PebNet

Michael Sullivan

October 26, 2009

Outline

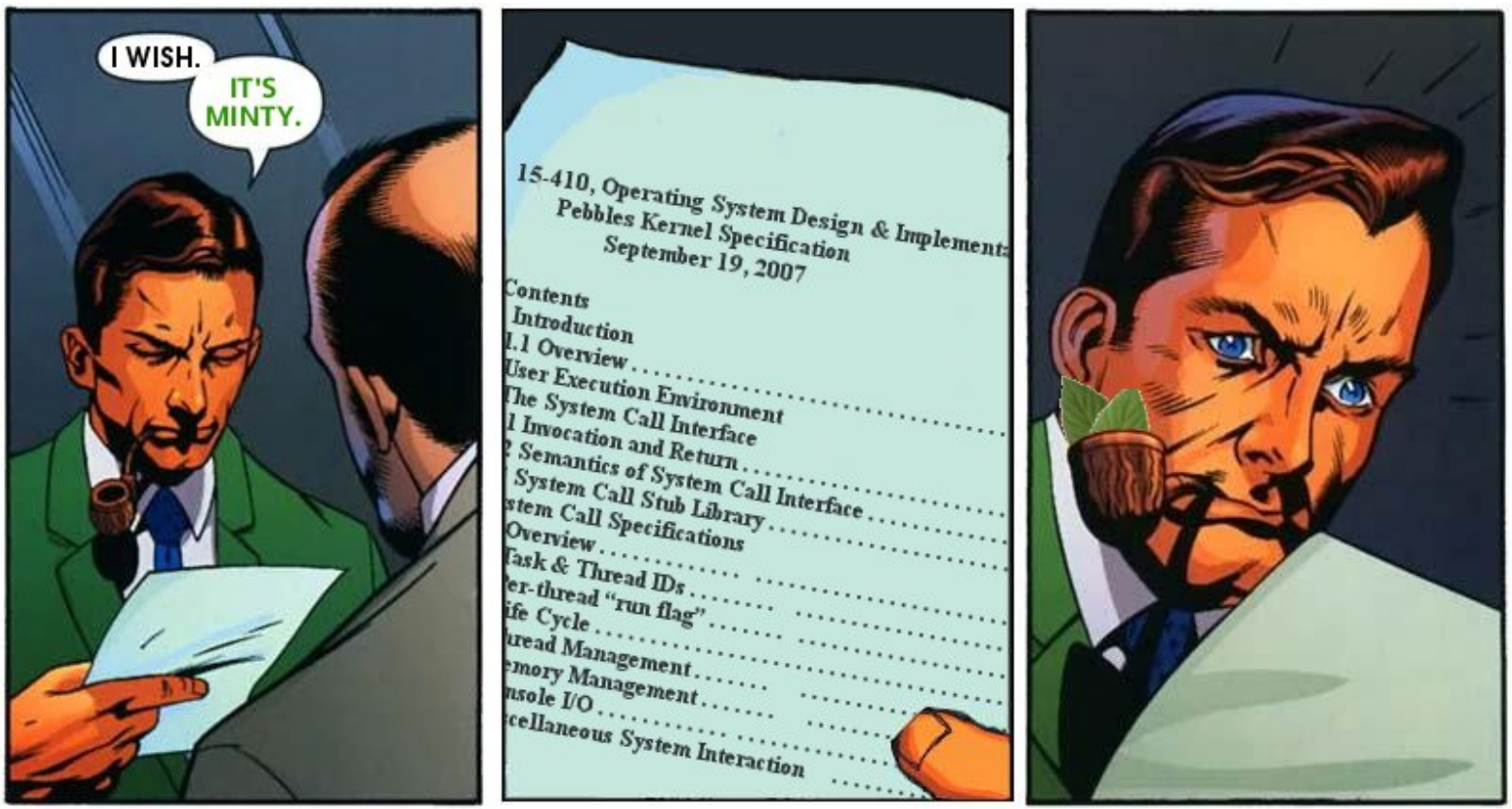
Introduction
15-441

- Brilliant Idea: for a Networks class, actually write parts of a networking stack!
- But on what platform?

Introduction
Pebbles

- Should need no introduction
- The kernel spec you had to implement in p3
- Small and fairly simple

Introduction
Pebbles



[Bau]

Introduction
Pebbles

- It's obviously a toy
- But it's a fairly *good* toy
- Could be a good base to build something like this on

Kernel Extensions

Problems
Fixes
Ethernet Driver
Thoth IPC
Status

Problems
Missing features

- No existing network drivers, etc.
- Not going to ask Networks students to write an ethernet driver...

Problems
Where to put the network stack?

- In Unixes, the network stack traditionally goes in the kernel
- But we certainly don't want to hand out source for a Pebbles...
- And putting it in the kernel means it can crash the system, is harder to debug, etc

Fixes

- So put the ethernet card driver in the kernel

Fixes

- So put the ethernet card driver in the kernel
- And the rest of the network stack in userland...

Fixes

- So put the ethernet card driver in the kernel
- And the rest of the network stack in userland...
- Communicating via IPC

Ethernet Driver Kernel Interface

- eth_send() - send a frame - fail if no buffer space
- eth_recv() - block until a frame is available
- eth_getaddr() - fetch the MAC address of a card; kind of hacky and special purpose; could get replaced with a more general eth_config()
- These functions all take a card number as a parameter so that multiple cards can be supported

Ethernet Driver
What card to support

We want:

- Simulated by Simics

Ethernet Driver
What card to support

We want:

- Simulated by Simics
- Commonly available in hardware

Ethernet Driver
What card to support

We want:

- Simulated by Simics
- Commonly available in hardware
- Don't tell Prof. Eckhardt, but...

Ethernet Driver
What card to support

We want:

- Simulated by Simics
- Commonly available in hardware
- Don't tell Prof. Eckhardt, but... simulated by QEMU

Ethernet Driver
Card choice

The Intel 8255x "Fast Ethernet" family of cards.

- Simics simulates the 82559

Ethernet Driver
Card choice

The Intel 8255x "Fast Ethernet" family of cards.

- Simics simulates the 82559
- QEMU simulates the 82557b and the 82559er

Ethernet Driver
Card choice

The Intel 8255x "Fast Ethernet" family of cards.

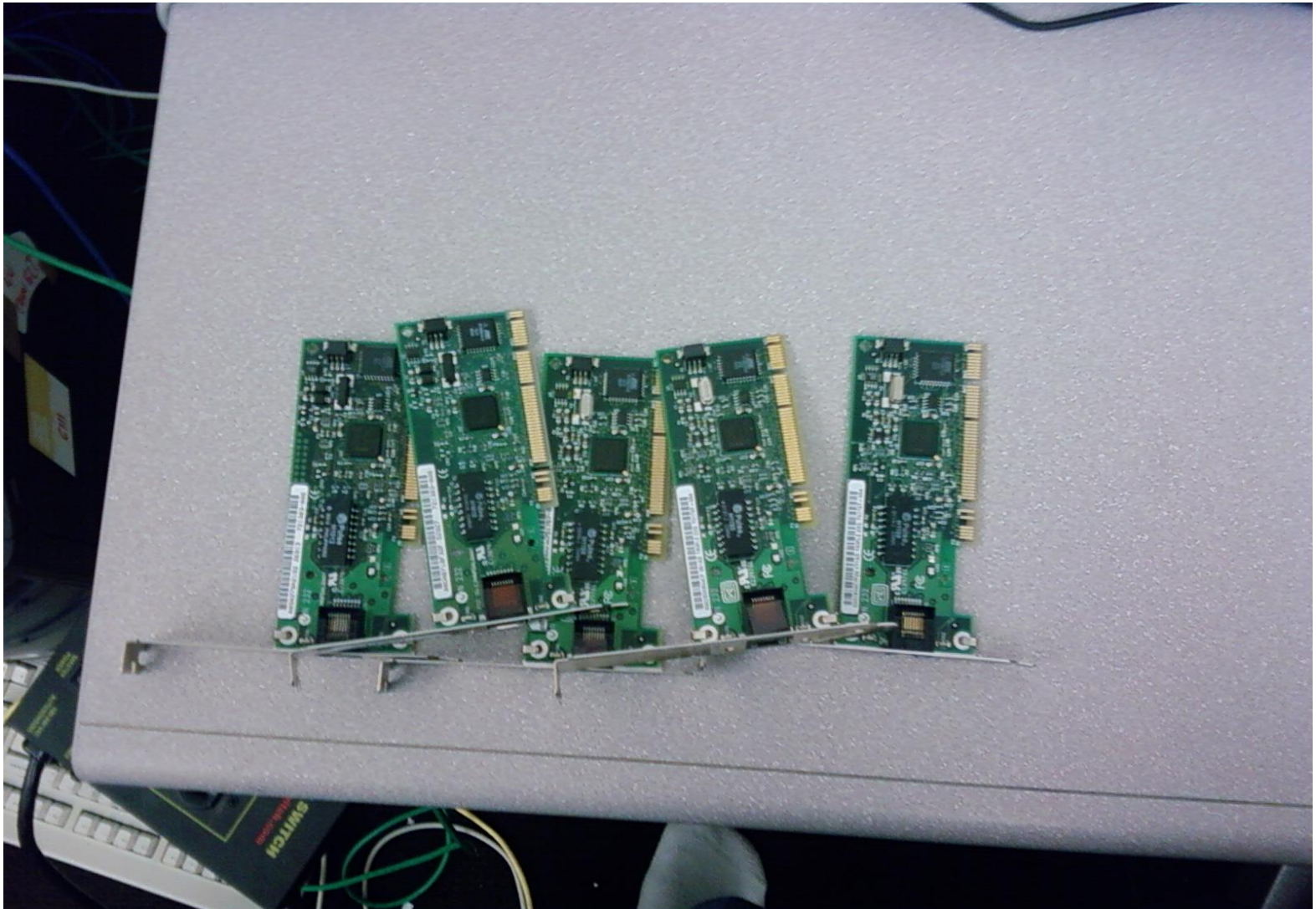
- Simics simulates the 82559
- QEMU simulates the 82557b and the 82559er
- Fairly well documented

Ethernet Driver
Card choice

The Intel 8255x "Fast Ethernet" family of cards.

- Simics simulates the 82559
- QEMU simulates the 82557b and the 82559er
- Fairly well documented
- Not *that* much of a CF

Ethernet Driver
Also readily available...



Ethernet Driver
Card Initialization

- Probe PCI bus looking for card we can handle

Ethernet Driver
Card Initialization

- Probe PCI bus looking for card we can handle
- Reset the card, turn on the card, enable PCI bus access

Ethernet Driver
Card Initialization

- Probe PCI bus looking for card we can handle
- Reset the card, turn on the card, enable PCI bus access
- Read the MAC address out of the card's onboard EEPROM

Ethernet Driver Card Initialization

- Probe PCI bus looking for card we can handle
- Reset the card, turn on the card, enable PCI bus access
- Read the MAC address out of the card's onboard EEPROM
- Configure card settings (24-byte array of settings)

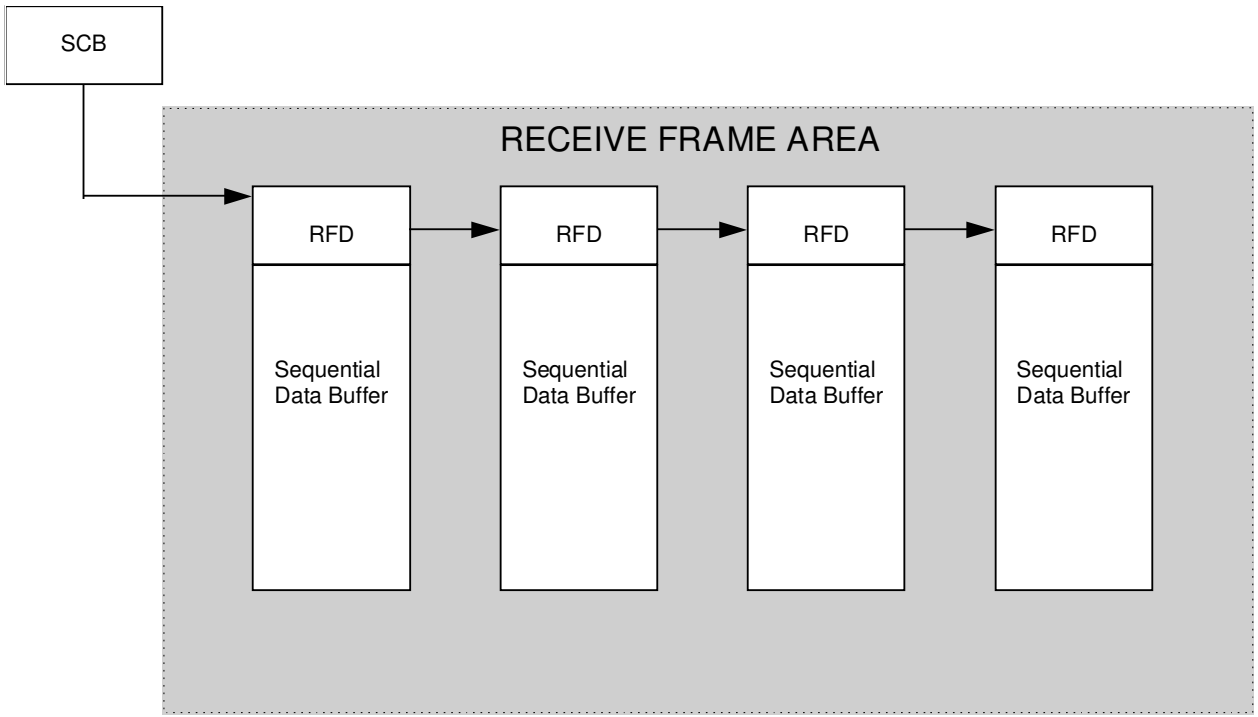
Ethernet Driver
Card Initialization

- Probe PCI bus looking for card we can handle
- Reset the card, turn on the card, enable PCI bus access
- Read the MAC address out of the card's onboard EEPROM
- Configure card settings (24-byte array of settings)
- The less said about these last two steps the better.

Ethernet Driver
Card Initialization

- Probe PCI bus looking for card we can handle
- Reset the card, turn on the card, enable PCI bus access
- Read the MAC address out of the card's onboard EEPROM
- Configure card settings (24-byte array of settings)
- The less said about these last two steps the better.
- "And when you gaze long into an abyss the abyss also gazes into you."

Ethernet Driver
Driver data structures



[Cor]

- Diagram of recieve setup; actually set up as a circular list
- The transmit descriptors look basically the same except that they point to a buffer not directly attached to the descriptor

Ethernet Driver
Driver Operation

- eth_send() fills the first available buffer, restarts the transmit unit
- eth_recv() blocks until there is a full buffer, restarts the receive unit if it had stalled

Thoth IPC
IPC Models

- Some sort of IPC mechanism is needed to tie together a userspace based network stack

Thoth IPC
IPC Models

- Some sort of IPC mechanism is needed to tie together a userspace based network stack
- But what kind?

Thoth IPC
IPC Models

- Some sort of IPC mechanism is needed to tie together a userspace based network stack
- But what kind?
- "The nice thing about standards is..."

Thoth IPC
The model

- Thoth-like port based IPC (s08's p4)
- Communication is done through "ports" which are owned by tasks
- send() sends a message from a source port you own to a destination port, and then blocks until another thread has done a receive() followed by a reply()
- receive() waits for a message to be sent to a port, and informs the caller who sent the message
- reply() sends a reply to a message that was previously received()

Thoth IPC Advantages

- Pretty simple
- Fits well with a "remote procedure call" model where one process requests a service from another and waits for a response

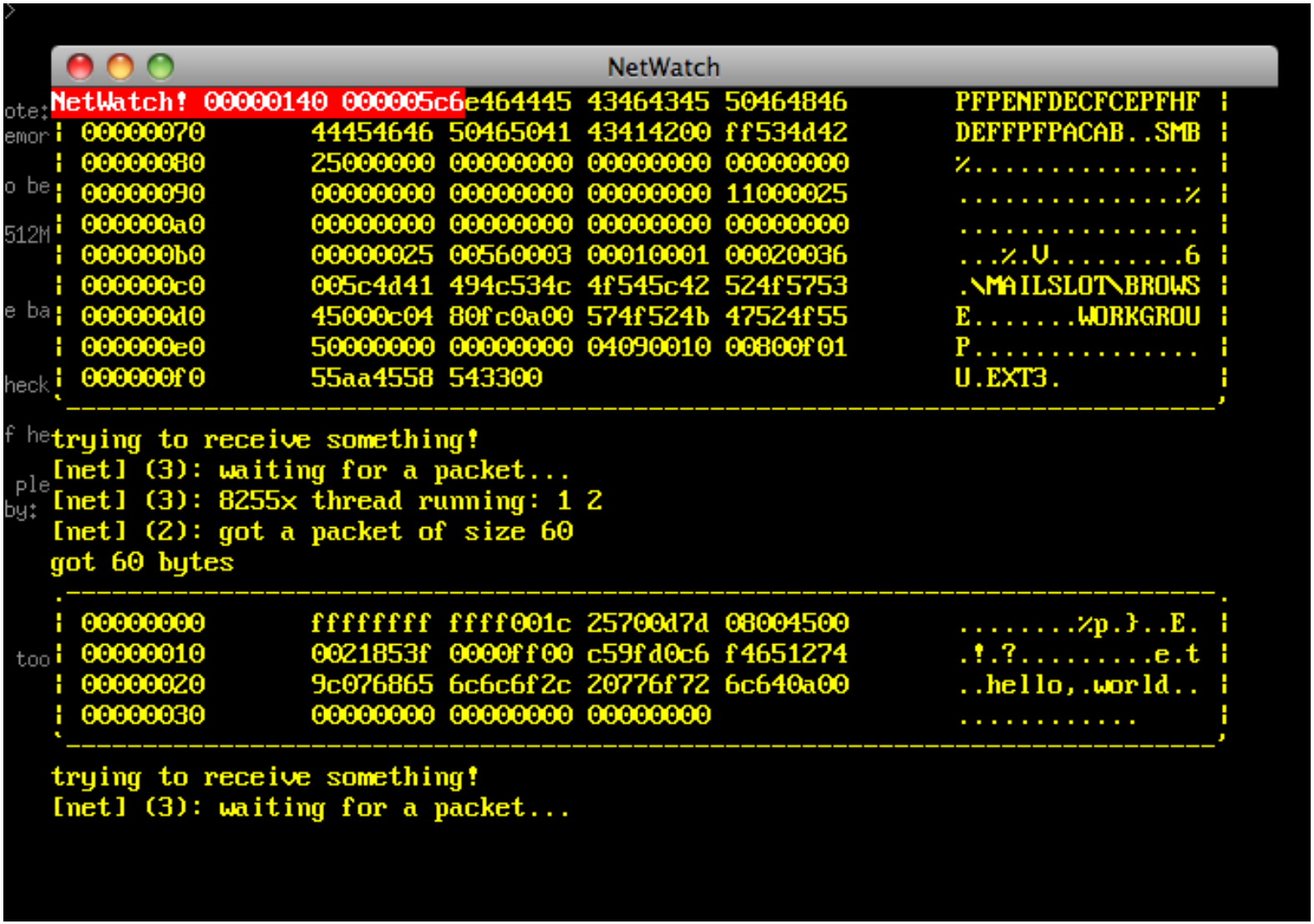
Thoth IPC Disadvantages

- Nontrivial uses of ports essentially require the application to be multithreaded
- Lots of ways to fall into a hole: if they other guy never reply()s, you are hosed.
- Flat port namespace

Status

- Platform for work: YAPI (Yet Another Pebbles Implementation) by Michael Sullivan (mjsulliv@) and Anand Subramanian (asubrama@).
- 8255x network driver and Thoth IPC implemented and working.

Status


NetWatch
NetWatch! 00000140 000005c6e464445 43464345 50464846 PFPENFDECFCEPFHF
00000070 44454646 50465041 43414200 ff534d42 DEFFPFPACAB..SMB
00000080 25000000 00000000 00000000 00000000 %...............
00000090 00000000 00000000 00000000 11000025 ....%
000000a0 00000000 00000000 00000000 00000000 ....
000000b0 00000025 00560003 00010001 00020036 ...%.V.........6
000000c0 005c4d41 494c534c 4f545c42 524f5753 .\MAILSLOT\BROWS
000000d0 45000c04 80fc0a00 574f524b 47524f55 E.......WORKGROU
000000e0 50000000 00000000 04090010 00800f01 P...............
000000f0 55aa4558 543300 U.EXT3.
trying to receive something!
[net] (3): waiting for a packet...
[net] (3): 8255x thread running: 1 2
[net] (2): got a packet of size 60
got 60 bytes
00000000 ffffffff ffff001c 25700d7d 08004500 ....%p.}..E.
00000010 0021853f 0000ff00 c59fd0c6 f4651274 .!.?.........e.t
00000020 9c076865 6c6c6f2c 20776f72 6c640a00 ..hello,.world..
00000030 00000000 00000000 00000000 ....
trying to receive something!
[net] (3): waiting for a packet...

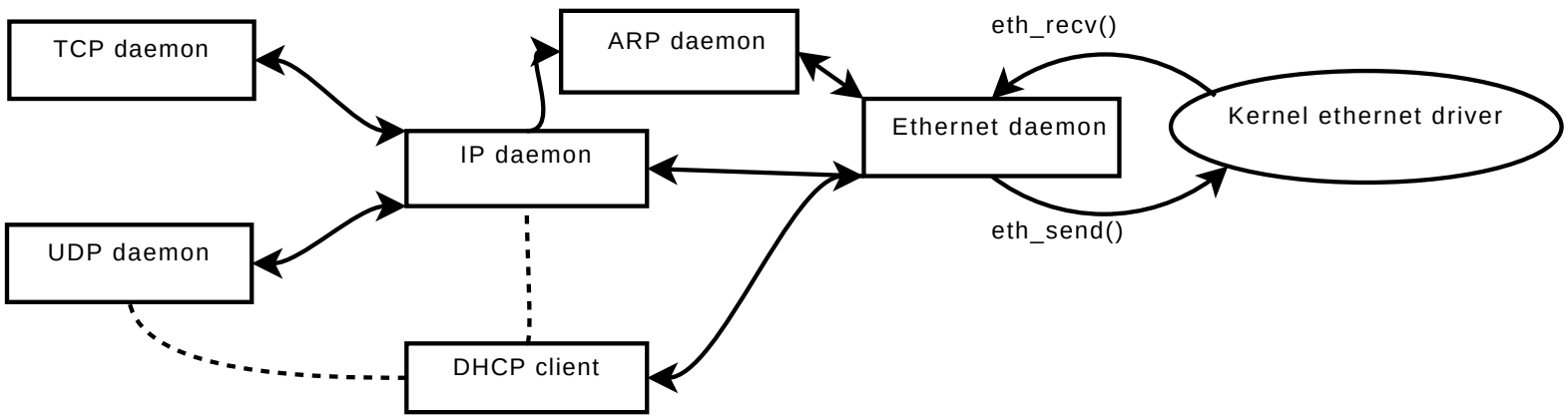
Stack Design

Design
Demultiplexer

Design
Overall design

- Put each layer in the stack in its own process, communicating with the others through IPC.
- This means seperate processess for Ethernet, ARP, IP, UDP, TCP...

Design Diagram



Design Advantages

- Fairly clean and modular.

Design Advantages

- Fairly clean and modular.
- Easy to give out binaries for $N - 1$ modules and have a student write the remaining one.

Design
Disadvantages

- The protocol stacks have layering violations, so the boundaries are something of a lie. Specifically, the UDP and TCP checksums include the IP header, so the IP daemon will probably need to know how to do checksumming for TCP and UDP.

Design
Disadvantages

- The protocol stacks have layering violations, so the boundaries are something of a lie. Specifically, the UDP and TCP checksums include the IP header, so the IP daemon will probably need to know how to do checksumming for TCP and UDP.
- DHCP is technically over UDP/IP, but is very special and violates a lot of the normal rules. It will talk directly to the Ethernet daemon...

Design
Disadvantages

- The protocol stacks have layering violations, so the boundaries are something of a lie. Specifically, the UDP and TCP checksums include the IP header, so the IP daemon will probably need to know how to do checksumming for TCP and UDP.
- DHCP is technically over UDP/IP, but is very special and violates a lot of the normal rules. It will talk directly to the Ethernet daemon...
- "Suffers from the microkernel." *Lots* of context switches and copies required to send/receive packets from a client application. The copies *could* be mitigated through zero-copy IPC and network calls, but the context switches are harder to avoid.

Demultiplexer

- One very common pattern is receiving data buffers from some source, performing some processing, and then demultiplexing it to another client based on some tag in the message.

Demultiplexer

- One very common pattern is receiving data buffers from some source, performing some processing, and then demultiplexing it to another client based on some tag in the message.
- Potentially multiple clients interested in messages with some tag.

Demultiplexer

- One very common pattern is receiving data buffers from some source, performing some processing, and then demultiplexing it to another client based on some tag in the message.
- Potentially multiple clients interested in messages with some tag.
- This shows up in Ethernet, IP, UDP.

Demultiplexer

- One very common pattern is receiving data buffers from some source, performing some processing, and then demultiplexing it to another client based on some tag in the message.
- Potentially multiple clients interested in messages with some tag.
- This shows up in Ethernet, IP, UDP.
- Want a generic facility for demultiplexing messages to ports based on a tag.

Goals

- Extend kernel with ethernet driver, IPC.
- Use DHCP to get an IP address.
- Be able to respond to pings
- Have some reasonable framework for continued work
- Initialize two cards (of the same type)

- Car Bauer, `http://qachan.org/img/minty410.jpg`.
- Intel Corporation, *Intel 8255x 10/100 mbps ethernet controller family open source software developer manual*, `http://download.intel.com/design/network/manuals/8255X_OpenSDM.pdf`.