
华中科技大学

电子信息与通信学院

实 验 报 告

实验名称 NS3 实验二

课程名称 计算机网络

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成绩 教师 黑晓军

1. 实验目的

1. 了解网络仿真的意义
2. 掌握 CSMA、DCF 协议的基本原理
3. 安装并熟悉使用 NS-3
4. 学会利用 NS-3 对 DCF 协议进行仿真

2. 实验环境

1. 环境：mac,Ubuntu18.04.1,虚拟机 Vmware ；
2. 实验过程：按照老师发的安装手册，一步一步来，没有出现任何报错，最后可以正常运行老师给的程序；

3. 实验内容与结果

软件编程类实验报告内容：

(1) time 为 0.001

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (10.409s)
1023 bytes
totalPacketsThrough: 145492
Throughput: 23.8141 Mbit/s
```

(2) time 为 0.0001

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (6.326s)
1023 bytes
totalPacketsThrough: 145496
Throughput: 23.8148 Mbit/s
```

(4) time 为 0.00001

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1803/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (34.899s)
1023 bytes
totalPacketsThrough: 145496
Throughput: 23.8148 Mbit/s
```

(5) time 为 0.01

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (3.165s)
1023 bytes
totalPacketsThrough: 25000
Throughput: 4.092 Mbit/s
```

(5) time 为 0.1

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1804/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (15.634s)
1023 bytes
totalPacketsThrough: 2500
Throughput: 0.4092 Mbit/s
```

(6) time 为 1

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1803/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (8.901s)
1023 bytes
totalPacketsThrough: 250
Throughput: 0.04092 Mbit/s
```

(7) time 为 10

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1809/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (7.692s)
1023 bytes
totalPacketsThrough: 25
Throughput: 0.004092 Mbit/s
```

(8) time 为 100

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1794/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (8.182s)
1023 bytes
totalPacketsThrough: 5
Throughput: 0.0008184 Mbit/s
```

实验二

(1) 用户数为 5

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (10.409s)
1023 bytes
totalPacketsThrough: 145492
Throughput: 23.8141 Mbit/s
```

(2) 用户数为 10

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (8.538s)
1023 bytes
totalPacketsThrough: 135787
Throughput: 22.2256 Mbit/s
```

(3) 用户数为 15

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (23.233s)
1023 bytes
totalPacketsThrough: 129818
Throughput: 21.2486 Mbit/s
```

(4) 用户数为 20

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1794/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (11.917s)
1023 bytes
totalPacketsThrough: 125064
Throughput: 20.4705 Mbit/s
```

(5) 用户数为 25

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (11.485s)
1023 bytes
totalPacketsThrough: 121783
Throughput: 19.9334 Mbit/s
```

(6) 用户数为 30

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1794/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (6.034s)
1023 bytes
totalPacketsThrough: 118683
Throughput: 19.426 Mbit/s
```

(7) 用户数为 35

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (12.567s)
1023 bytes
totalPacketsThrough: 115641
Throughput: 18.9281 Mbit/s
```

(8) 用户数为 40

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1804/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (7.592s)
1023 bytes
totalPacketsThrough: 113494
Throughput: 18.5767 Mbit/s
```

(9) 用户数为 45

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (11.537s)
1023 bytes
totalPacketsThrough: 111427
Throughput: 18.2384 Mbit/s
```

(10) 用户数为 50

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1793/1842] Compiling scratch/testBASnew.cc
[1802/1842] Linking build/scratch/testBASnew
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (12.164s)
1023 bytes
totalPacketsThrough: 109400
Throughput: 17.9066 Mbit/s
```


实验三

(1) $cwmin = 3, cwmax = 255$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1383/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1786/1842] Compiling scratch/testBASnew.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1793/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1794/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1795/1842] Linking build/lib/libns3-dev-wave-debug.so
[1803/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (20.663s)
1023 bytes
totalPacketsThrough: 132195
Throughput: 21.6377 Mbit/s
```

(2) $cwmin = 7, cwmax = 511$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1363/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (15.168s)
1023 bytes
totalPacketsThrough: 138904
Throughput: 22.7358 Mbit/s
```

(3) $cwmin = 15, cwmax = 1023$

```

zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1298/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1794/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.149s)
1023 bytes
totalPacketsThrough: 145492
Throughput: 23.8141 Mbit/s

```

(4) cwmin = 31, cwmax = 2047

```

zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1386/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.240s)
1023 bytes
totalPacketsThrough: 148095
Throughput: 24.2402 Mbit/s

```

(5) cwmin = 63, cwmax = 4095


```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1381/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1796/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.890s)
1023 bytes
totalPacketsThrough: 142156
Throughput: 23.2681 Mbit/s
```

(6) cwmin = 127, cwmax = 8191

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1329/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (7.826s)
1023 bytes
totalPacketsThrough: 124750
Throughput: 20.4191 Mbit/s
```

(7) cwmin = 255, cwmax = 16383

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1359/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (8.901s)
1023 bytes
totalPacketsThrough: 97792
Throughput: 16.0066 Mbit/s
```

(8) cwmin = 511, cwmax = 32767

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1336/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1798/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-test-debug.so
[1838/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (18.688s)
1023 bytes
totalPacketsThrough: 67574
Throughput: 11.0605 Mbit/s
```

(9) cwmin = 1023, cwmax = 65535

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1366/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (10.152s)
1023 bytes
totalPacketsThrough: 41634
Throughput: 6.81465 Mbit/s
```

实验四

(1) $cwmax = 5095$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1305/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1794/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.836s)
1023 bytes
totalPacketsThrough: 145458
Throughput: 23.8086 Mbit/s
```

(2) $cwmax = 2047$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1326/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1793/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.795s)
1023 bytes
totalPacketsThrough: 145604
Throughput: 23.8325 Mbit/s
```

(3) $cwmax = 1023$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
[sudo] password for zqj:
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1345/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1797/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-test-debug.so
[1838/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (40.547s)
1023 bytes
totalPacketsThrough: 145492
Throughput: 23.8141 Mbit/s
```

(4) $cwmax = 511$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1299/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1795/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (10.989s)
1023 bytes
totalPacketsThrough: 145226
Throughput: 23.7706 Mbit/s
```

(5) $cwmax = 255$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1326/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1795/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utls/ns3-dev-test-runner-debug
[1842/1842] Linking build/utls/ns3-dev-print-introspected-doxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.406s)
1023 bytes
totalPacketsThrough: 145261
Throughput: 23.7763 Mbit/s
```

(6) cwmax = 127

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1335/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utls/ns3-dev-test-runner-debug
[1842/1842] Linking build/utls/ns3-dev-print-introspected-doxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (10.080s)
1023 bytes
totalPacketsThrough: 144824
Throughput: 23.7048 Mbit/s
```

(7) cwmax = 63


```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1317/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1792/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.631s)
1023 bytes
totalPacketsThrough: 143857
Throughput: 23.5465 Mbit/s
```

(8) $cwmax = 31$

```
zqj@ubuntu:~/Desktop/ns-3-dev$ sudo ./waf --run testBASnew
Waf: Entering directory `/home/zqj/Desktop/ns-3-dev/build'
[1334/1842] Compiling src/wifi/model/regular-wifi-mac.cc
[1794/1842] Linking build/lib/libns3-dev-wifi-debug.so
[1833/1842] Linking build/lib/libns3-dev-dsr-debug.so
[1834/1842] Linking build/lib/libns3-dev-mesh-debug.so
[1835/1842] Linking build/lib/libns3-dev-wave-debug.so
[1836/1842] Linking build/lib/libns3-dev-aodv-debug.so
[1837/1842] Linking build/lib/libns3-dev-netanim-debug.so
[1838/1842] Linking build/lib/libns3-dev-test-debug.so
[1839/1842] Linking build/scratch/subdir/subdir
[1840/1842] Linking build/scratch/testBASnew
[1841/1842] Linking build/utils/ns3-dev-test-runner-debug
[1842/1842] Linking build/utils/ns3-dev-print-introspected-doxxygen-debug
Waf: Leaving directory `/home/zqj/Desktop/ns-3-dev/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (9.951s)
1023 bytes
totalPacketsThrough: 142158
Throughput: 23.2684 Mbit/s
```


4. 思考题

实验二 无线局域网的网络吞吐量与网络用户数量的关系

(1) 根据所得仿真结果, 说明所观察到的现象;

答: 有试验结果可以知道, 当用户流量到达率为 0.01-100 时, 吞吐量和用户到达率成正比关系。当用户到达率大于 100 时, 吞吐量基本保持不变。

(2) 根据你对 DCF 协议的理解, 解释所观察到的现象。

答: 1. 在 802.11 协议中, DCF 机制是节点共享无线信道进行数据传输的基本接入方式, 它把 CSMA/CA 技术和确认 (ACK) 技术结合起来。它采用二进制指数回退策略来避免冲撞;

2. DCF 是基于竞争机制, 提供分布式接入, 多个分布式无线节点抢同一资源;

3. 这是由于在用户流量到达率较小时, 网络处于非饱和的状态, 吞吐量会随着用户流量到达率的增加而增加, 当用户流量到达率增加到一个临界值的时候, 此时网络状态由不饱和变为饱和, 网络吞吐量到达最大值, 不会再随着用户流量到达率的增加而改变。

实验三 无线局域网的网络吞吐量与初始退避窗口的关系

(1) 根据所得仿真结果, 说明所观察到的现象;

答: 当其他的条件不变的情况下, 网络吞吐量随着 $cwmin$ 和 $cwmax$ 的增大而减小;

(2) 根据你对 DCF 协议的理解, 解释所观察到的现象;

答: 由于退避窗口设置的过大, 当发生冲突时, 用户选择退避的时间过长, 导致了网络状态的不饱和, 也最终导致了网络吞吐量的减少。

(3) 记录网络吞吐量达到最大时对应的最优初始退避窗口值, 试试看改变用户数量后该最优值的变化情况, 解释原因。

答: 当 $cwmin = 31$, $cwmax = 2047$ 时为最优的值;

最优值减小, 因为当用户数增加时, 会导致冲突增多, 用户处于退避的时间部分增加, 最终导致网络吞吐量减小。

思考问题

(1) 除以上关键参数外，还有哪些参数可能会影响无线局域网的性能？

- 答：1. 传输功率。无线 AP 发送功率大多在 100mW 以下，网桥最大功率为 250mW。
2. 天线类型和方向。全向天线的性能较差，定向天线的传输速率会更高。通常情况下，无线 AP 采用全向天线，无线客户端采用定向天线。
3. 噪音和干扰。微波炉、无线电话、相同或相邻的无线 AP 信道等，都会对传输速率产生重要影响。
4. 建筑物结构。无线信号会在建筑物内多次反射后，到达无线设备，从而引发多路径传输，相互干扰。另外，无线信号在穿透墙体时，会有较大的损耗。
5. 无线 AP 位置。无线 AP 应当置于较高的位置，从而避免有其他物体阻挡。将无线天线置于同一水平位置时，信号强度最高。
6. 连接损耗。无线网卡与无线天线间的连接头损耗、馈线损耗等，也会在一定程度上减弱无线信号。
7. 外界因素。物体阻挡、大雾和雨，也会导致无线信号衰减。

(2) IEEE 802.11 DCF 协议中的基本接入机制和 RTS/CTS 接入机制的主要区别？

答：1. 基本接入机制：当 MAC 层有帧需要发送，在物理载波侦听和虚拟载波侦听都表示信道空闲之后，若退避窗口的计数值不为 0，则继续一 slot time 为单位减少计数值，否则随机生成一个退避窗口进行退避。

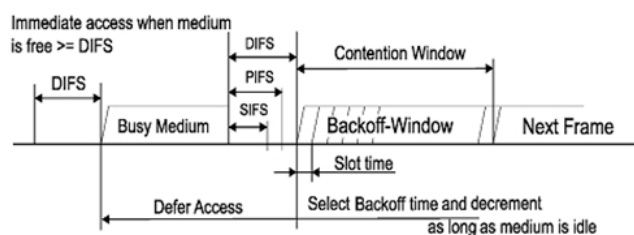


Figure 9-5—Basic access method / LIN_SHUQING

2. RTS/CTS 接入机制：

802.11 中可以选择使用或者不适用 RTS/CTS 机制来预约信道。在 802.11 中，并不是每次的数据帧、管理帧的传输过程都要借助 RTS/CTS 来预约信道，多余的 RTS/CTS 会导致效率降低，该机制并不是总是有效，尤其对于短数据帧（可能是短帧的发送成功率高，冲突可能性低吧）。广播和多目标传输不能使用 RTS 机制，因为其会引起多个目标地址进行 CTS 应答。

只有当定向帧的 MPDU 或者 MMPDU 的长度超过了属性值 dot11RTSThreshold 后 STA 才在帧交换前使用 RTS/CTS 交换。

(3) 能否分别获得 DCF 协议中使用不同接入机制（基本接入机制和 RTS/CTS 接入机制）时的网络性能，比较其差异，并分析在实际无线局域网中应当如何选择接入机制？

答：当数据包比较短时，可以选择基本接入机制，当数据包比较长时，可以选择 RTS/CTS 接入机制。因为数据包较长时，RTS/CTS 接入机制需要回复 ACK 会降低网络的利用率。

5. 实验中的问题

问题：说明在实验中碰到哪些问题，是否已经解决，有哪些经验或者教训。

答：1.用虚拟机跑实验比较慢。解决方法：使用双系统直接跑；
2.更改代码比较麻烦，建议使用脚本，直接把所有需要执行的步骤都写入脚本

附件

1. 程序源代码
2. 参考文献列表