计网联合实验 报告 week4

Group 7（不是助教）：王润基，王逸松

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为什么做这个实验?

- ✓ 硬件转发IP分组，性能更高
- ✓ 熟悉FPGA如何处理IP分组，解决实际问题
- ✓ 进一步锻炼系统能力
- ✓ 获得不一样的人生体验
- ✓ 可能获得额外的分数

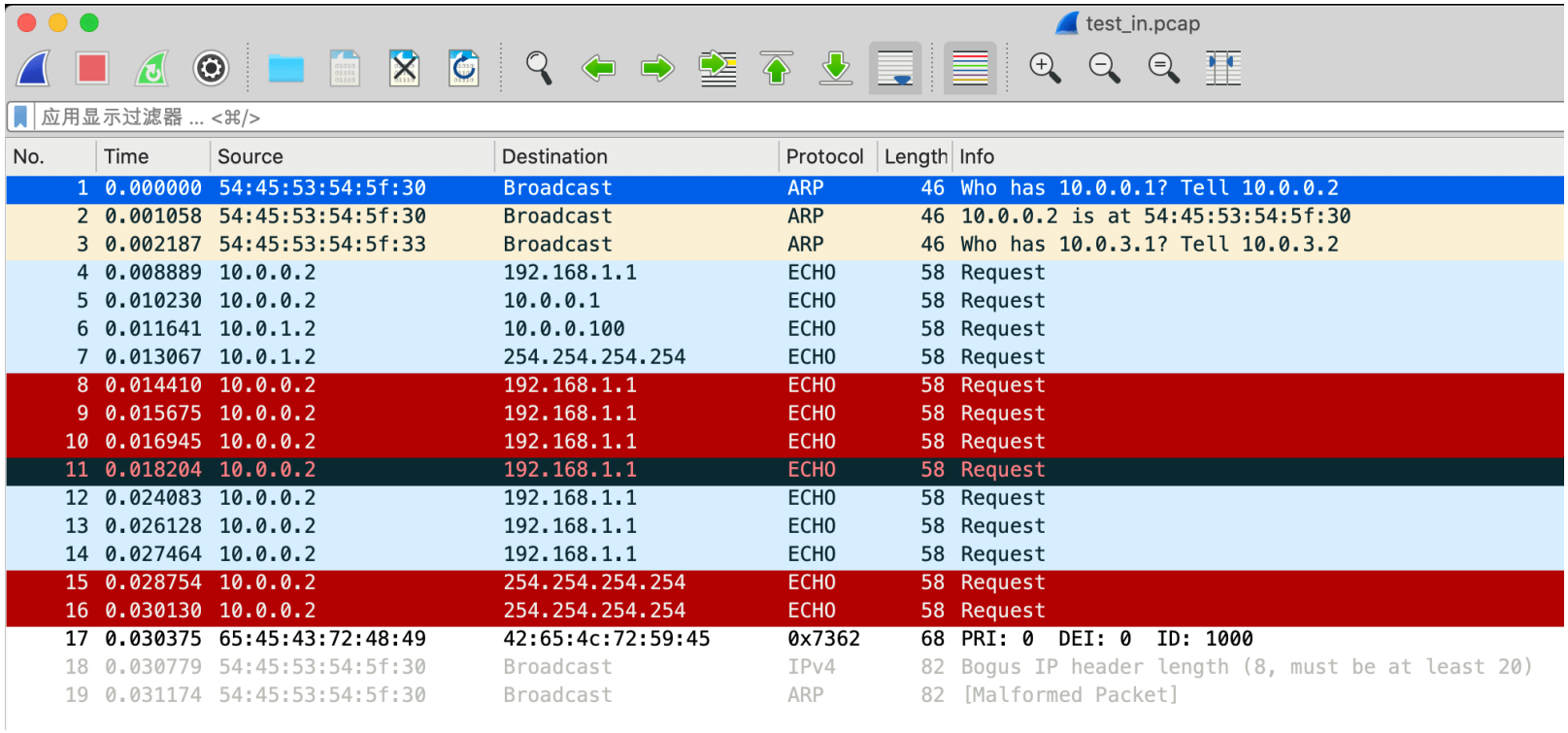
Chisel

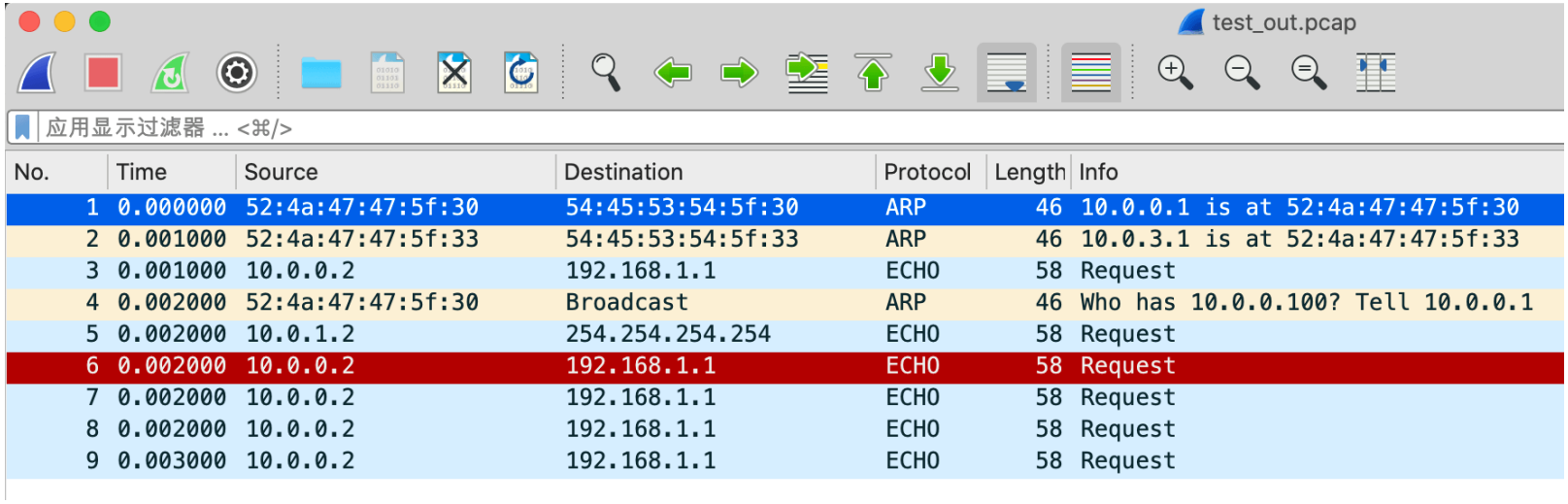
Constructing Hardware In a Scala Embedded Language

- 避免一些 Verilog 中的危险写法
- 内置组件：`Decoupled = valid + ready + bits`
- 方便的仿真测试框架：vcd 波形文件 + GtkWave 查看
- 通用高级语言

进展和问题

- 搭好了 Chisel 的测试框架：pcap -> pcap
- 实现了转发引擎：ARP 请求、响应、IP 转发
- 实现了简单的 ARP 缓存
- Chisel 仿真通过，TanLabs 仿真出错，尚未上板子（
- 时序爆炸！💥


test_in.pcap
应用显示过滤器 ... <⌘/>
No. Time Source Destination Protocol Length Info
1 0.000000 54:45:53:54:5f:30 Broadcast ARP 46 Who has 10.0.0.1? Tell 10.0.0.2
2 0.001058 54:45:53:54:5f:30 Broadcast ARP 46 10.0.0.2 is at 54:45:53:54:5f:30
3 0.002187 54:45:53:54:5f:33 Broadcast ARP 46 Who has 10.0.3.1? Tell 10.0.3.2
4 0.008889 10.0.0.2 192.168.1.1 ECHO 58 Request
5 0.010230 10.0.0.2 10.0.0.1 ECHO 58 Request
6 0.011641 10.0.1.2 10.0.0.100 ECHO 58 Request
7 0.013067 10.0.1.2 254.254.254.254 ECHO 58 Request
8 0.014410 10.0.0.2 192.168.1.1 ECHO 58 Request
9 0.015675 10.0.0.2 192.168.1.1 ECHO 58 Request
10 0.016945 10.0.0.2 192.168.1.1 ECHO 58 Request
11 0.018204 10.0.0.2 192.168.1.1 ECHO 58 Request
12 0.024083 10.0.0.2 192.168.1.1 ECHO 58 Request
13 0.026128 10.0.0.2 192.168.1.1 ECHO 58 Request
14 0.027464 10.0.0.2 192.168.1.1 ECHO 58 Request
15 0.028754 10.0.0.2 254.254.254.254 ECHO 58 Request
16 0.030130 10.0.0.2 254.254.254.254 ECHO 58 Request
17 0.030375 65:45:43:72:48:49 42:65:4c:72:59:45 0x7362 68 PRI: 0 DEI: 0 ID: 1000
18 0.030779 54:45:53:54:5f:30 Broadcast IPv4 82 Bogus IP header length (8, must be at least 20)
19 0.031174 54:45:53:54:5f:30 Broadcast ARP 82 [Malformed Packet]


test_out.pcap
应用显示过滤器 ... <⌘/>
No. Time Source Destination Protocol Length Info
1 0.000000 52:4a:47:47:5f:30 54:45:53:54:5f:30 ARP 46 10.0.0.1 is at 52:4a:47:47:5f:30
2 0.001000 52:4a:47:47:5f:33 54:45:53:54:5f:33 ARP 46 10.0.3.1 is at 52:4a:47:47:5f:33
3 0.001000 10.0.0.2 192.168.1.1 ECHO 58 Request
4 0.002000 52:4a:47:47:5f:30 Broadcast ARP 46 Who has 10.0.0.100? Tell 10.0.0.1
5 0.002000 10.0.1.2 254.254.254.254 ECHO 58 Request
6 0.002000 10.0.0.2 192.168.1.1 ECHO 58 Request
7 0.002000 10.0.0.2 192.168.1.1 ECHO 58 Request
8 0.002000 10.0.0.2 192.168.1.1 ECHO 58 Request
9 0.003000 10.0.0.2 192.168.1.1 ECHO 58 Request

流水线设计

- `L2Filter`：过滤非法目的 MAC 地址包
- `Arp`：处理 ARP 请求和响应包
- `Ipv4Check`：检查 IP 包（检查校验和、TTL等）
- `Ipv4Forward`：转发 IP 包（查转发表，更新校验和）
- `Ipv4SetMac`：填目的 MAC 地址（查 ARP 缓存）

模块设计

- `ArpCache`：直接映射（继承 TLB 祖传代码）

```
You, a few seconds ago | 1 author (You)
class ArpCache(val SIZE_LOG2: Int = 4) extends Module {
  val io = IO(new Bundle {
    val query = Flipped(new ArpQuery)
    val modify = Flipped(new ArpModify)
  })
}

You, a few seconds ago | 1 author (You)
class ArpQuery extends Bundle {
  val ipv4 = Output(new Ipv4Addr)
  val mac = Input(Valid(new MacAddr))
}

You, a few seconds ago | 1 author (You)
class ArpModify extends Bundle {
  val op = Output(UInt(3.W))
  val ipv4 = Output(new Ipv4Addr)
  val mac = Output(new MacAddr)
}

You, a few seconds ago | 1 author (You)
object ArpOp {
  val None = 0.U
  val Insert = 1.U
  val Update = 2.U
  val Remove = 3.U
  val Clear = 4.U
}      You, a few seconds ago • Uncommitted changes
```

对造机实验的帮助

模块

- 转发表 <=> 页表
- ARP Cache <=> TLB

流水线

模块之间的握手信号 vs 统一控制的暂停信号

谢谢

Have fun!