A brief tutorial for coursework

UG3 Computer Communications & Networks (COMN)

Myungjin Lee
myungjin.lee@ed.ac.uk
Coursework Overview

• Goal
  – Implementation and evaluation of three end-to-end reliable data transfer protocols
  – Stop-and-Wait, Go-back-N, and Selective Repeat

• Assessment: 40% of course mark
  – Part 1 (30%)
    • Part 1a (10%): rdt1.0
    • Part 1b (20%): rdt 3.0 (Stop-and-Wait)
  – Part 2 (70%)
    • Part 2a (30%): Go-back-N
    • Part 2b (40%): Selective Repeat + iperf experiment
Virtual Machine (VM) Setup

• Need Oracle’s VirtualBox virtualization software

• VirtualBox exists by default on all DICE machines
• List of DICE machines can be found at https://piazza.com/class/j7a9hnwbwr626j?cid=16

• The VM image for the assignment
  – Can be accessed on DICE machines
  – Has dummynet link emulator and other relevant software
Creating VM

1. Log into a DICE machine
2. Open a terminal
3. Create a directory (e.g., comn-cwk) and `cd` into it
   ```bash
   mkdir comn-cwk
   cd comn-cwk
   ```
mlee@dhcp-90-168:~$ ssh mlee23@staff.compute.inf.ed.ac.uk
mlee23@staff.compute.inf.ed.ac.uk's password:
This is staff.compute.inf.ed.ac.uk running Scientific Linux 7 (sl7) DICE.
Please 'nice' all processes to preserve a quick response
on the command line. Use a nice value between 10 and 19. 'man nice' gives details. Thanks.
[haight]mlee23:  

Creating VM

1. Log into a DICE machine
2. Open a terminal
3. Create a directory (e.g., comn-cwk) and `cd` into it
   
   ```
   mkdir comn-cwk
   cd comn-cwk
   ```
4. Issue the following command:
   
   `/disk/scratch/dummynet/createdummynetvm`
# You don't appear to have a ~/.VirtualBox directory
# Hit <Return> to initialize VirtualBox,
# (agree to the VirtualBox licence if asked)
# and then close VirtualBox.

Hit <Return>...
Welcome to VirtualBox!

The left part of this window is a list of all virtual machines on your computer. The list is empty now because you haven't created any virtual machines yet.

In order to create a new virtual machine, press the **New** button in the main tool bar located at the top of the window.

You can press the **F1** key to get instant help, or visit [www.virtualbox.org](http://www.virtualbox.org) for the latest information and news.
3. Downloading the disk image...

4. Registering hard disks...

5. Setting-up shared folder (dummynetshared)...

Your virtual machine 'DummynetSL6' is now ready. You can start the VM with './startvm.sh' or 'VirtualBox'.

As root, use "mount -t vboxsf dummynetshared /mnt/shared" to mount the folder "/afs/inf.ed.ac.uk/user/m/mlee23/comn-cwk/dummynetshared" on the VM.

Your shared folder is '/mnt/shared' on the VM.

# Put your data in '/work' or in '/mnt/shared' - otherwise data will be lost when you close the VM.
[event] mlee23: pwd
/afs/inf.ed.ac.uk/user/m/mlee23/comn-cwk
[event] mlee23: ls
dummynetshared  DummynetSL6  dummynetwork.vdi  startvm.sh
[event] mlee23:  
Creating and Starting VM

1. Log into a DICE machine
2. Open a terminal
3. Create a directory (e.g., comn-cwk) and `cd` into it
   ```
   mkdir comn-cwk
   cd comn-cwk
   ```
4. Issue the following command:
   ```
   /disk/scratch/dummynet/createdummynetvm
   ```
5. Run the following command:
   ```
   ./startvm.sh
   ```
The Virtual Machine reports that the guest OS supports **mouse pointer integration**. This means that you do not need to

```
dummynetsl6
```

```
SL6 VM User
```

```
Password: |
```

```
Cancel  Log In
```

```
vmuserpw
```
terminal
[vmuser@dummynetsl6 ~]$
How to shut down VM

• Become a root using ‘su’
  – Root password: vmrootpw
    su

• Run the following command:
  shutdown -h now
Shared Folder

• When the VM is set up for you, a directory called "dummynetshared" gets created in your assignment directory

• You can mount this in the VM by (as root):

  
  mount -t vboxsf dummynetshared /mnt/shared
Running VM on Your Computer

1. VirtualBox should be installed on your local machine

2. Download ‘comnvm.tar.gz’ from one of two places
   – /disk/scratch/dummynet/ on DICE machine
   – https://goo.gl/gcwQAT

3. Uncompress the file
Running VM on Your Computer

4. In the folder, open a terminal and run the following command:
   – For linux and Mac OS
     ./configvm.sh
   – For MS Windows
     ./configvm.bat

• Make sure that your implementations run correctly on VM in DICE machine
• For more details, refer to README
Before Running `configvm.sh` (or `*.bat`)
After Running configvm.sh (or .bat)
Conceptual Structure

- Dummynet
  - Creates emulated network link(s)
  - Configuration of link characteristics (BW, delay, loss)
  - Command-line program: ipfw
**Conceptual Structure**

- **Sender**
  - Reads a file and breaks it into a number of packets
  - Sends the packets to a receiver over a simulated network link
- **Receiver**
  - Receives the packets; extracts data in the packets; and saves the data in a file
Conceptual Structure

- Sender and Receiver
  - Support reliable data transfer protocol at the application layer using UDP
Dummynet Configuration Example

Virtual Machine

Unidirectional communication

Sender

Pipe 100 10Mbps, 1ms delay
Pipe 200 1Mbps, 5ms, 0.5% loss

Receiver

% ipfw add pipe 100 in
% ipfw add pipe 200 out
% ipfw pipe 100 config delay 1ms bw 10Mbits/s
% ipfw pipe 200 config delay 5ms plr 0.005 bw 1Mbits/s
Effect of Dummynet

When processes within the same host (or virtual machine) communicate with each other.

% ipfw add pipe 100 in
% ipfw add pipe 200 out
% ipfw pipe 100 config delay 5ms
% ipfw pipe 200 config delay 5ms
Miscellaneous

• Binary programs for the assignment are available at
  https://drive.google.com/drive/folders/0B6rUEJFM3QjTdkkxT21XclNtcUU?usp=sharing
  
  – First read README file
  – Sender1b, Receiver1b, Sender2a, Receiver2a, Sender2b and Receiver2b
  – Use these binary programs ONLY FOR debugging your implementations
  – Using them for other purposes is completely prohibited
Miscellaneous

• Some essential Java packages for the assignment
  – java.io.File
  – java.io.FileInputStream
  – java.io.FileOutputStream
  – java.net.DatagramPacket
  – java.net.DatagramSocket
  – java.net.InetAddress

• FAQs on the assignment available at
  https://piazza.com/class/j7a9hnwbwr626j?cid=19
The following formats should be used for both parts

- **Exception**: no ACK packets for part1a

### Data packet (sender $\rightarrow$ receiver)

<table>
<thead>
<tr>
<th>Offset</th>
<th>Octet</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3 ~ up to 1026</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>16-bit sequence number</td>
<td>8-bit EoF flag</td>
<td>Data</td>
<td></td>
</tr>
</tbody>
</table>

### ACK packet (receiver $\rightarrow$ sender)

<table>
<thead>
<tr>
<th>Offset</th>
<th>Octet</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>16-bit sequence number</td>
<td></td>
</tr>
</tbody>
</table>
Example scenario for Part 1b

| Seq no. (=0) | EoF | Data (1024 bytes) |

Sender  Dummynet emulated link  Receiver

Seq no. (= 0)
Example scenario for Part 1b

<table>
<thead>
<tr>
<th>Seq no. (=1)</th>
<th>EoF</th>
<th>Data (1024bytes)</th>
</tr>
</thead>
</table>

Sender → Dummynet emulated link → Receiver

Seq no. (= 1)
Example scenario for Part 1b

| Seq no. (=0) | EoF   | Data (1024bytes) |

Discard duplicate
Example scenario for Part 1b

Sender | Dummynet emulated link | Receiver
Seq no. (=0) | EoF (=1) | Data (< 1024bytes)

Terminate sender | Terminate receiver
Q&A