SCTP: An Overview

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Our Objectives

- **Be able to *explain***

  ***what* SCTP is, and what its major features are**

  ***when* and *why* you might use it (instead of TCP or UDP)**

  ***where* to find it, and find out more about it**

Our plan:

quick overview

- **Be able to *write code* to use SCTP**

  Sockets API

emphasis

But first, lets find out:
who are *you*, and what are *your* objectives?

Prerequisites

- **Basic understanding of**
  - **IP, and transport protocols TCP and UDP**
  - **socket programming in C under Unix**

if you aren't sure about something, ask, and we'll fill in the gaps

- **Willingness to put up with an engineer attempting to teach a tutorial :-D**

Also, please note:

- ***Please* interrupt to ask questions if you get lost.**
- **We will cover a lot of ground in a limited time so hold on to your seats :-D**

These slides will be online at:

- **http://pel.cis.udel.edu/tutorial**

  Faster download here

- **http://www.sctp.org**

  Also reachable with HTTP over SCTP!

  Downloads may be slow for while... be patient (hosted in Randy's barn while the Stewart family redecorates).

Outline

10h00-11h00	intro (almost finished)	Randy
	overview of SCTP What is SCTP? What are the major features?	Phill
11h15-12h15	SCTP details	Randy
13h15-14h15	details of sockets API	Randy or Phill
	open Q and A	Both

What is SCTP? Why SCTP?

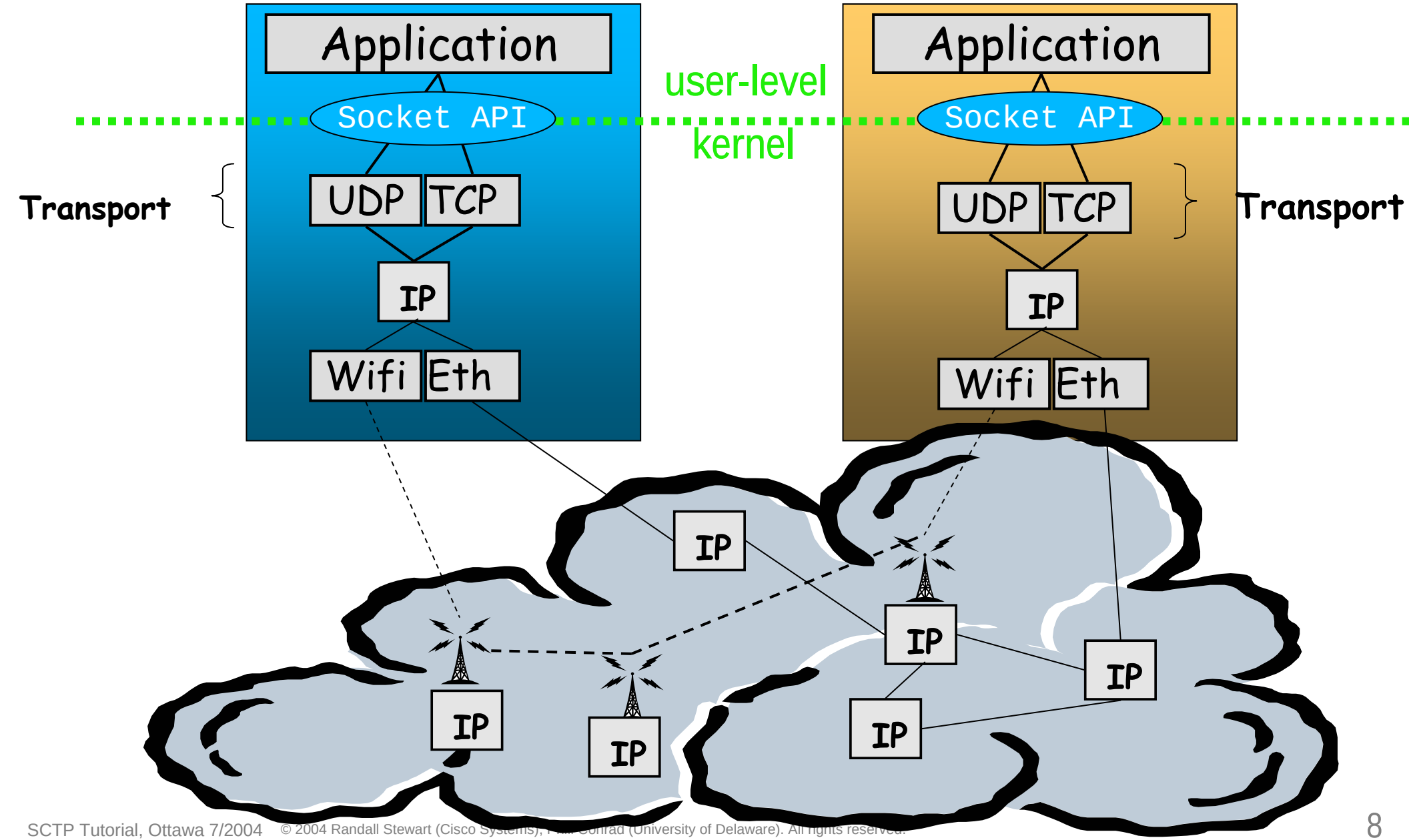
- **SCTP is a new IETF standard transport protocol (RFC2960)**
  - **Stream Control Transmission Protocol**
- **An alternative to TCP and UDP**
- **It came out of the "signaling transport" community...**
  - **doing telephone switching over IP networks**
- **.. but it emerged as a general-purpose transport protocol**
- **Why?**
  - **because TCP and UDP lacked some features that were needed**
- **What was so special about sigtran?**
  - **small message sizes**
  - **need for high availability, absolute minimum delay**
- **Why talk about SCTP in this form?**
  - **Because SCTP is coming soon to a Linux kernel near you (LK-SCTP)**

What was special about sigtran?

- **Aspects of signaling transport driving SCTP design**
  - **need for high availability**
    - **failover between multiple redundant network interfaces**
    - **need to monitor reachability status**
  - **message oriented**
  - **small message sizes**
  - **real-time (need absolute minimum delay)**
  - **upper layer timers**
  - **need for tunability (Big-I internet vs. engineered networks)**

Why SCTP? The big picture...

The transport layer...



Why SCTP? The big picture... TCP and UDP...

- **The transport layer sits between IP and the application**
- **Traditionally, just two choices: TCP and UDP**
- **UDP: bare minimum**

  just port numbers, and an optional checksum

  no flow control, no congestion control, no reliability or ordering
- **TCP: a package deal**

  flow control, congestion control, *byte-stream orientation*

  ***total* ordering and *total* reliability**

However, there are some things you can't get with either!

(see next slide...)

With SCTP you can do...

- **Almost everything you can do with TCP and UDP**
  (a very few minor exceptions we will note later but for instance:

  Can do reliable, flow controlled, congestion controlled data exchange, like TCP
  Can also do unordered, unreliable data exchange, like UDP)

- **Plus the following features NOT available in UDP or TCP.**
  (A quick list only; details follow!)
  - **Multi-homing**
  - **Multi-streaming**
  - **Message boundaries (with reliability*)**
  - **Improved SYN-flood protection**
  - **Tunable parameters (Timeout, Retrans, etc.)**
  - **A range of reliability and order (full to partial to none) along with congestion control**
  - **and more...**

*UDP: msg boundaries, not reliable
TCP reliable, no msg boundaries

Slightly more detail about key SCTP features... (1 of 3)

- **Multi-homing** ***improved robustness to failures***

  In TCP, connections made between <IP addr,port> and <IP addr, port>

  If a host is multi-homed, you have to choose ONE IP Addr only, at each end

  If that interface goes down, so does the connection

  With SCTP, you can list as many IP addresses per endpoint as you like

  If host is still reachable through ANY of those addresses, connection stays up!

- **Multi-streaming** ***reduced delay***

  A.k.a. partial ordering. Eliminates Head of Line (HOL) blocking

  In TCP, all data must be sent in order; loss at head of line delays delivery of subsequent data

  In SCTP, you can send over up to 64K independent streams, each ordered independently

  A loss on one stream does not delay the delivery on other streams i.e. multi-streaming eliminates HOL blocking

Slightly more detail about key SCTP features... (2 of 3)

- **Message boundaries preserved** ***easier coding***

  TCP repacketizes data any old way it sees fit (message boundaries not preserved)

  SCTP preserves message boundaries

  Application protocols easier to write, and application code simpler.

- **Improved SYN-flood protection** ***more secure***

  TCP vulnerable to SYN flood; (techniques to combat are "bags on the side")

  Protection against SYN floods is built-in with SCTP (Four way handshake (4WHS) vs 3WHS in TCP)

  Listening sockets don't set up state until a connection is validated

Slightly more detail about key SCTP features... (3 of 3)

- **Tunable parameters (Timeout, Retrans, etc.)** ***more flexibility***

  Tuning TCP parameters requires system admin privs, kernel changes, kernel hacking

  SCTP parameters can be tuned on a socket by socket basis

- **Congestion controlled unreliable/unordered data** ***more flexibility***

  TCP has congestion control, but can't do unreliable/unordered delivery

  UDP can do unreliable/unordered delivery, but not congestion controlled

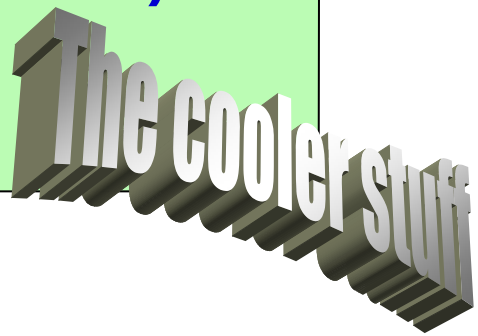
  SCTP is always congestion controlled, and offers a range of services from full reliability to none, and full ordering to none.

  With SCTP, reliable and unreliable data can be multiplexed over same connection.

Features of SCTP (review)

TCP-ish

- Reliable data transfer w/SACK
- Congestion control and avoidance
- PMTU discovery and message fragmentation
- Message boundary preservation (with bundling)
- Multi-homing support
- Multi-stream support
- Unordered data delivery option
- Security cookie against connection flood attack (SYN flood)
- Built-in heartbeat (reachability check)
- Extensibility



What you can't do with SCTP

- **byte-stream oriented communication**

  SCTP inserts message boundaries between each "write()"

  write() a length field, then a data field ➔ result is 2 messages

  not a major issue, but need to be aware of when coding apps

- **avoid congestion control**

  UDP lets you blast away, but SCTP won't let you

  (you shouldn't be doing that anyway)

- **true on-the-wire connectionless communication**

  sockets API will let you send without doing a connection setup first (as with UDP), but connection setup still occurs on the wire

  connection setup required for congestion control (see above)

Now a VERY brief example: daytime client/server (full socket API discussion comes later)

Network applications are typically client/server

daytime server

- **open a socket and bind it to a port**
- **listen for connections**
- **while (1)**
- **{**
  - **accept a connection**
  - **send a string containing current date/time**
  - **close the connection**
- **}**

daytime client

- **create a socket**
- **open a connection to daytime server**
- **read bytes until EOF (meaning connection was closed)**
- **close connection**

A TCP daytime client becomes an SCTP daytime client...

TCP daytime client (many details omitted, including error checking; see Stevens et al. 2004 for details (and don't omit the error checking!)

```
int sockfd, n;
char recvline[MAXLINE + 1]; /* read buffer*/
struct sockaddr_in servaddr;
sockfd = socket(AF_INET, SOCK_STREAM, 0); /* create TCP socket */
sockfd = socket(AF_INET, SOCK_STREAM, IP_PROTO_SCTP); /* SCTP socket */
/* fill in socket address structure */
servaddr.sin_family = AF_INET; servaddr.sin_port = htons(13);
inet_pton(AF_INET, argv[1], &servaddr.sin_addr); /*dot dec to n.b.o.*/
connect(sockfd, (struct sockaddr *) &servaddr, sizeof(servaddr));
while ( (n = read(sockfd, recvline, MAXLINE)) > 0 )
{
      recvline[n]=0; /* null terminate */
      fputs(recvline, stdout);
}
close (sockfd);
```

Note: 0 implies IP_PROTO_TCP

But... what is different?

(among other things) changing IP_PROTO_TCP to IP_PROTO_SCTP means...

- **There has to be a listening SCTP process on the other side (port number spaces independent, just like UDP vs TCP)**
- **Bits on wire flow in IP datagrams with protocol number 132 (vs. 6 (TCP)or 17 (UDP)**
- **Four-way handshake instead of three-way handshake**
- **By default, both sides will exchange the IP addresses of ALL available network interfaces (both IPv4 AND IPv6!) and will use *alternate* IP addresses for retransmission in case of errors.**
- **Each read() on client side will correspond to exactly one write() on the server side.**

  With TCP, sizes of write() and read() system calls on the two sides are independent

  With SCTP, each write() by the sending side produces a message with a specific length. That message becomes a "data chunk" inside the packet on the wire, and is delivered as a single message

  If the message is too large to be put in a single packet, it will be fragmented and reassembled. Likewise, small messages may be bundled in a single pkt.

  If it is too large to be delivered all at once, the "partial delivery" API will be invoked (details later).

  But, these last two items are exceptions, not the rule.

OK, so what?

- **What you should know at this point is...**

  SCTP is a new transport protocol

  It's available now in bleeding edge Linux and BSD kernels, and will make its way into the mainstream

  It has some cool new features (reviewed on next slide)

  If you know how to do socket programming with TCP, you can just change one field, and start using SCTP quickly

- **But...**

  to really take advantage of the cool new features, you need to know a bit more about them, and about the socket API for SCTP.

- **So, that's what's next...**

Stuff we'll talk about how to do...

The stuff you need advanced socket API features to take advantage of...

- **implicit connection establishment**
- **using multiple interfaces (multi-homing)**
- **parallel streams**
- **unordered data**
- **mixing reliable and best effort traffic**
- **timed reliability**

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