实验报告

一、实验名称

Lab 6: Reliable Communication

二、实验目的

实现以下功能以提供额外的传输保证：

1. blastee上对每个成功接收的数据包实施ACK机制
2. blaster上实现固定大小的滑动窗口
3. blaster上实施粗略的超时机制，以重新发送未收到ACK的数据包

三、实验内容

通过start_mininet.py读出每个节点的ip和mac，然后打表

	ip	mac
blaster	192.168.100.1	10:00:00:00:00:01
middlebox(eth0 - blaster)	192.168.100.2	40:00:00:00:00:01
middlebox(eth1 - blastee)	192.168.200.2	40:00:00:00:00:02
blastee	192.168.200.1	20:00:00:00:00:01

middlebox

对于来自blaster的包，修改ethHeader并转发到blastee，以dropRate随机丢包；对于来自blastee的ack回复，修改ethHeader并转发到blaster，不丢包。

```
def handle_packet(self, recv: switchyard.llnetbase.ReceivedPacket):
    _, fromIface, packet = recv
    if not packet.has_header(IPv4):
        log_info("Received non-IPv4 packet")
        return
    seq_num = int.from_bytes(packet[RawPacketContents].data[:4], 'big')
    if fromIface == "middlebox-eth0": # Received from blaster
        if random() < self.dropRate:
            log_info(f"Drop packet {seq_num}")
            return
        log_info(f"Forwarding packet {seq_num}")
        packet[Ethernet].src = middlebox_eth1
        packet[Ethernet].dst = blastee_eth
```

```
        self.net.send_packet("middlebox-eth1", packet)
    elif fromIface == "middlebox-eth1": # Received from blastee
        packet[Ethernet].src = middlebox_eth0
        packet[Ethernet].dst = blaster_eth
        log_info(f"Forwarding ACK {seq_num}")
        self.net.send_packet("middlebox-eth0", packet)
```

blastee

收到来自blaster的包，创建ack回复，并发到blaster

```
def create_ack(self, packet, seq_num):
    eth = Ethernet(src=blastee_eth, dst=middlebox_eth1, ethertype=EtherType.IPv4)
    ip = IPv4(src=blastee_ip, dst=blaster_ip, protocol=IPProtocol.UDP, ttl=64)
    udp = UDP()
    blaster_payload = packet[RawPacketContents].data.ljust(8, b'\0')
    payload = blaster_payload[:8]
    raw_data = struct.pack('!I8s', seq_num, payload)
    raw_packet = RawPacketContents(raw_data)
    ack = eth + ip + udp + raw_packet
    return ack

def handle_packet(self, recv: switchyard.llnetbase.ReceivedPacket):
    _, fromIface, packet = recv
    seq_num = int.from_bytes(packet[RawPacketContents].data[:4], 'big')
    log_info(f"Received packet {seq_num}")
    ack = self.create_ack(packet, seq_num)
    self.net.send_packet("blastee-eth0", ack)
    if not self.recved[seq_num]:
        self.recved[seq_num] = True
        self.recv_num += 1
```

blaster

收到窗口最左端lhs位置的的ack，就向右移动lhs到没有ack过的位置

```
def handle_packet(self, recv: switchyard.llnetbase.ReceivedPacket):
    _, fromIface, packet = recv
    seq_num = int.from_bytes(packet[RawPacketContents].data[:4], 'big')
    log_info(f"Received ACK{seq_num}")
    if(seq_num < self.lhs or seq_num > self.rhs):
        return
    if(not self.acked[seq_num]):
        self.acked[seq_num] = True
        self.acked_num += 1
        if(seq_num == self.lhs):
            while(self.lhs <= self.num and self.acked[self.lhs]):
                self.lhs += 1
                if self.lhs == self.num + 1:
                    self.end_time = time.time()
            self.lhs_time = time.time()
```

如果rhs还能向右移动（不超过窗口大小），就发送一个rhs位置的包并将rhs右移

```
def create_packet(self, seq_num):
    eth = Ethernet(src=blaster_eth, dst=middlebox_eth0, ethertype=EtherType.IPv4)
    ip = IPv4(src=blaster_ip, dst=self.blasteeIp, protocol=IPProtocol.UDP,
ttl=64)
    udp = UDP()
    payload = bytes([randint(0, 255) for _ in range(self.length)])
    length = len(payload)
    raw_data = struct.pack('!IH', seq_num, length) + payload
    raw_packet = RawPacketContents(raw_data)
    pkt = eth + ip + udp + raw_packet
    return pkt

def handle_no_packet(self):
    # log_info(f"lhs: {self.lhs}, rhs: {self.rhs}")
    log_info(f"{list(range(self.lhs, self.rhs + 1))}")
    self.handle_timeout()
    if self.rhs < self.num and self.rhs - self.lhs + 1 < self.senderWindow:
        self.rhs += 1
        if self.rhs == 1:
            self.begin_time = time.time()
        pkt = self.create_packet(self.rhs)
        log_info(f"Sending packet{self.rhs}")
        self.net.send_packet("blaster-eth0", pkt)
```

如果lhs一直停在一个位置，就把窗口内没ack过的包全部重发

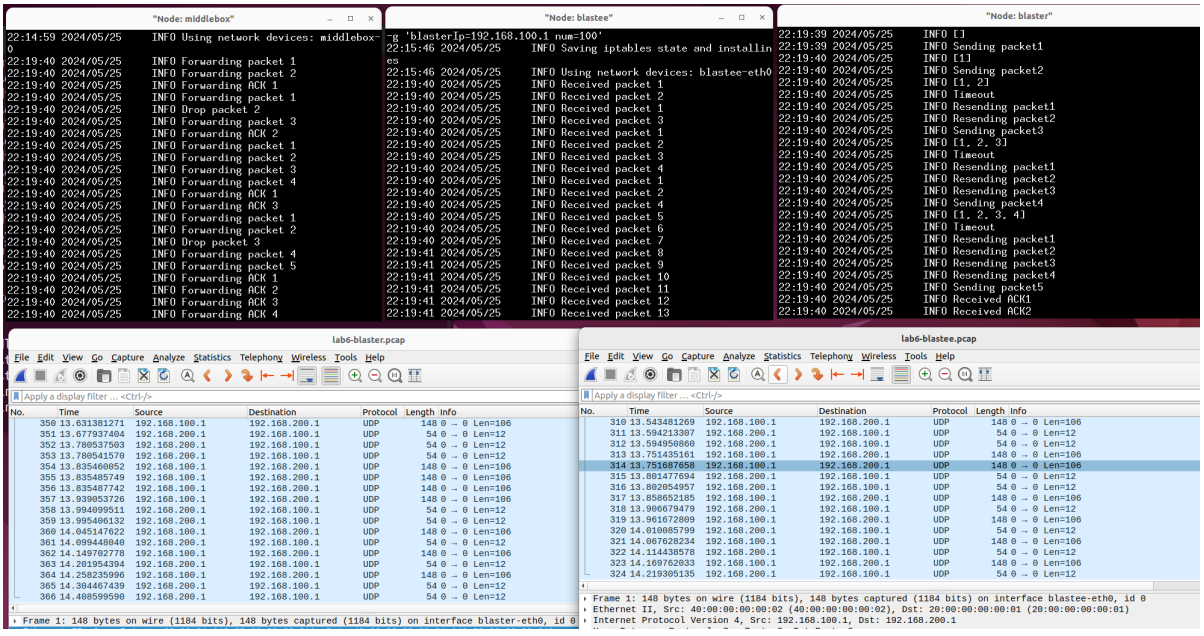
```
def handle_timeout(self):
    if(time.time() - self.lhs_time > self.timeout/1000.0):
        log_info("Timeout")
        self.timeout_num += 1
        for i in range(self.lhs, self.rhs + 1):
            if(not self.acked[i]):
                pkt = self.create_packet(i)
                log_info(f"Resending packet{i}")
                self.net.send_packet("blaster-eth0", pkt)
                self.resend_num += 1
```

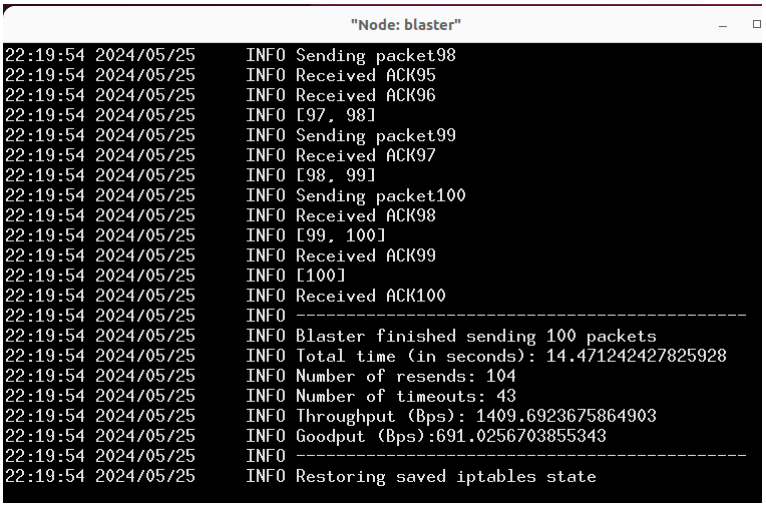
最后全都ack掉了就结束，输出统计信息

```
def shutdown(self):
    self.net.shutdown()
    log_info("-----------------------------------------------")
    log_info(f"Blaster finished sending {self.num} packets")
    # log_info(f"begin_time: {self.begin_time}")
    # log_info(f"end_time: {self.end_time}")
    log_info(f"Total time (in seconds): {self.end_time - self.begin_time}")
    log_info(f"Number of resends: {self.resend_num}")
    log_info(f"Number of timeouts: {self.timeout_num}")
    log_info(f"Throughput (Bps): {(self.num + self.resend_num) * self.length /
(self.end_time - self.begin_time)}")
    log_info(f"Goodput (Bps):{self.num * self.length / (self.end_time -
self.begin_time)}")
    log_info("-----------------------------------------------")
```

四、实验结果

mininet测试





共发了100个包，有43次timeout和104个重传，总用时14秒