

# 802.11ad with MPTCP: Improve throughput in mobility and blockage

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# Integrate with NS3-mmwave

- Environment
  - Ubuntu 14.04.5
  - GCC-5, G++-5
  - DCE-1.10

# Integrate with NS3-mmwave

- Install NS3-DCE-1.10

```
hg clone http://code.nsnam.org/bake bake
export BAKE_HOME=`pwd`/bake
export PATH=$PATH:$BAKE_HOME
export PYTHONPATH=$PYTHONPATH:$BAKE_HOME
mkdir test
cd test
bake.py configure -e dce-linux-1.10
bake.py download
```



[dce-test@dcetest-desktop:~/test/source\$ ls

bash

bash-4.1.tar.gz

castxml

ccnx

ccnx-0.6.2.tar.gz

elf-loader

iperf

iperf-2.0.5.tar.gz

iproute2-4.4.0

libaspect

netanim-3.108

net-next-nuse-4.4.0

ns-3.28

ns-3-dce

pybindgen

pygccxml-1.9.1

thttpd

thttpd-2.25b.tar.gz

v1.9.1.tar.gz

wget

wget-1.15.tar.gz

# Integrate with NS3-mmwave

- Replace ns-3.28 to mmwave module

```
git clone https://github.com/nyuwireless-unipd/ns3-mmwave.git
rm -r ns-3.28
mv ns3-mmwave ns-3.28
```

- Apply patch file to kernel-socket-fd-factory.cc

```
cd /home/dce-test/test/source/ns-3-dce/model
cp ../../ns-3.28/utils/mmWave-dce18-patch.diff ./patch.diff
patch < patch.diff
```



```
[dce-test@dcetest-desktop:~/dce/source/ns-3-dce/model$ patch < patch.diff
patching file kernel-socket-fd-factory.cc
patching file kernel-socket-fd-factory.h
```

# Integrate with NS3-mmwave

- Modify ./ns-3-dce/wscript file

```
ns3waf.check_modules(conf, ['visualizer'], mandatory = False)
ns3waf.check_modules(conf, ['applications'], mandatory = False)
ns3waf.check_modules(conf, ['fd-net-device'], mandatory = False)
conf.check(header_name='stdint.h', define_name='HAVE_STDINT_H', mandatory=False)
conf.check(header_name='inttypes.h', define_name='HAVE_INTTYPES_H', mandatory=False)
```



```
ns3waf.check_modules(conf, ['applications'], mandatory = False)
ns3waf.check_modules(conf, ['fd-net-device'], mandatory = False)
ns3waf.check_modules(conf, ['mmwave'], mandatory = False)
conf.check(header_name='stdint.h', define_name='HAVE_STDINT_H', mandatory=False)
conf.check(header_name='inttypes.h', define_name='HAVE_INTTYPES_H', mandatory=False)
```

# Integrate with NS3-mmwave

- Modify `./ns-3-dce/model/unix-datagram-socket-fd.cc`
  - `ICMPV4_DEST_UNREACH` -> `DEST_UNREACH`
  - `ICMPV4_FRAG_NEEDED` -> `FRAG_NEEDED`
  - `ICMPV4_PORT_UNREACHABLE` -> `PORT_UNREACHABLE`
  - `ICMPV4_TIME_EXCEEDED` -> `TIME_EXCEEDED`
  - `ICMPV4_TIME_TO_LIVE` -> `TIME_TO_LIVE`
  - `ICMPV4_FRAGMENT_REASSEMBLY` -> `FRAGMENT_REASSEMBLY`

# Integrate with NS3-mmwave

- Modify `./ns-3-dce/test/addons/dce-linux-ip6-test.cc`
  - ICMPV4\_ECHO\_REPLY -> ECHO\_REPLY
- Modify `./ns-3.28/src/mmwave/model/mmwave-beamforming.cc`

```
std::string filename = "../src/mmwave/model/BeamFormingMatrix/SmallScaleFading.txt";
```



```
std::string filename = "../../ns-3.28/src/mmwave/model/BeamFormingMatrix/SmallScaleFading.txt"
```

- Build NS3-DCE-1.10

```
bake.py build
```



# Integrate with NS3-mmwave

- DCE-iperf example

```
[dce-test@dcetest-desktop:~/test/source/ns-3-dce$ ./waf --run "dce-iperf --stack=linux"
Waf: Entering directory `/home/dce-test/test/source/ns-3-dce/build'
[ 10/381] Creating build/lib/pkgconfig/libns3-dev-netlink-debug.pc
[116/381] Creating build/lib/pkgconfig/libns3-dev-dce-debug.pc
[128/381] Linking build/bin/dce-mptcp-lte-wifi
[168/381] Linking build/bin/dce-iperf-mptcp
Waf: Leaving directory `/home/dce-test/test/source/ns-3-dce/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (0.913s)
[dce-test@dcetest-desktop:~/test/source/ns-3-dce$ cat files-0/var/log/*/stdout
```

```
-----
Client connecting to 10.1.1.2, TCP port 5001
TCP window size: 44.4 KByte (default)
-----
```

```
-----
[  3] local 10.1.1.1 port 57064 connected with 10.1.1.2 port 5001
[ ID] Interval      Transfer    Bandwidth
[  3] 0.0- 1.0 sec    896 KBytes  7.34 Mbits/sec
[  3] 1.0- 2.0 sec    640 KBytes  5.24 Mbits/sec
[  3] 2.0- 3.0 sec    512 KBytes  4.19 Mbits/sec
[  3] 3.0- 4.0 sec    640 KBytes  5.24 Mbits/sec
[  3] 4.0- 5.0 sec    512 KBytes  4.19 Mbits/sec
[  3] 5.0- 6.0 sec    640 KBytes  5.24 Mbits/sec
[  3] 6.0- 7.0 sec    512 KBytes  4.19 Mbits/sec
[  3] 7.0- 8.0 sec    640 KBytes  5.24 Mbits/sec
[  3] 8.0- 9.0 sec    512 KBytes  4.19 Mbits/sec
[  3] 9.0-10.0 sec    640 KBytes  5.24 Mbits/sec
[  3] 0.0-10.0 sec    6.12 MBytes  5.13 Mbits/sec
```

# Integrate with NS3-mmwave

- mmwave example

```
TttBasedHandover: alreadyAssociatedImsi 1 onHandoverImsi 0
Current SINR 1.35886
alreadyAssociatedImsi 1 onHandoverImsi 0
Cell 0 reports -inf
Cell 2 reports 1.30096
Cell 3 reports -14.9683
MaxSinr 1.30096 in cell 2 current cell 2 currentSinr 1.30096 sinrDifference 0
TttBasedHandover: alreadyAssociatedImsi 1 onHandoverImsi 0
Current SINR 1.30096
alreadyAssociatedImsi 1 onHandoverImsi 0
Cell 0 reports -inf
Cell 2 reports 1.23749
Cell 3 reports -15.028
MaxSinr 1.23749 in cell 2 current cell 2 currentSinr 1.23749 sinrDifference 0
TttBasedHandover: alreadyAssociatedImsi 1 onHandoverImsi 0
Current SINR 1.23749
alreadyAssociatedImsi 1 onHandoverImsi 0
Cell 0 reports -inf
Cell 2 reports 1.17422
Cell 3 reports -15.0754
MaxSinr 1.17422 in cell 2 current cell 2 currentSinr 1.17422 sinrDifference 0
```

# Integrate with NS3-mmwave

- Install NS3-DCE-1.10

```
hg clone http://code.nsnam.org/bake bake
export BAKE_HOME=`pwd`/bake
export PATH=$PATH:$BAKE_HOME
export PYTHONPATH=$PYTHONPATH:$BAKE_HOME
mkdir dce
cd dce
bake.py configure -e dce-ns3-1.10
bake.py download
bake.py build
```

- Install LibOS

```
git clone -b mptcp_trunk_libos https://github.com/libos-nuse/net-next-nuse.git
cd net-next-nuse mptcp
cd mptcp
```

# Integrate with MPTCP

- Modify LibOS configuration to use MPTCP

```
cat >> arch/lib/defconfig <<END
CONFIG_MPTCP=y
CONFIG_MPTCP_PM_ADVANCED=y
CONFIG_MPTCP_FULLMESH=y
CONFIG_MPTCP_NDIFFPORTS=y
CONFIG_DEFAULT_FULLMESH=y
CONFIG_DEFAULT_MPTCP_PM="fullmesh"
CONFIG_MPTCP_SCHED_ADVANCED=y
CONFIG_MPTCP_ROUNDROBIN=y
CONFIG_DEFAULT_MPTCP_SCHED="default"
END
```

- Configure and compile kernel

```
make defconfig ARCH=lib
make library ARCH=lib
```

# Integrate with NS3-mmwave

- Install iproute2 and patch it with DCE

```
wget http://ftp.osuosl.org/pub/clfs/conglomeration/iproute2/iproute2-2.6.38.tar.bz2
cd iproute2-2.6.38
patch -p1 -i ../ns-3-dce/utils/iproute-2.6.38-fix-01.patch
* KERNEL_INCLUDE should point to mptcp directory so:
  1. pico Makefile
  2. Change config line to: sh configure /home/{Your home directory}/mptcp
  3. make clean
  4. LDFLAGS=-pie make CCOPTS='-fpic -D_GNU_SOURCE -O0 -U_FORTIFY_SOURCE'
```

- Configure DCE

```
export DCE_PATH=$HOME/mptcp:$HOME/iproute2-2.6.38/ip
cd dce/source/ns-3-dce
./waf configure
  --with-ns3=$HOME/dce/build
  --enable-kernel-stack=$HOME/mptcp/arch
  --prefix=$HOME/dce/build
./waf build
./waf --run dce-iperf-mptcp
```

# Integrate with NS3-mmwave

- Example

18	1970-01-01	09:00:05.040516	10.2.0.1	10.1.0.1	TCP	54
19	1970-01-01	09:00:05.042048	10.1.0.1	10.2.0.1	TCP	1502
20	1970-01-01	09:00:05.043033	10.2.0.1	10.1.0.1	TCP	54
21	1970-01-01	09:00:05.044451	10.1.0.1	10.2.0.1	TCP	1502
22	1970-01-01	09:00:05.045436	10.2.0.1	10.1.0.1	TCP	54
23	1970-01-01	09:00:05.046854	10.1.0.1	10.2.0.1	TCP	1502
24	1970-01-01	09:00:05.047839	10.2.0.1	10.1.0.1	TCP	54
25	1970-01-01	09:00:05.049257	10.1.0.1	10.2.0.1	TCP	1502
26	1970-01-01	09:00:05.050243	10.2.0.1	10.1.0.1	TCP	54



42	1970-01-01	09:00:05.057581	10.2.0.1	10.1.0.1	MPTCP	
43	1970-01-01	09:00:05.057581	10.1.0.1	10.2.0.1	MPTCP	
44	1970-01-01	09:00:05.057701	10.1.0.1	10.2.0.1	MPTCP	
45	1970-01-01	09:00:05.059984	10.2.0.1	10.1.0.1	MPTCP	
46	1970-01-01	09:00:05.059984	10.1.0.1	10.2.0.1	MPTCP	
47	1970-01-01	09:00:05.060105	10.1.0.1	10.2.0.1	MPTCP	
48	1970-01-01	09:00:05.061013	10.1.0.2	10.1.0.1	ICMP	
49	1970-01-01	09:00:05.062388	10.2.0.1	10.1.0.1	MPTCP	
50	1970-01-01	09:00:05.062388	10.1.0.1	10.2.0.1	MPTCP	
51	1970-01-01	09:00:05.062508	10.1.0.1	10.2.0.1	MPTCP	
52	1970-01-01	09:00:05.064791	10.2.0.1	10.1.0.1	MPTCP	
53	1970-01-01	09:00:05.064791	10.1.0.1	10.2.0.1	MPTCP	

# Integrate with NS3-mmwave

- Example

Ethernet IPv4 · 2 IPv6 · 3 TCP · 2 UDP							
Address ▲	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	
10.1.0.1	63,856	64 M	41,916	62 M	21,940	1208 k	
10.2.0.1	63,856	64 M	21,940	1208 k	41,916	62 M	



Ethernet IPv4 · 4 IPv6 · 3 TCP · 4 UDP								
Address ▲	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Country	
10.1.0.1	32,444	29 M	18,845	28 M	13,599	853 k	—	
10.1.0.2	1	102	1	102	0	0	—	
10.2.0.1	32,442	29 M	13,598	853 k	18,844	28 M	—	
10.2.1.1	1	74	0	0	1	74	—	

# TODO list

- Integrate NS3-mmwave module and MPTCP
- How to configure MPTCP scheduler and MPTCP congestion control algorithm
- Create scenario file using both mmwave module and MPTCP