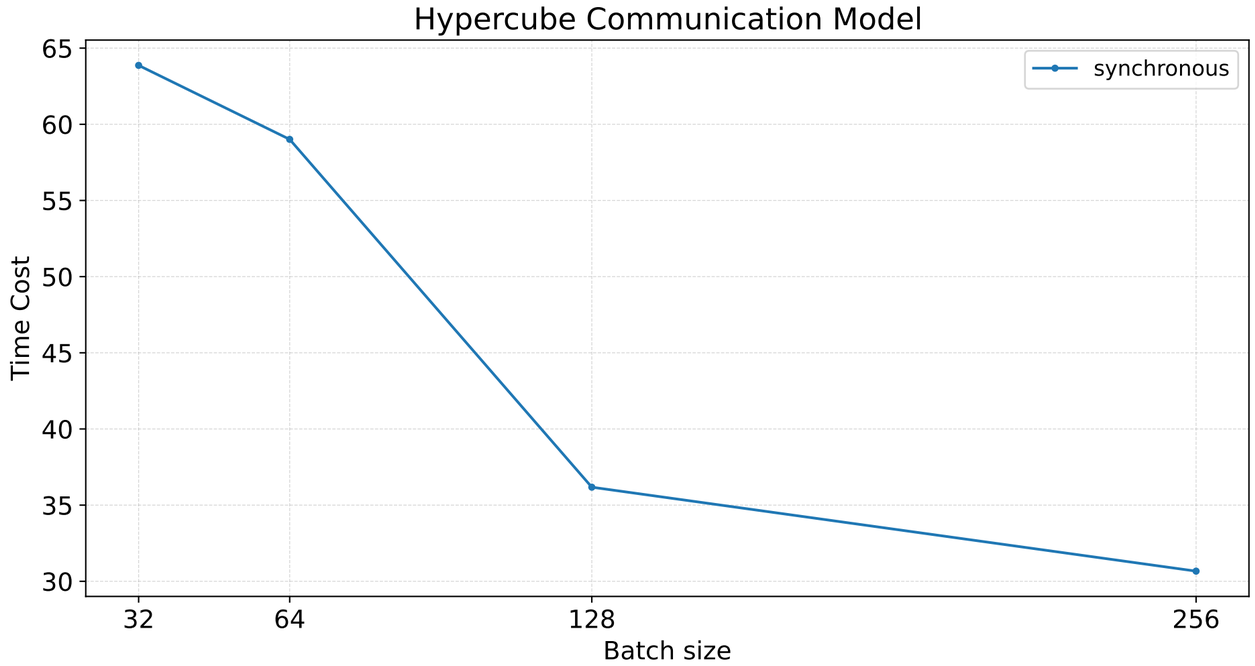
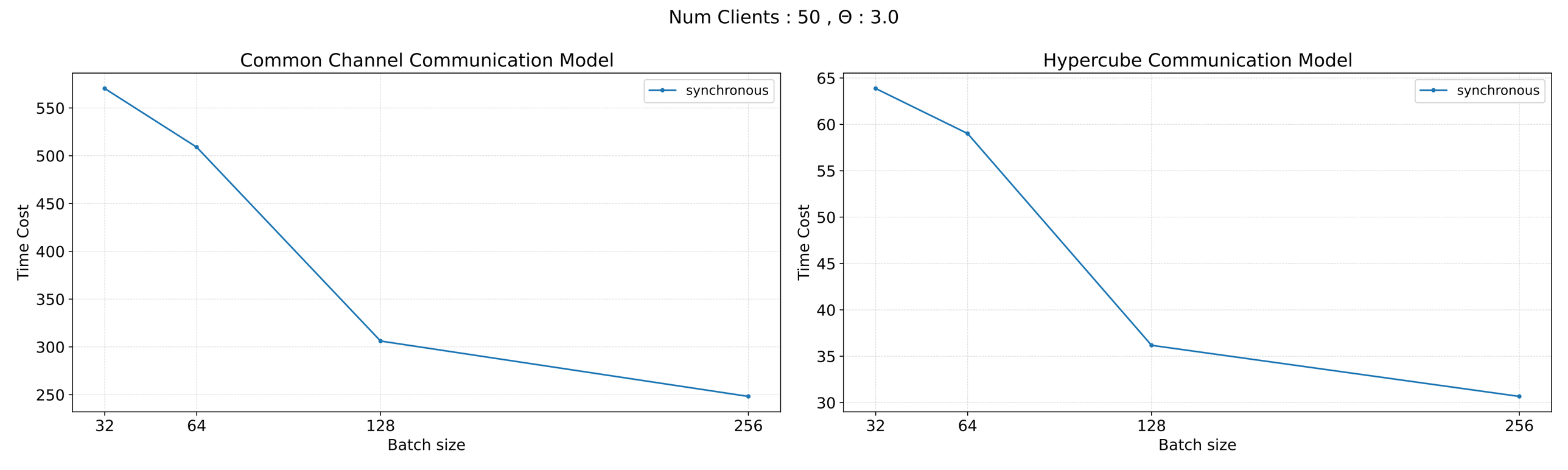
32
64
128
256

Num Clients : 50 , Θ : 2.0






Num Clients : 50 , Θ : 3.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
250
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
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50
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40
35
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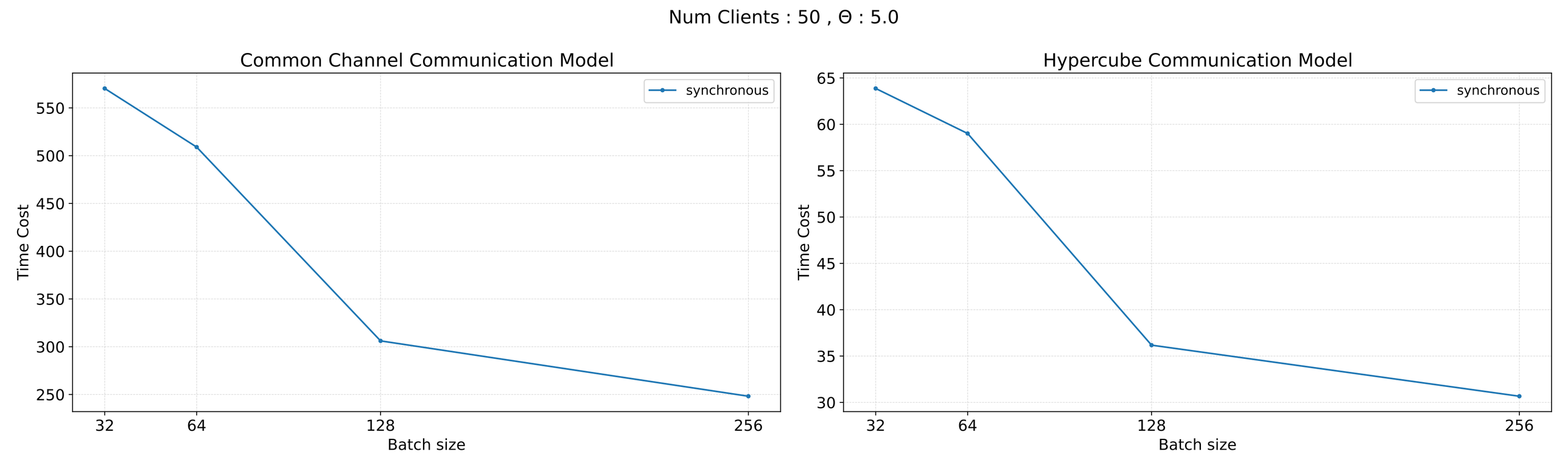
32
64
128
256
Batch size


Num Clients : 50 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
250
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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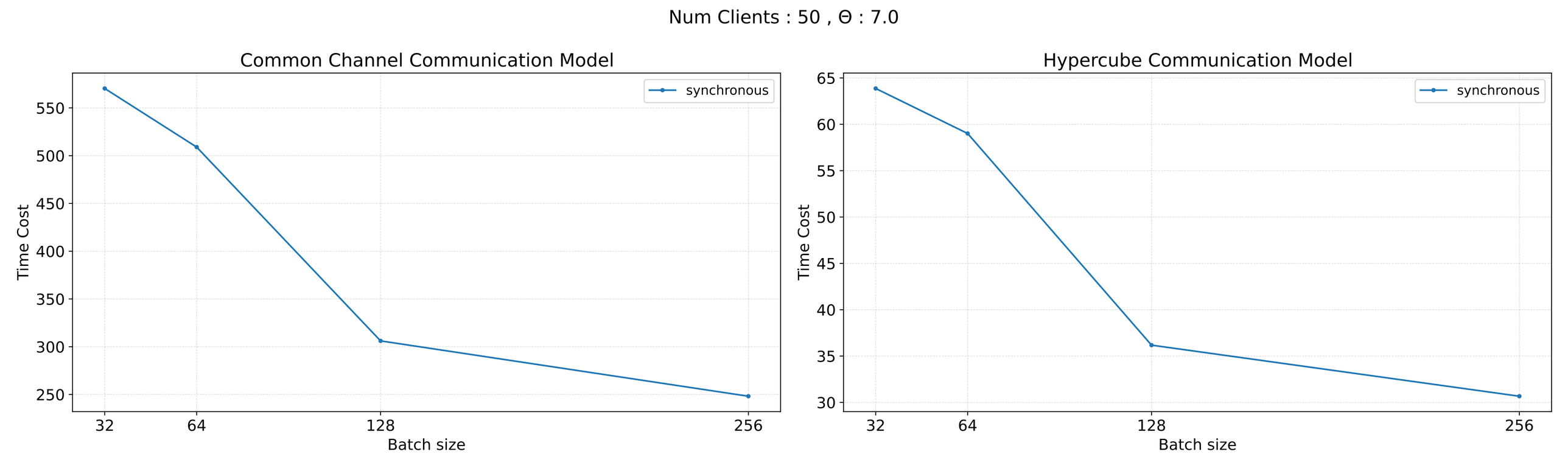
128
256
Batch size


Num Clients : 50 , Θ : 7.0
Common Channel Communication Model
synchronous
Time Cost
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450
400
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300
250
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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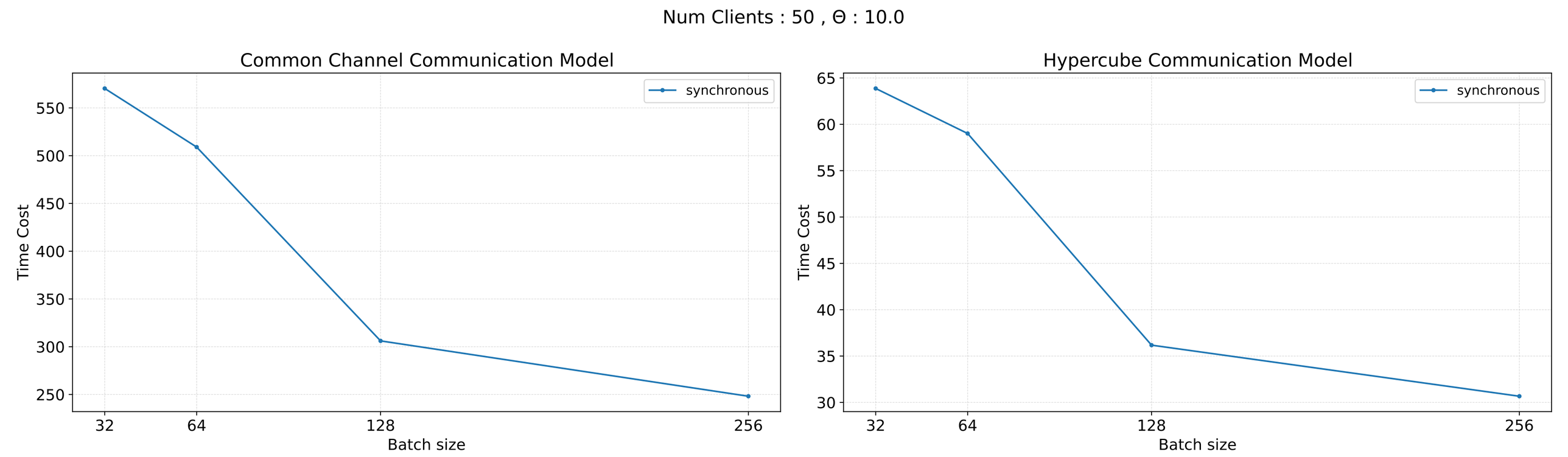
256
Batch size


Num Clients : 50 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
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400
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300
250
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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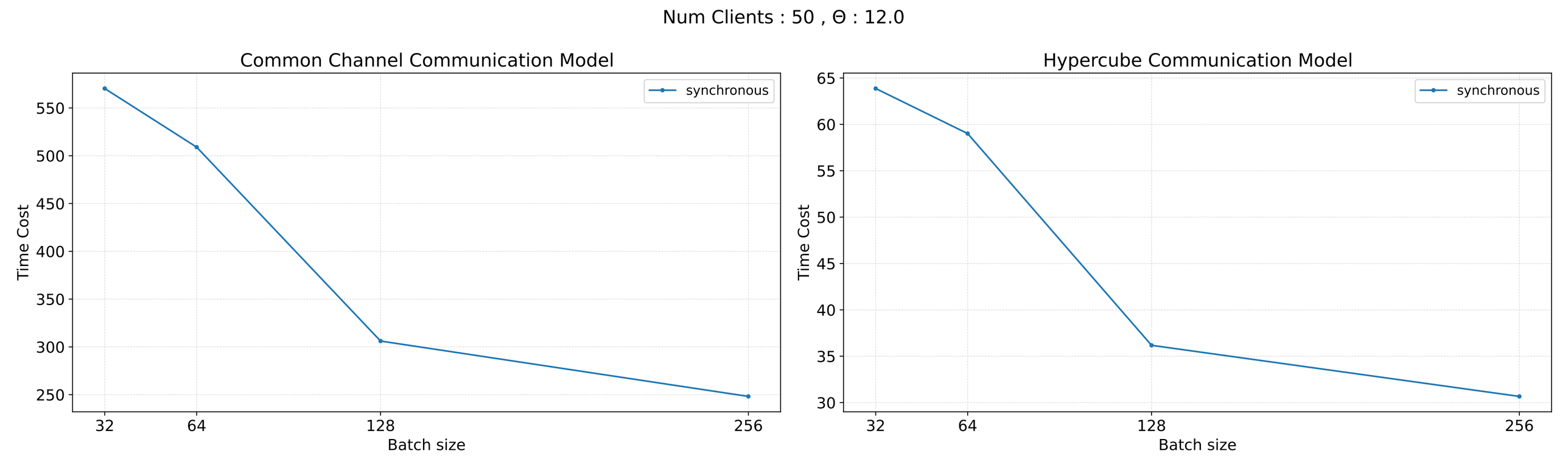
128
256
Batch size


Num Clients : 50 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
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300
250
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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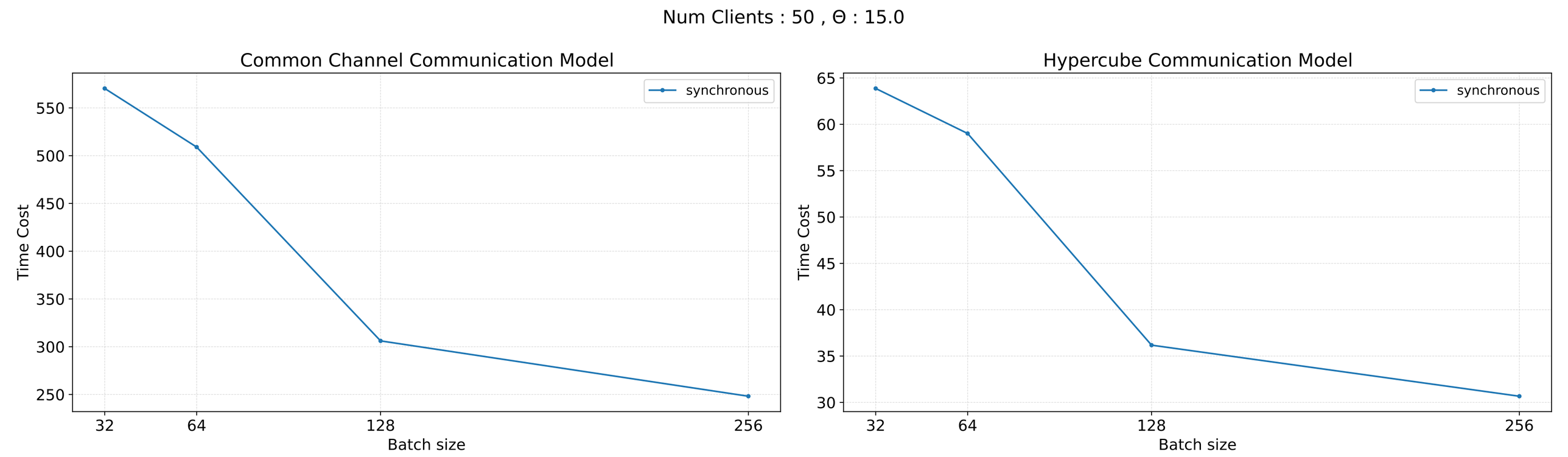
256
Batch size


Num Clients : 50 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
250
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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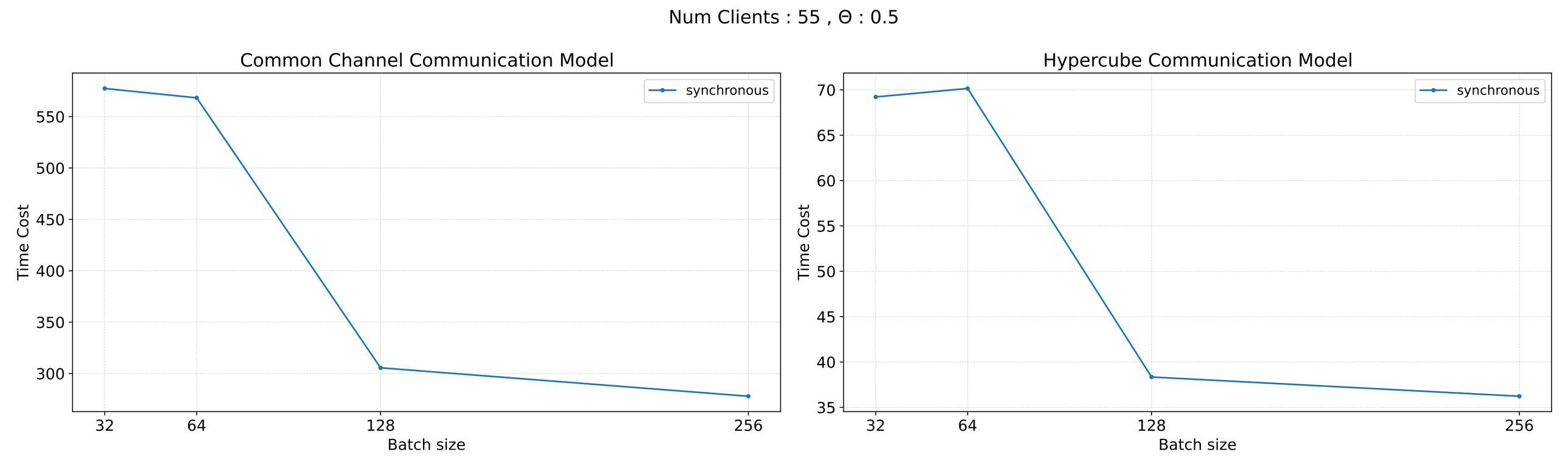
128
256
Batch size


Num Clients : 55 , Θ : 0.5
Common Channel Communication Model
synchronous
Time Cost
550
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400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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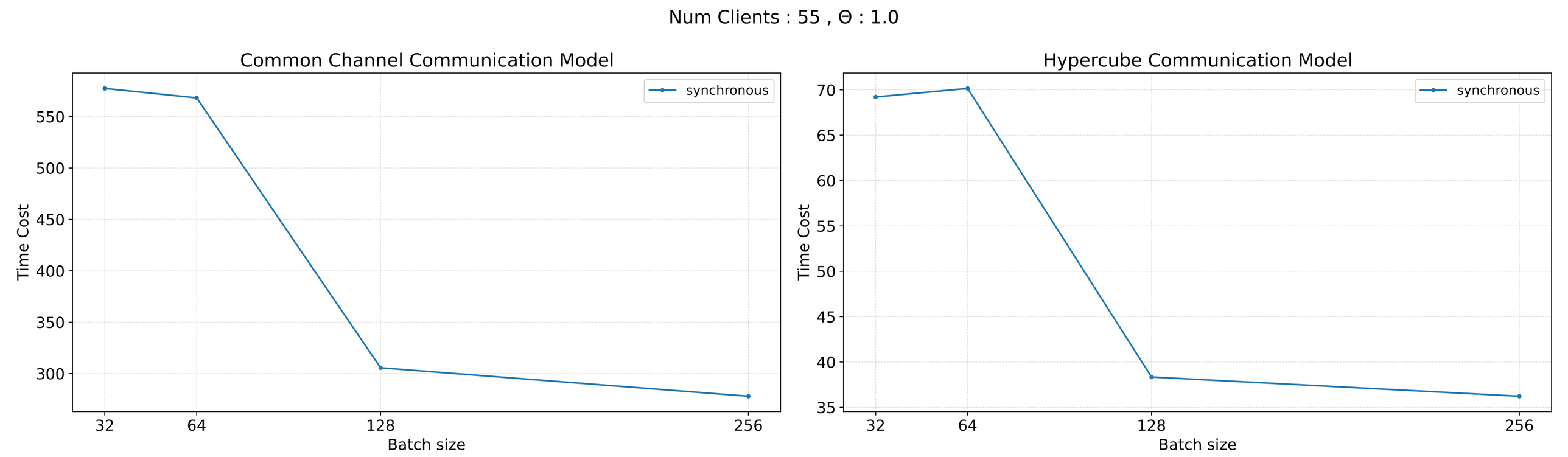
128
256
Batch size


Num Clients : 55 , Θ : 1.0
Common Channel Communication Model
synchronous
Time Cost
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500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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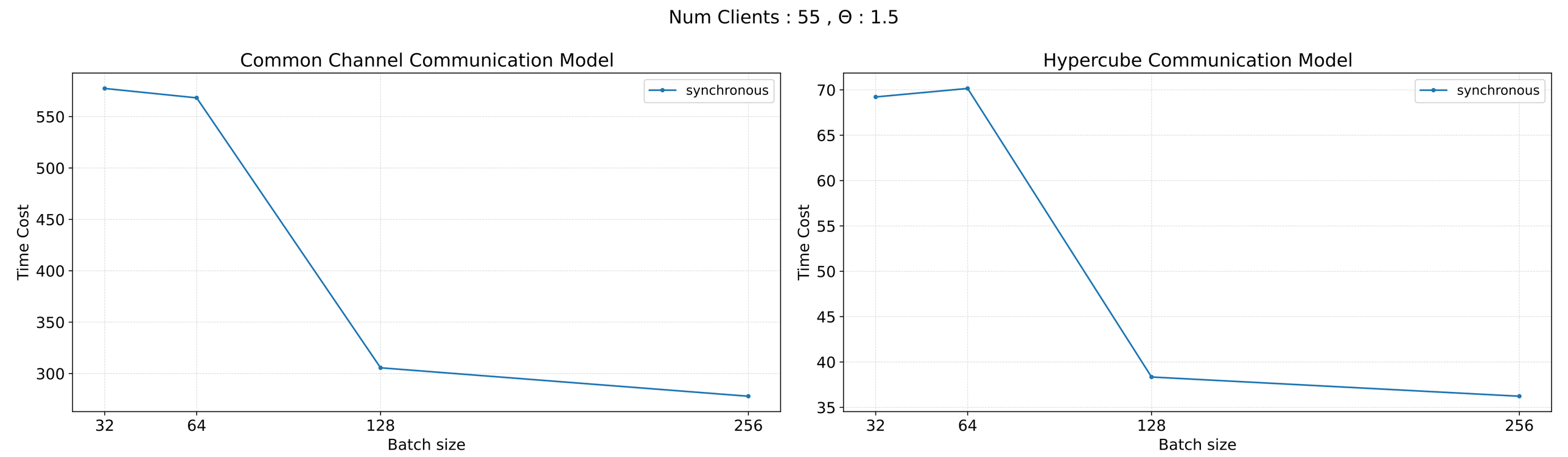
128
256
Batch size


Num Clients : 55 , Θ : 1.5
Common Channel Communication Model
synchronous
Time Cost
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500
450
400
350
300
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
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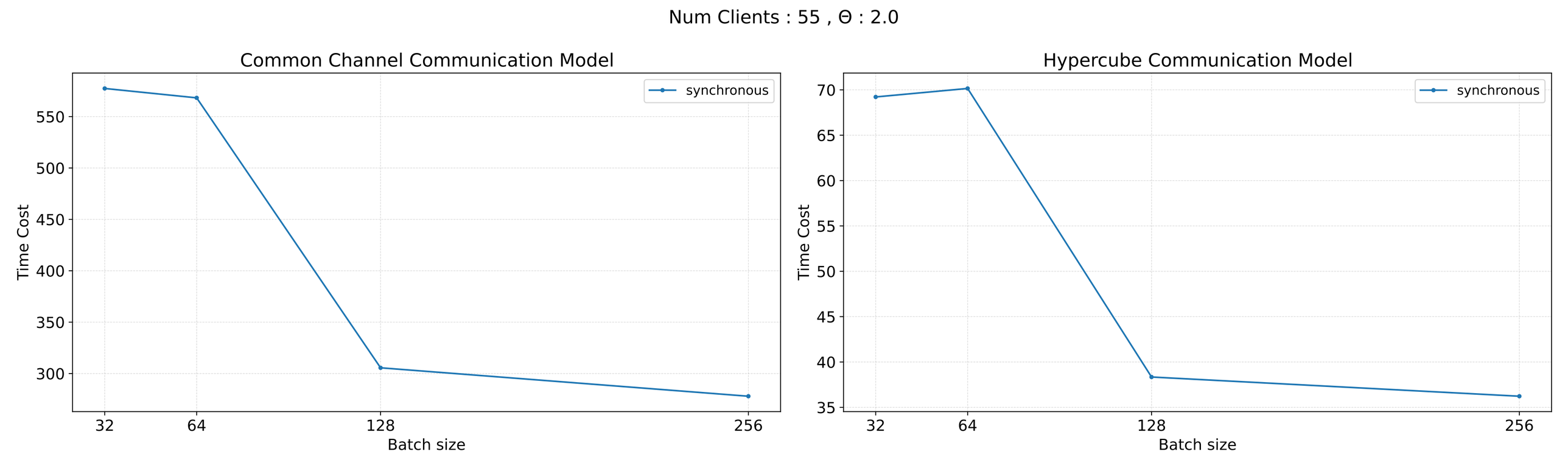
128
256
Batch size


Num Clients : 55 , Θ : 2.0
Common Channel Communication Model
synchronous
Time Cost
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400
350
300
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
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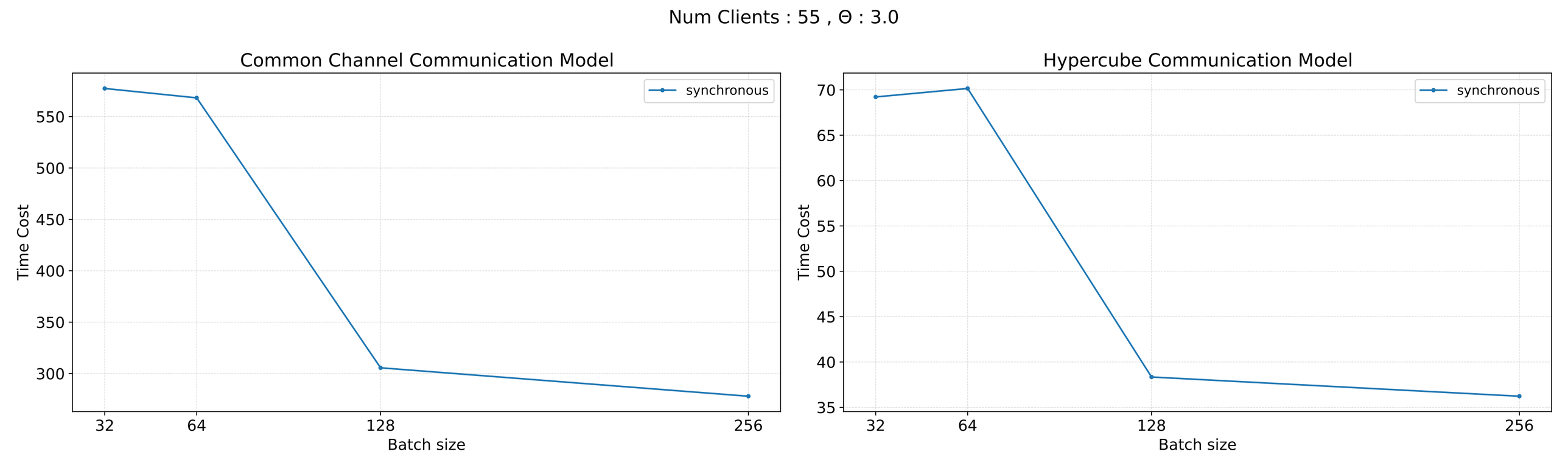
64
128
256
Batch size


Num Clients : 55 , Θ : 3.0
Common Channel Communication Model
synchronous
Time Cost
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500
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400
350
300
32
64
128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
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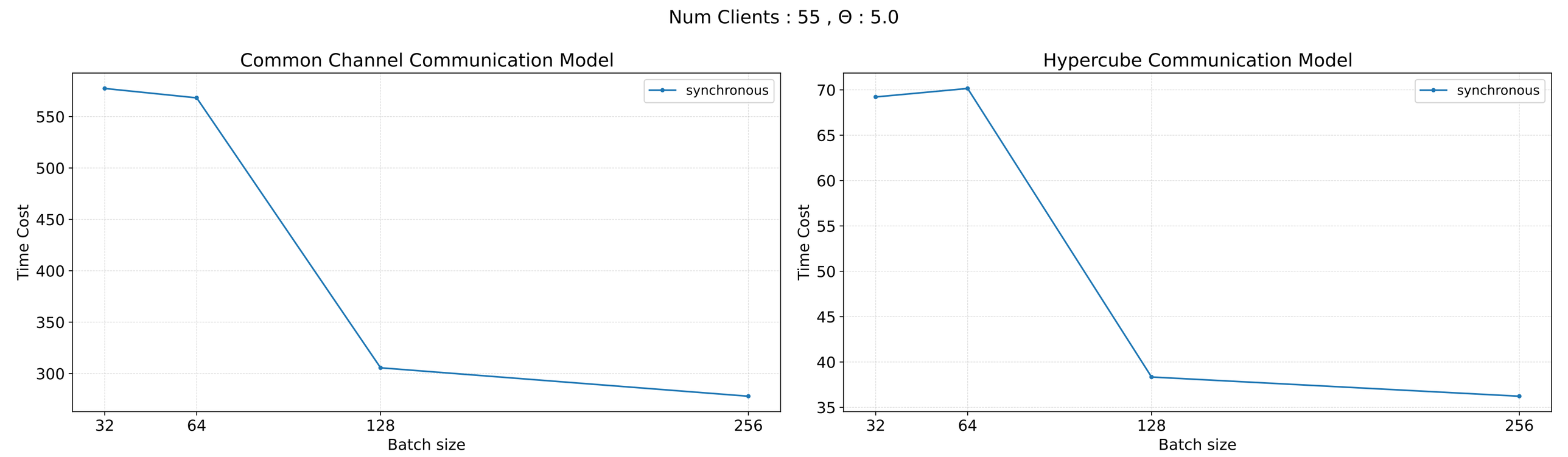
128
256
Batch size


Num Clients : 55 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
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500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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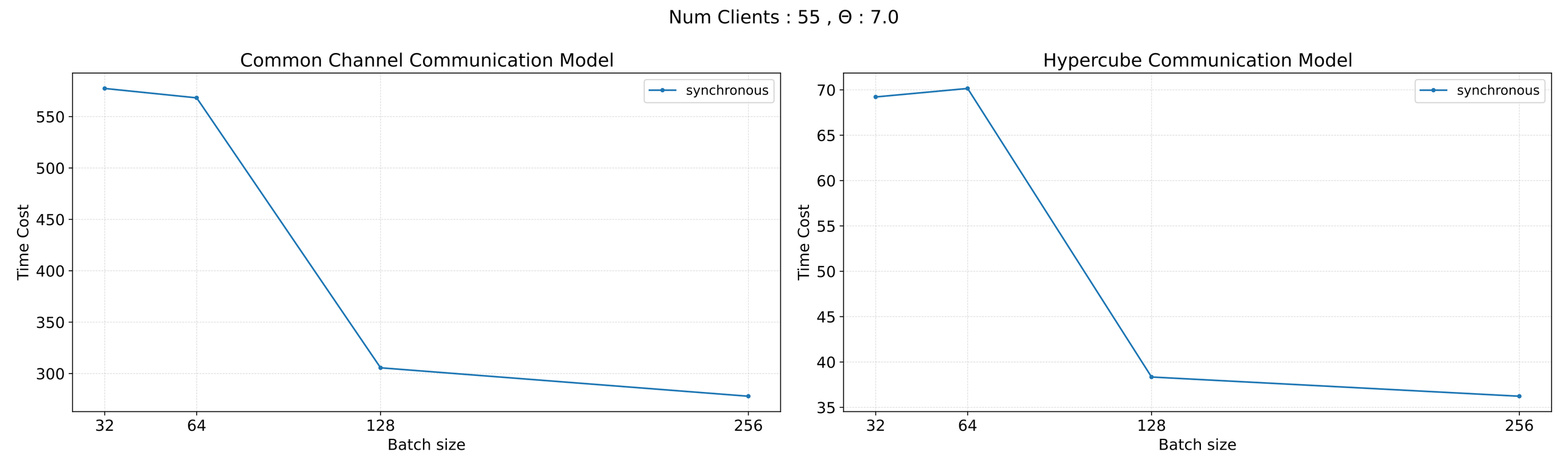
128
256
Batch size


Num Clients : 55 , Θ : 7.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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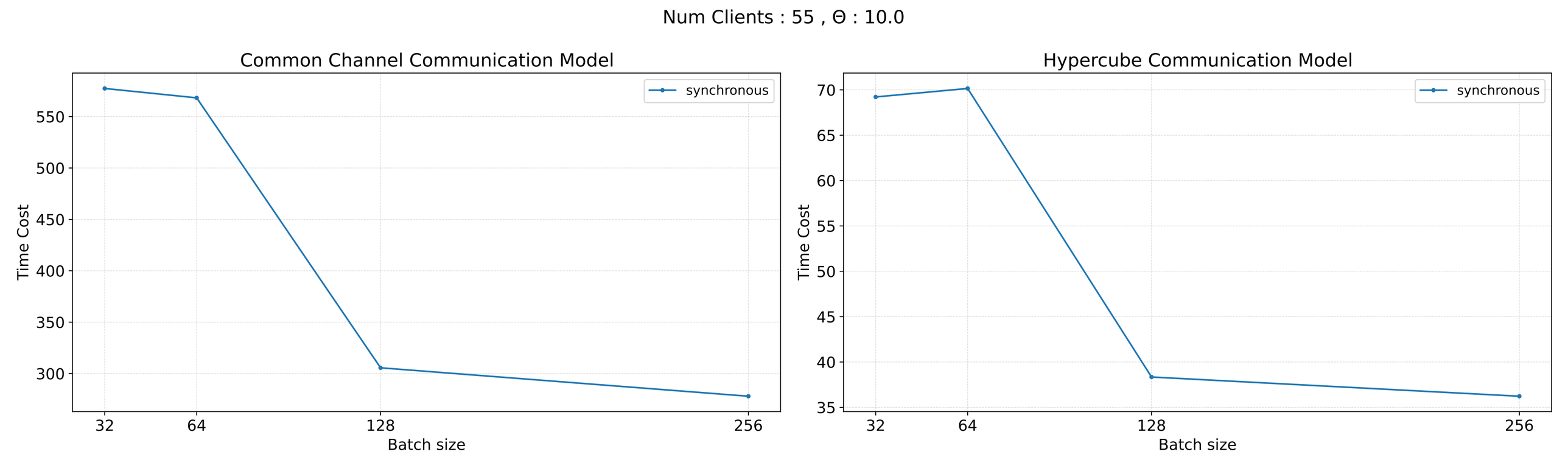
128
256
Batch size


Num Clients : 55 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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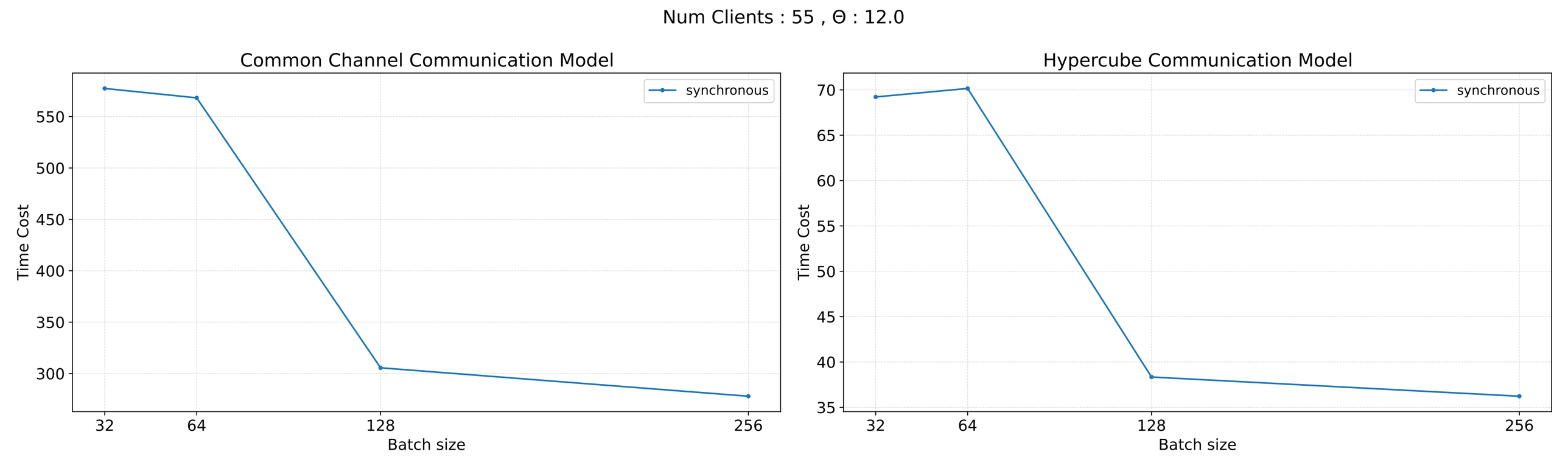
Batch size


Num Clients : 55 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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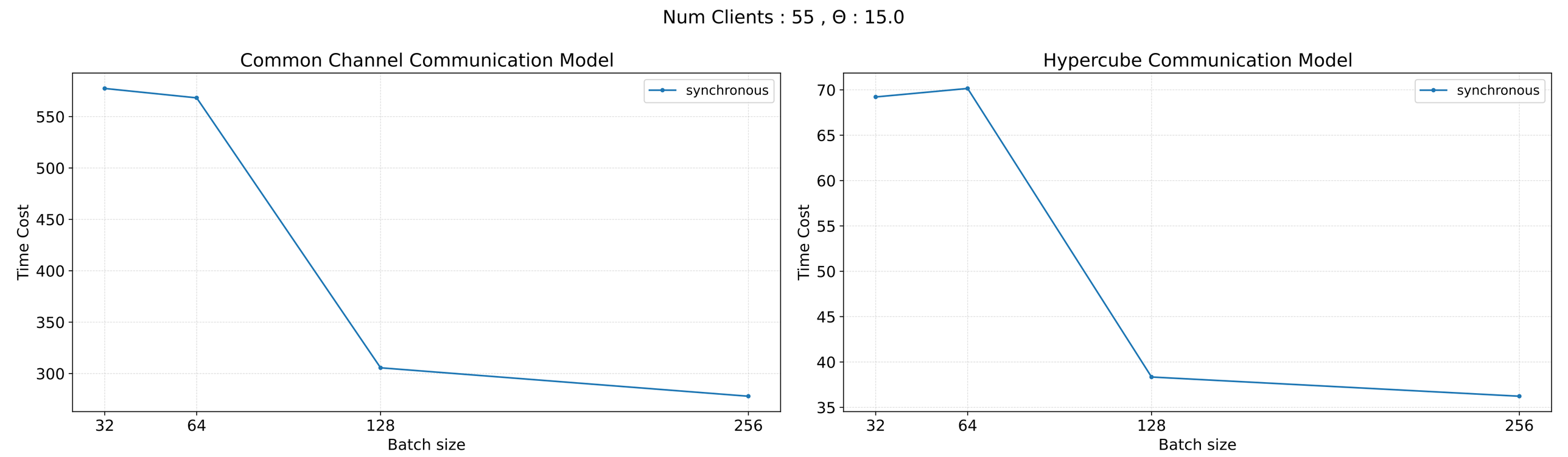
256
Batch size


Num Clients : 55 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
550
500
450
400
350
300
32
64
128
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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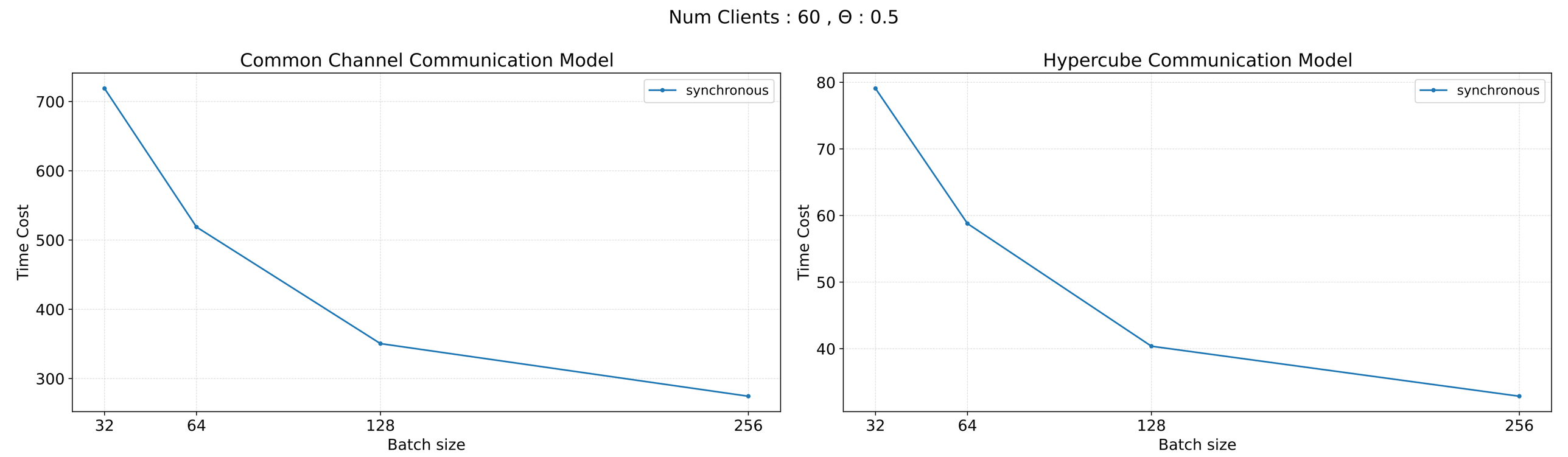
128
256
Batch size


Num Clients : 60 , Θ : 0.5
Common Channel Communication Model
synchronous
Time Cost
700
600
500
400
300
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Batch size
Hypercube Communication Model
synchronous
Time Cost
80
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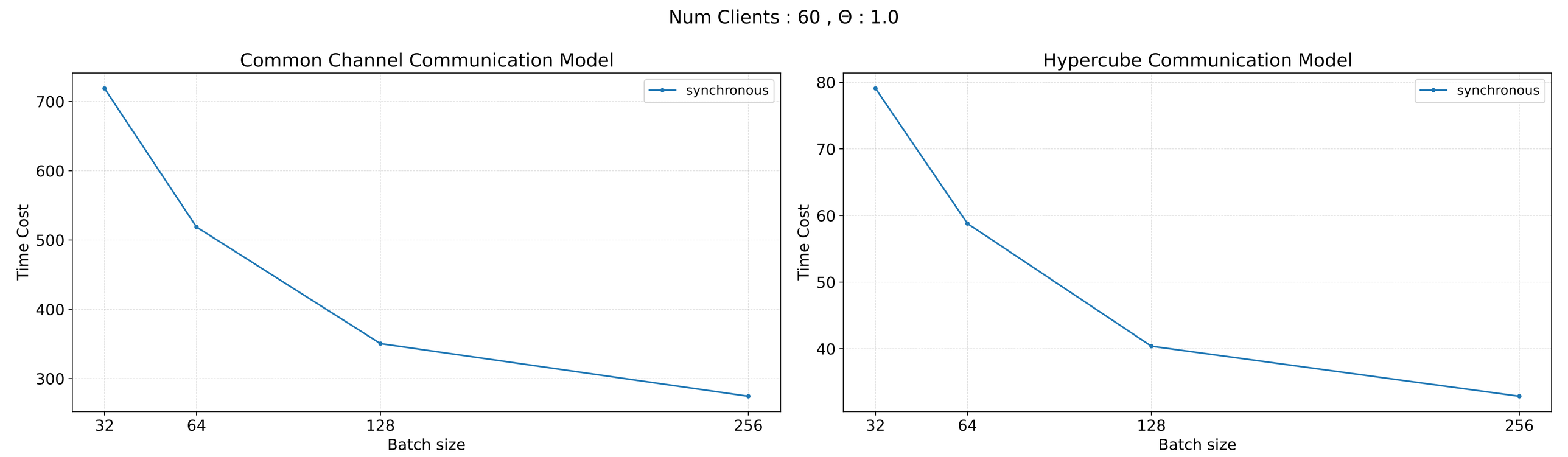
128
256
Batch size


Num Clients : 60 , Θ : 1.0
Common Channel Communication Model
synchronous
Time Cost
700
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500
400
300
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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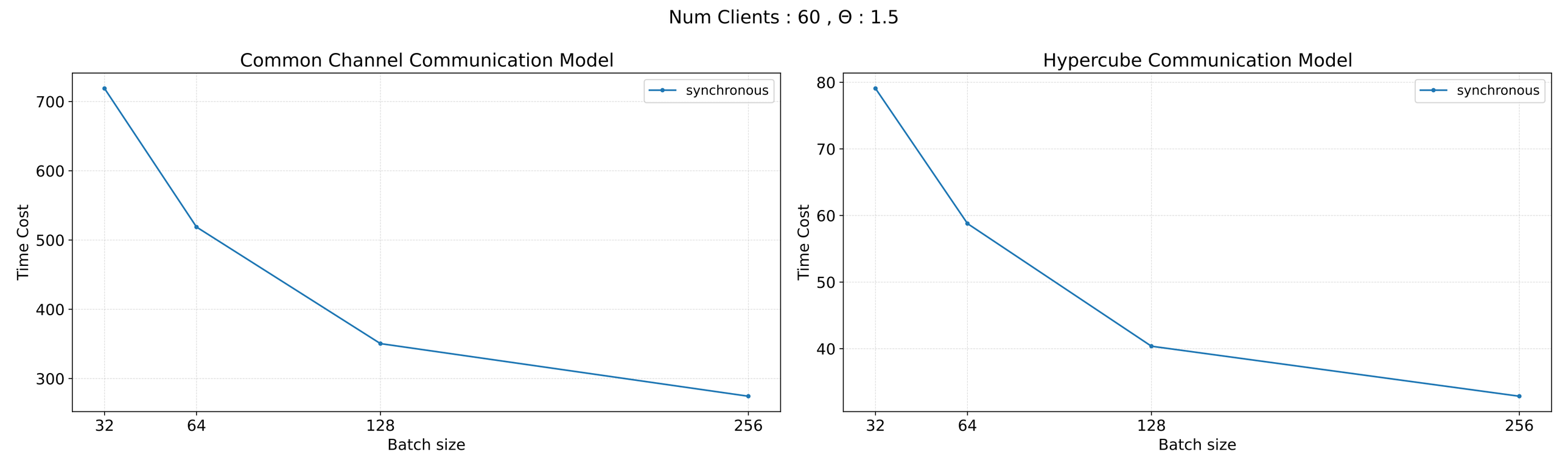
Batch size


Num Clients : 60 , Θ : 1.5
Common Channel Communication Model
synchronous
Time Cost
700
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400
300
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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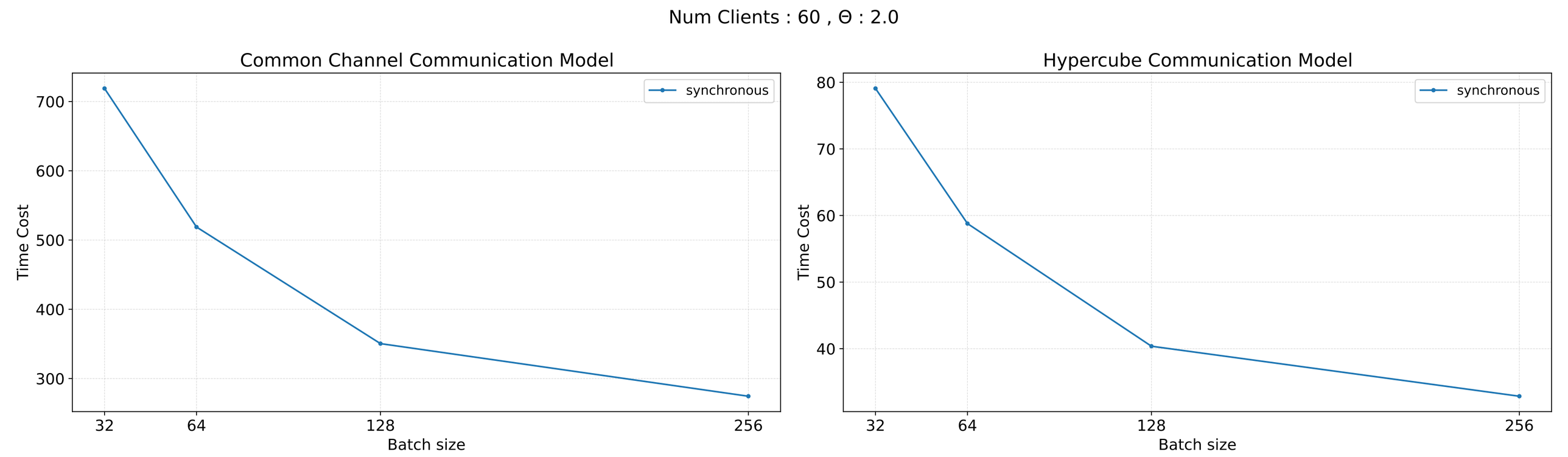
Batch size


Num Clients : 60 , Θ : 2.0
Common Channel Communication Model
Time Cost
Batch size
synchronous
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Hypercube Communication Model
Time Cost
Batch size
synchronous
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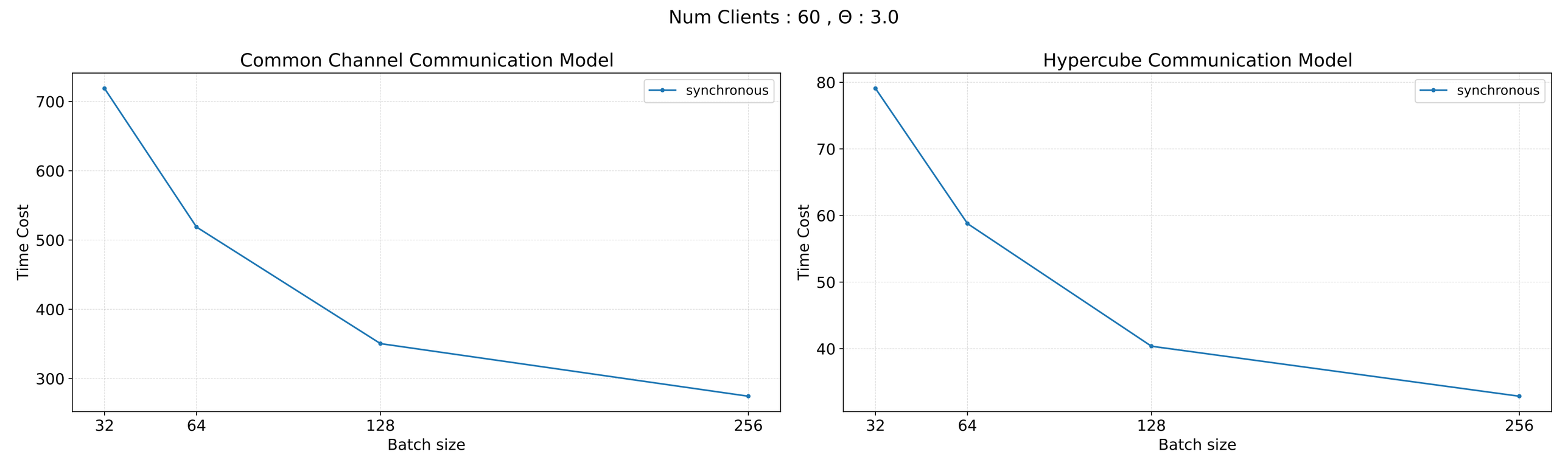
Num Clients : 60 , Θ : 3.0
Common Channel Communication Model
Time Cost
Batch size
synchronous
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Hypercube Communication Model
Time Cost
Batch size
synchronous
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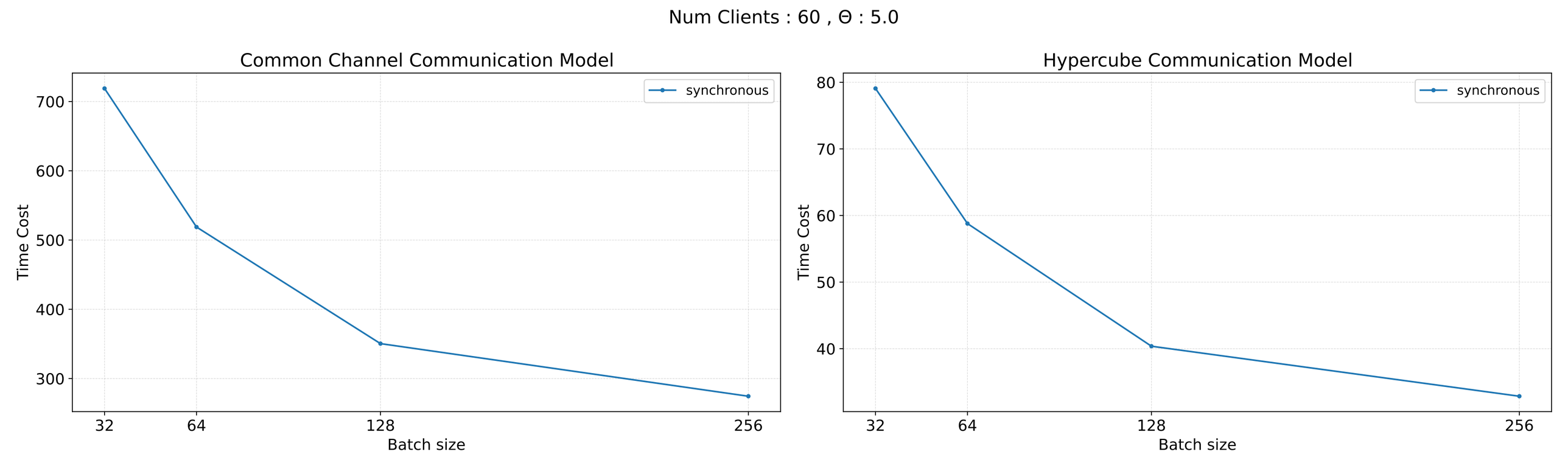
Num Clients : 60 , Θ : 5.0
Common Channel Communication Model
synchronous
Time Cost
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400
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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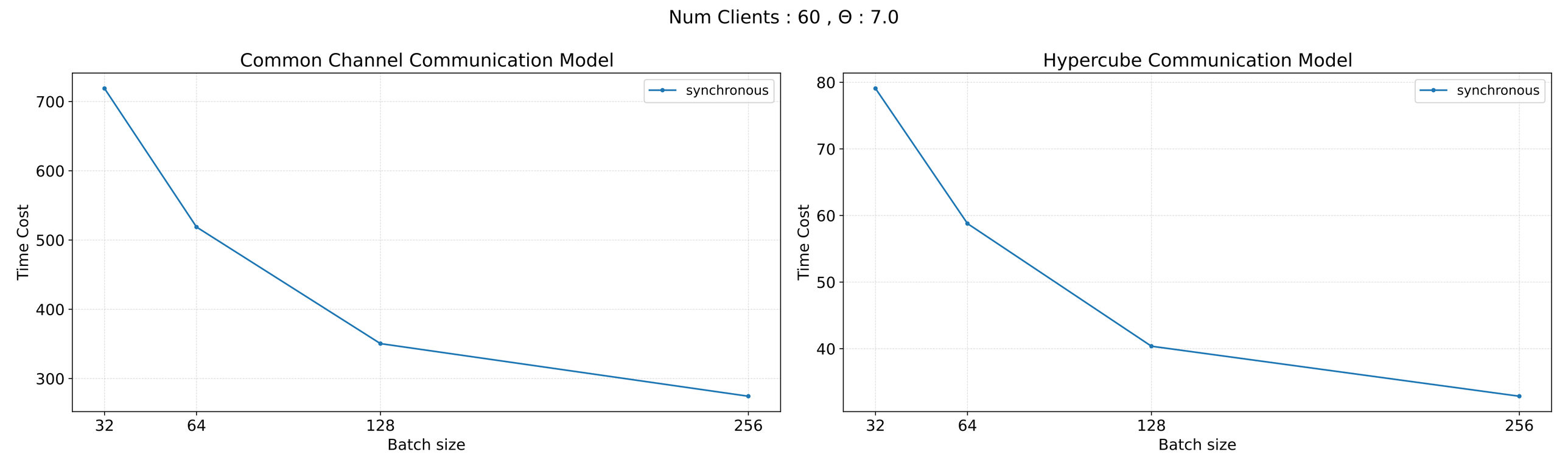
Batch size


Num Clients : 60 , Θ : 7.0
Common Channel Communication Model
synchronous
Time Cost
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500
400
300
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Batch size
Hypercube Communication Model
synchronous
Time Cost
80
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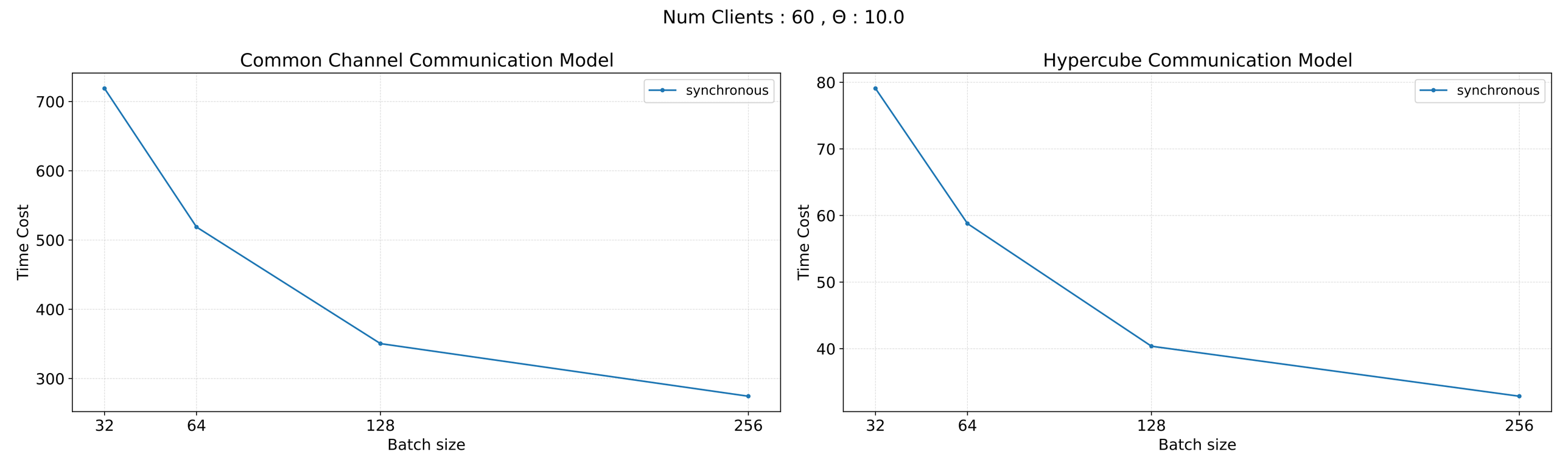
Batch size


Num Clients : 60 , Θ : 10.0
Common Channel Communication Model
synchronous
Time Cost
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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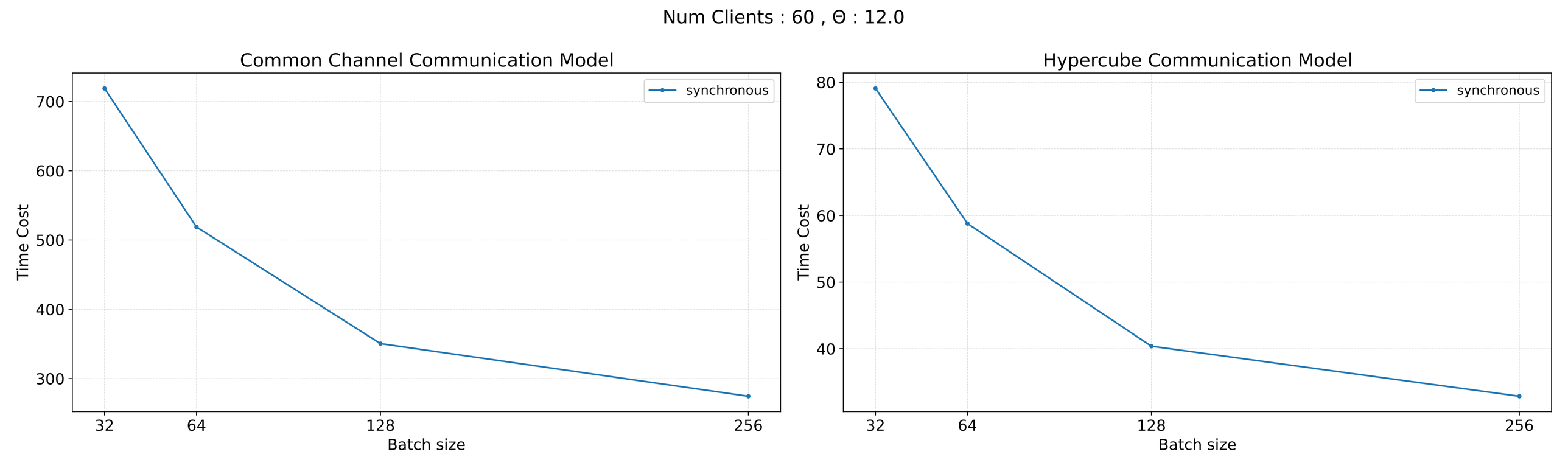
Batch size


Num Clients : 60 , Θ : 12.0
Common Channel Communication Model
synchronous
Time Cost
700
600
500
400
300
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Batch size
Hypercube Communication Model
synchronous
Time Cost
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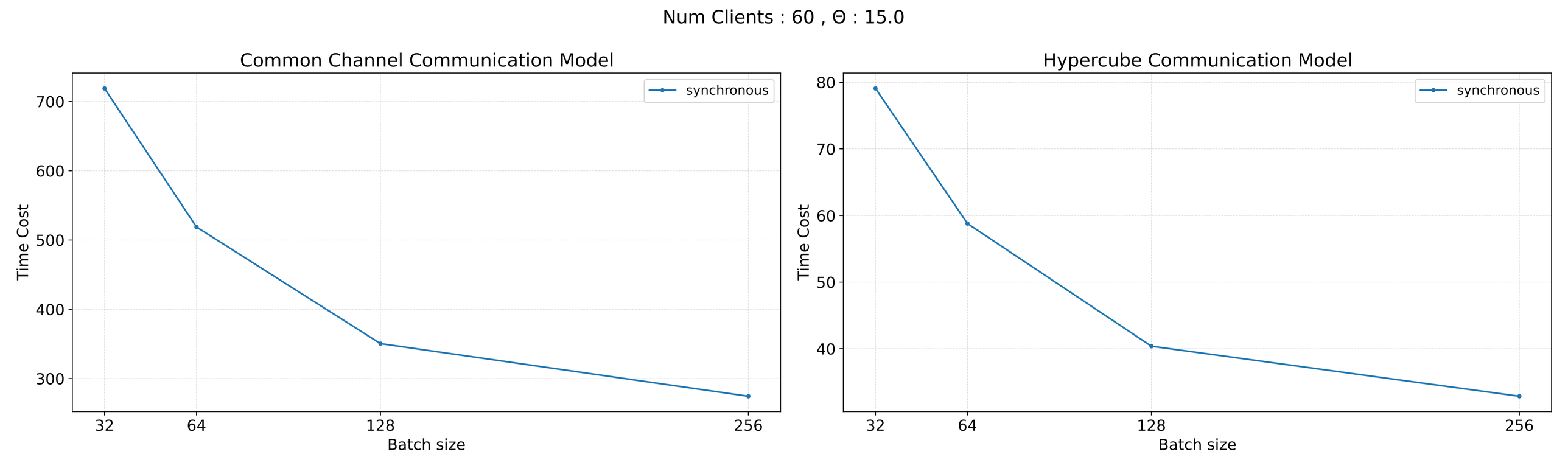
Batch size


Num Clients : 60 , Θ : 15.0
Common Channel Communication Model
synchronous
Time Cost
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400
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128
256
Batch size
Hypercube Communication Model
synchronous
Time Cost
80
70
60
50
40
32
64
128
256
Batch size