The amount of data is too large in simulations. It is difficult to show the detailed raw data obtained by NS3 in this document. Therefore, the data need to be arranged.

Fig 9 Affection of different schemes

N=number of nodes

(a) The delivery ratio in different cases

The data obtained by NS3 are arranged as follows:

Case 1

N=20

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=25

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

N=30

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=35

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

N=40

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

N=45

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=50

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=55

Sink: 3 receive :118packets

Source nodes send : 122 packets

N=60

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

N=65

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=70

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=75

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

Case 2

N=20

Sink: 3 receive : 120packets

Source nodes send : 122 packets

N=25

Sink: 3 receive : 118packets

Source nodes send : 122 packets

N=30

Sink: 3 receive : 120packets

Source nodes send : 122 packets

N=35

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=40

Sink: 3 receive : 118packets

Source nodes send : 122 packets

N=45

Sink: 3 receive : 117packets

Source nodes send : 122 packets

N=50

Sink: 3 receive : 121 packets

Source nodes send : 122 packets

N=55

Sink: 3 receive :118packets

Source nodes send : 122 packets

N=60

Sink: 3 receive : 118packets

Source nodes send : 122 packets

N=65

Sink: 3 receive : 120packets

Source nodes send : 122 packets

N=70

Sink: 3 receive : 118packets

Source nodes send : 122 packets

N=75

Sink: 3 receive : 120 packets

Source nodes send : 122 packets

Case 3

N=20

Sink: 3 receive : 120 packets

Source nodes send : 122 packets
N=25
Sink: 3 receive : 118 packets
Source nodes send : 122 packets
N=30
Sink: 3 receive : 120 packets
Source nodes send : 122 packets
N=35
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=40
Sink: 3 receive : 118 packets
Source nodes send : 122 packets
N=45
Sink: 3 receive : 117 packets
Source nodes send : 122 packets
N=50
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=55
Sink: 3 receive :118packets
Source nodes send : 122 packets
N=60
Sink: 3 receive : 118 packets
Source nodes send : 122 packets
N=65
Sink: 3 receive : 120 packets
Source nodes send : 122 packets
N=70
Sink: 3 receive : 118 packets
Source nodes send : 122 packets
N=75
Sink: 3 receive : 120 packets
Source nodes send : 122 packets

Case 4
N=20
Sink: receive : 117packets
Source nodes send : 122 packets
N=25
Sink: 3 receive : 118packets
Source nodes send : 122 packets
N=30
Sink: 3 receive : 116packets
Source nodes send : 122 packets
N=35
Sink: 3 receive : 117packets
Source nodes send : 122 packets
N=40
Sink: 3 receive : 117packets
Source nodes send : 122 packets
N=45
Sink: 3 receive : 116packets
Source nodes send : 122 packets
N=50
Sink: 3 receive : 113packets
Source nodes send : 122 packets
N=55
Sink: 3 receive :112packets
Source nodes send : 122 packets
N=60
Sink: 3 receive : 110packets
Source nodes send : 122 packets
N=65
Sink: 3 receive : 111packets
Source nodes send : 122 packets
N=70
Sink: 3 receive : 109packets
Source nodes send : 122 packets
N=75
Sink: 3 receive : 107packets
Source nodes send : 122 packets

The results are shown using MATLAB as follows:

```
x=[20,25,30,35,40,45,50,55,60,65,70,75];
y1=[0.99,0.98,0.99,0.98,0.98,0.99,0.99,0.97,0.98
,0.99,0.99,0.98];
y2=[0.98,0.97,0.98,0.99,0.97,0.96,0.96,0.97,0.97
,0.98,0.97,0.98];
y3=[0.96,0.97,0.97,0.95,0.96,0.95,0.93,0.92,0.90
,0.91,0.89,0.88];
y4=[0.94,0.95,0.92,0.93,0.91,0.92,0.92,0.91,0.90
,0.89,0.87,0.87];
```

The results are shown using MATLAB as follows:

```
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x',x,y4,'->');
legend('case 1','case2','case3','case 4');
xlabel('number of nodes');
```

```
ylabel('delivery ratio');
axis([20 75 0.6 1.2])
h = gca;
set(h,'FontSize',20)
```

(b) The network life ratio

T=The performing time until the first node drains its energy

The data obtained by NS3 are arranged as follows:

Case 1

N=20

T=15360000000000.0ns node 14 drains its energy

N=25

T= 15720000000000.0ns node 21 drains its energy

N=30

T= 15840000000000.0ns node 28 drains its energy

N=35

T= 16200000000000.0ns node 31 drains its energy

N=40

T= 15960000000000.0ns node 19 drains its energy

N=45

T= 16200000000000.0ns node 23 drains its energy

N=50

T= 15960000000000.0ns node 36 drains its energy

N=55

T= 19800000000000.0ns node 45 drains its energy

N=60

T= 15720000000000.0ns node 24 drains its energy

N=65

T= 15840000000000.0ns node 38 drains its energy

N=70

T= 15720000000000.0ns node 44 drains its energy

N=75

T= 15840000000000.0ns node 23 drains its energy

Case 2

N=20

T= 16080000000000.0ns node 13 drains its energy

N=25

T= 15840000000000.0ns node 22 drains its energy

N=30

T= 16080000000000.0ns node 24 drains its energy

N=35

T= 16200000000000.0ns node 35 drains its energy

N=40

T= 15960000000000.0ns node 40 drains its energy

N=45

T= 16200000000000.0ns node 23 drains its energy

N=50

T= 15840000000000.0ns node 22 drains its energy

N=55

T= 1620000000000.0ns node 15 drains its energy

N=60

T= 15960000000000.0ns node 35 drains its energy

N=65

T= 15720000000000.0ns node 45 drains its energy

N=70

T= 16080000000000.0ns node 54 drains its energy

N=75

T= 16080000000000.0ns node 28 drains its energy

Case 3

N=20

T= 1200000000000.0ns node 11 drains its energy
N=25
T= 12120000000000.0ns node 18 drains its energy
N=30
T= 11760000000000.0ns node 22 drains its energy
N=35
T= 11520000000000.0ns node 19 drains its energy
N=40
T= 11640000000000.0ns node 24 drains its energy
N=45
T= 11520000000000.0ns node 34 drains its energy
N=50
T= 1140000000000.0ns node 21 drains its energy
N=55
T= 1092000000000.0ns node 17 drains its energy
N=60
T= 10800000000000.0ns node 45 drains its energy
N=65
T= 10680000000000.0ns node 52 drains its energy
N=70
T= 10440000000000.0ns node 42 drains its energy
N=75
T= 10560000000000.0ns node 34 drains its energy
Case 4
N=20
T= 1320000000000.0ns node 15 drains its energy
N=25
T= 12000000000000.0ns node 21 drains its energy
N=30
T= 11880000000000.0ns node 25 drains its energy
N=35
T= 11640000000000.0ns node 29 drains its energy
N=40
T= 11640000000000.0ns node 24 drains its energy
N=45
T= 11520000000000.0ns node 37 drains its energy
N=50
T= 111600000000.0ns node 27 drains its energy
N=55
T= 1092000000000.0ns node 17 drains its energy
N=60
T= 10800000000000.0ns node 47 drains its energy
N=65
T= 10800000000000.0ns node 59 drains its energy
N=70
T= 10560000000000.0ns node 18 drains its energy
N=75
T= 10560000000000.0ns node 34 drains its energy
The results are shown using MATLAB as follows:

```
x=[20,25,30,35,40,45,50,55,60,65,70,75];
y1=[1.28,1.31,1.32,1.35,1.33,1.35,1.33,1.32,1.31
,1.32,1.31,1.32];
y2=[1.34,1.32,1.34,1.35,1.33,1.35,1.32,1.34,1.33
,1.31,1.34,1.336];
y3=[1,1.01,0.98,0.96,0.97,0.96,0.95,0.91,0.90,0.
89,0.87,0.878];
y4=[1.1,1.0,0.99,0.97,0.96,0.95,0.93,0.91,0.90,0.
90,0.88,0.88];
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x',x,y4,'->');
legend('case 1','case2','case3','case 4');
xlabel('number of nodes');
ylabel('network life ratio');
axis([20 75 0.8 1.5])
h = gca;
set(h,'FontSize',20)
```

Fig 10 The affection of number ratio of regular nodes to advanced nodes(RRTA)

The data obtained by NS3 are arranged as follows:

N=2

RRTA=2.5 T= 16000000000000.0ns node 38 drains its energy

RRTA=3 T= 16160000000000.0ns node 43 drains its energy

RRTA=3.5 T= 15840000000000.0ns node 52 drains its energy

RRTA=4 T= 15840000000000.0ns node 55 drains its energy

RRTA=4.5 T= 16048000000000.0ns node 24 drains its energy

RRTA=5 T= 15936000000000.0ns node 18 drains its energy

RRTA=5.5 T= 15936000000000.0ns node 14 drains its energy

RRTA=6 T= 14080000000000.0ns node 5 drains its energy

RRTA=6.5 T= 12480000000000.0ns node 7 drains its energy

N=3

RRTA=2.5 T= 16000000000000.0ns node 36 drains its energy

RRTA=3 T= 16160000000000.0ns node 53 drains its energy

RRTA=3.5 T= 15840000000000.0ns node 62 drains its energy

RRTA=4 T= 14720000000000.0ns node 65 drains its energy

RRTA=4.5 T= 14240000000000.0ns node 44 drains its energy

RRTA=5 T= 13840000000000.0ns node 23 drains its energy

RRTA=5.5 T= 12960000000000.0ns node 18 drains its energy

RRTA=6 T= 12480000000000.0ns node 11 drains its energy

RRTA=6.5 T= 10400000000000.0ns node 5 drains its energy

N=4

RRTA=2.5 T= 15680000000000.0ns node 43 drains its energy

RRTA=3 T= 15360000000000.0ns node 23 drains its energy

RRTA=3.5 T= 14400000000000.0ns node 7 drains its energy

RRTA=4 T= 13600000000000.0ns node 10drains its energy

RRTA=4.5 T= 12800000000000.0ns node 8 drains its energy

RRTA=5 T= 12160000000000.0ns node 5 drains its energy

RRTA=5.5 T= 11200000000000.0ns node 7 drains its energy

RRTA=6 T= 10400000000000.0ns node 9 drains its energy

RRTA=6.5 T= 9920000000000.0ns node 5 drains its energy

N=5

RRTA=2.5 T= 14560000000000.0ns node 60 drains its energy

RRTA=3 T= 14400000000000.0ns node 45 drains its energy

RRTA=3.5 T= 14400000000000.0ns node 58 drains its energy

RRTA=4 T= 13120000000000.0ns node 10 drains its energy

RRTA=4.5 T= 10720000000000.0ns node 12 drains its energy

RRTA=5 T= 9600000000000.0ns node 8 drains its energy

RRTA=5.5 T= 8480000000000.0ns node 9 drains its energy

RRTA=6.5 T= 7680000000000.0ns node 5 drains its energy

The results are shown use MATLAB as follows:

x=[2.5,3,3.5,4,4.5,5,5.5,6,6.5];

y1=[1,1.01,0.99,0.992,1.003,0.996,0.996,0.88,0.78];

y2=[1,1.01,0.99,0.92,0.89,0.865,0.81,0.78,0.72];

y3=[0.98,0.96,0.90,0.85,0.80,0.76,0.70,0.65,0.62

```
];
y4=[0.91,0.9,0.82,0.78,0.67,0.60,0.53,0.50,0.48]
;
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x',x,y4,'->');
legend('N=2','N=3','N=4','N=5');
xlabel('number ratio of regular nodes to cluster
heads ');
ylabel('network life ratio');
axis([2.5 6.5 0.5 1.2])
h = gca
set(h,'FontSize',20)
```

Fig 11 Comparation with NCRP and VBF

N=number of nodes

1. End-to-end delay

t=the average end to end delay

RSHSC

N=20From the sender to the receiver is 1010000000.0ns

N=25From the sender to the receiver is 1000000000.0ns

N=30From the sender to the receiver is 1050000000.0ns

N=35From the sender to the receiver is 990000000.0ns

N=40From the sender to the receiver is 980000000.0ns

N=45From the sender to the receiver is 1000000000.0ns

N=50From the sender to the receiver is 1010000000.0ns

N=55From the sender to the receiver is 970000000.0ns

N=60From the sender to the receiver is 950000000.0ns

N=65From the sender to the receiver is 1000000000.0ns

N=70From the sender to the receiver is 1060000000.0ns

N=75From the sender to the receiver is 1000000000.0ns

VBF

N=20From the sender to the receiver is 14010000000.0ns

N=25From the sender to the receiver is 12000000000.0ns

N=30From the sender to the receiver is 16050000000.0ns

N=35From the sender to the receiver is 1040000000.0ns

N=40From the sender to the receiver is 1200000000.0ns

N=45From the sender to the receiver is 14000000000.0ns

N=50From the sender to the receiver is 13000000000.0ns

N=55From the sender to the receiver is 1400000000.0ns

N=60From the sender to the receiver is 1200000000.0ns

N=65From the sender to the receiver is 13000000000.0ns

N=70From the sender to the receiver is 14060000000.0ns

N=75From the sender to the receiver is 13000000000.0ns

NCRP

N=20From the sender to the receiver is 1000000000.0ns

N=25From the sender to the receiver is 11400000000.0ns

N=30From the sender to the receiver is 1100000000.0ns

N=35From the sender to the receiver is 1000000000.0ns

N=40From the sender to the receiver is 1100000000.0ns

N=45From the sender to the receiver is 900000000.0ns

N=50From the sender to the receiver is 950000000.0ns

N=55From the sender to the receiver is 960000000.0ns

N=60From the sender to the receiver is 950000000.0ns
N=65From the sender to the receiver is 1010000000.0ns
N=70From the sender to the receiver is 1020000000.0ns
N=75From the sender to the receiver is 980000000.0ns
The results are shown using MATLAB as follows:

```
x=[20,25,30,35,40,45,50,55,60,65,70,75];
y1=[1.01,1.0,1.05,0.99,0.98,1.0,1.01,0.97,0.95,1.0,1.06,1.0];
y2=[14,12,14,16,12,14,13,14,12,13,14,13];
y3=[1,1.14,1.1,1,1.1,0.9,0.95,0.96,1.01,1.02,1.05,0.98];
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x');
legend('RSHSC','VBF','NCRP');
xlabel('number of nodes');
ylabel('end-to-end delay');
axis([20 75 0 18])
h = gca;
set(h,'FontSize',20)
```

2. Consumption energy per packets

RSHSC

N=20
Sink: 3 receive : 121 packets
Average Energy Consumption of each node1920J
N=25
Sink: 3 receive : 120 packets
Average Energy Consumption of each node2040J
N=30
Sink: 3 receive : 121 packets
Average Energy Consumption of each node1936J
N=35
Sink: 3 receive : 120 packets
Average Energy Consumption of each node2160J
N=40
Sink: 3 receive : 120 packets
Average Energy Consumption of each node1800J
N=45
Sink: 3 receive : 121 packets
Average Energy Consumption of each node2057J
N=50
Sink: 3 receive : 121 packets
Average Energy Consumption of each node1815J
N=55
Sink: 3 receive :118packets
Average Energy Consumption of each node1888J
N=60
Sink: 3 receive : 120 packets
Average Energy Consumption of each node1800J
N=65
Sink: 3 receive : 121 packets
Average Energy Consumption of each node2057J
N=70
Sink: 3 receive : 121 packets
Average Energy Consumption of each node2057J
N=75
Sink: 3 receive : 120 packets
Average Energy Consumption of each node1920J

VBF

N=20
Sink: 3 receive :61 packets
Average Energy Consumption of each node4026J
N=25
Sink: 3 receive :61 packets
Average Energy Consumption of each node4575J
N=30

Sink: 3 receive :95packets
Average Energy Consumption of each node 5700J
N=35
Sink: 3 receive :87 packets
Average Energy Consumption of each node 5916J
N=40
Sink: 3 receive :89 packets
Average Energy Consumption of each node 6408J
N=45
Sink: 3 receive :90 packets
Average Energy Consumption of each node 7380J
N=50
Sink: 3 receive :99 packets
Average Energy Consumption of each node 8811J
N=55
Sink: 3 receive :101packets
Average Energy Consumption of each node 9595J
N=60
Sink: 3 receive :104 packets
Average Energy Consumption of each node 10608J
N=65
Sink: 3 receive :102 packets
Average Energy Consumption of each node 11832J
N=70
Sink: 3 receive :104 packets
Average Energy Consumption of each node 12064J
N=75
Sink: 3 receive :105 packets
Average Energy Consumption of each node 12705J

NCRP

N=20
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 1936J
N=25
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 2057J
N=30
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 1936J
N=35
Sink: 3 receive : 120 packets
Average Energy Consumption of each node 2160J
N=40
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 1815J
N=45
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 2057J
N=50
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 1815J
N=55
Sink: 3 receive :120packets
Average Energy Consumption of each node 1920J
N=60
Sink: 3 receive : 120 packets
Average Energy Consumption of each node 1800J
N=65
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 2057J
N=70
Sink: 3 receive : 121 packets
Average Energy Consumption of each node 2057J
N=75
Sink: 3 receive : 120 packets

Average Energy Consumption of each node 1920J

The results are shown using MATLAB as follows:

```
x=[20,25,30,35,40,45,50,55,60,65,70,75];
y1=[16,17,16,18,15,17,15,16,15,17,17,16];
y2=[66,75,60,68,72,82,89,95,102,110,116,121];
y3=[18,20,21,23,22,19,22,23,21,20,22,21];
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x');
legend('RSHSC','VBF','NCRP');
xlabel('number of nodes');
ylabel('total energy consumption(J)/ packets');
axis([20 75 10 130])
h = gca;
set(h,'FontSize',20)
```

3. Delivery ratio

RSHSC

N=20
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=25
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=30
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=35
Sink: 3 receive : 120 packets
Source nodes send : 122 packets
N=40
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=45
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=50
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=55
Sink: 3 receive :120packets
Source nodes send : 122 packets
N=60
Sink: 3 receive : 120 packets
Source nodes send : 122 packets
N=65
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=70
Sink: 3 receive : 121 packets
Source nodes send : 122 packets
N=75
Sink: 3 receive : 120 packets
Source nodes send : 122 packets

VBF

N=20
Sink: 3 receive :61 packets
Source nodes send : 122 packets
N=25
Sink: 3 receive :61 packets
Source nodes send : 122 packets
N=30
Sink: 3 receive :95packets
Source nodes send : 122 packets
N=35
Sink: 3 receive :87 packets
Source nodes send : 122 packets
N=40
Sink: 3 receive :89 packets
Source nodes send : 122 packets
N=45
Sink: 3 receive :90 packets
Source nodes send : 122 packets
N=50
Sink: 3 receive :99 packets
Source nodes send : 122 packets
N=55
Sink: 3 receive :101ackets
Source nodes send : 122 packets
N=60
Sink: 3 receive :104 packets
Source nodes send : 122 packets
N=65
Sink: 3 receive :102 packets
Source nodes send : 122 packets
N=70

Sink: 3 receive :104 packets
Source nodes send : 122 packets
N=75
Sink: 3 receive :105 packets
Source nodes send : 122 packets

NCRP

N=20
Sink: 3 receive :120 packets
Source nodes send : 122 packets
N=25
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=30
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=35
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=40
Sink: 3 receive :120 packets
Source nodes send : 122 packets
N=45
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=50
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=55
Sink: 3 receive :120 packets
Source nodes send : 122 packets
N=60
Sink: 3 receive :119 packets
Source nodes send : 122 packets
N=65
Sink: 3 receive :120 packets
Source nodes send : 122 packets
N=70
Sink: 3 receive :120 packets
Source nodes send : 122 packets
N=75
Sink: 3 receive :121 packets
Source nodes send : 122 packets

The results are shown using MATLAB as follows:

```
x=[20,25,30,35,40,45,50,55,60,65,70,75];
y1=[0.99,0.99,0.99,0.98,0.99,0.99,0.99,0.98,0.98
,0.99,0.99,0.98];
y2=[0.5,0.5,0.78,0.71,0.73,0.74,0.81,0.83,0.85,0.
84,0.85,0.86];
y3=[0.98,0.97,0.97,0.97,0.98,0.97,0.97,0.98,0.97
,0.98,0.98,0.99];
plot(x,y1,'-o',x,y2,'-+',x,y3,'-x');
legend('RSHSC','VBF','NCRP');
xlabel('number of nodes');
ylabel('delivery ratio');
axis([20 75 0.6 1.2])
h = gca;
set(h,'FontSize',20)
```