An Erlang High Performance TCP/IP Stack

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Motivation

- Problem:
  - Streaming video server ir Erlang.
  - Uses protocols like HTTP and RTSP => TCP.
  - Connections usually last for hours.
  - Cut in the connection => playing stops.
  - Clients are usually closed settop boxes.
- Tcp must be fault tolerant in the server side.

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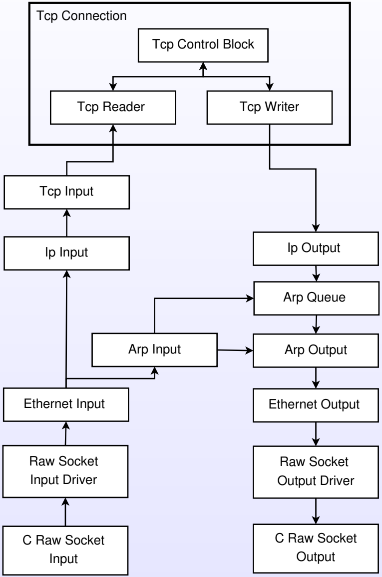
Overall Design

Proccess Structure:



Network Interface

- Erlang does not support file operation on devices => Linked-in driver.
- Linked-in to avoid unnecessary data copies.
- Interface with the card is a Linux Raw Socket.
- Network Card must be in promiscous mode.
- Data is read and written directly to the interface.

Server Model

- Two proccesses for each stateless protocol:

```
init_writer(Conf) ->
  register(protocol_writer, self()),
  writer_loop(Conf).

writer_loop(Conf) ->
  receive
    {send, Packet, Dst} ->
      {ok, Bin_Packet}=build_packet(Packet,
                                      Dst),
      send_packet(Bin_Packet, Dst, Conf);
  end,
  writer_loop(Conf).
```

Server Model

- The reader is similar:

```
init_reader(Conf) ->
  register(protocol_reader, self()),
  reader_loop(Conf).

reader_loop(Conf) ->
  receive
    {recv, Packet} ->
      case catch decode(Packet, Conf) of
        {ok, Upper_protocol, Data} ->
          Upper_protocol:recv(Data);
        {error, Error} ->
          {error, Error};
      end
  end,
  reader_loop(Conf).
```

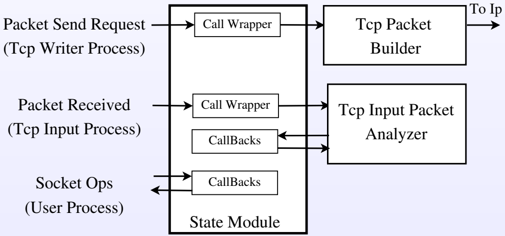
Tcp Design

Tcp is stateful. Must keep state for each connection:

- Reader process.
- Writer process.
- TCB(Tcp Control Block): state and synchrnization.

State Behaviour

State beaviour is implemented using callbacks and wrappers:



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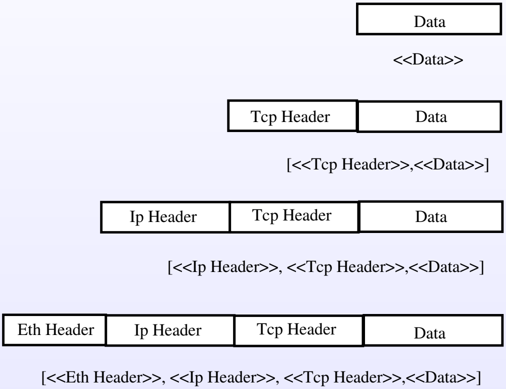
Scatter/Gather

Functional Scatter Gather:



Checksum

Checksum was done in several ways:

- Deconstructing a binary one byte at a time: 13MB/s

```
checksum(<<Num:16/integer, Remainder/binary>>,
         Csum) ->
    checksum(Remainder, Csum + Num);
```

- Deconstructing a binary eight bytes at a time: 28MB/s

```
checksum(Bin = <<N1:16/integer,N2:16/integer,
                 N3:16/integer,N4:16/integer,
                 N5:16/integer,N6:16/integer,
                 N7:16/integer,N8:16/integer,
                 Rem/binary>>, Csum)
                   when size(Bin) >= 16 ->
    checksum(Rem, Csum+N1+N2+N3+N4+N5+N6+
                  N7+N8);
```

Checksum

- Using the same binary eight bytes at a time: 32MB/s

```
checksum(Bin, Position) when size(Bin) >= 8 ->
<<_:(Position)/integer, N1:16/integer,
         N2:16/integer, ..., _/binary>> = Bin,
        checksum(Rem, Csum+N1+N2..+N8);
```

- Using a C linked-in driver: 136MB/s

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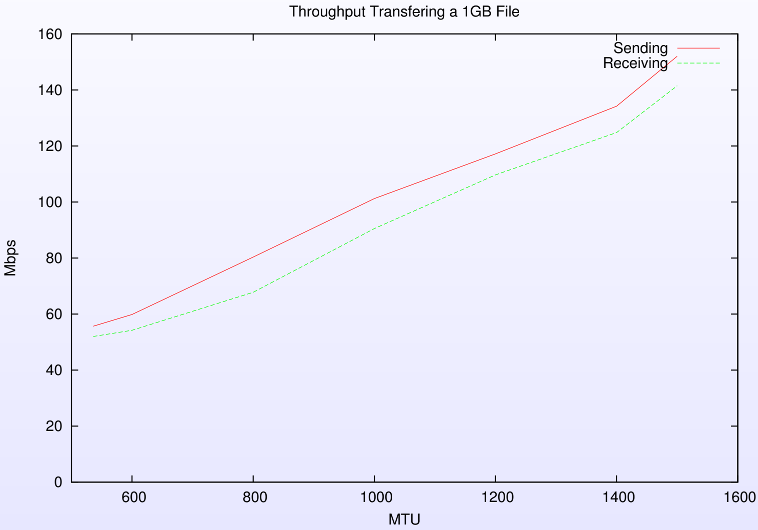
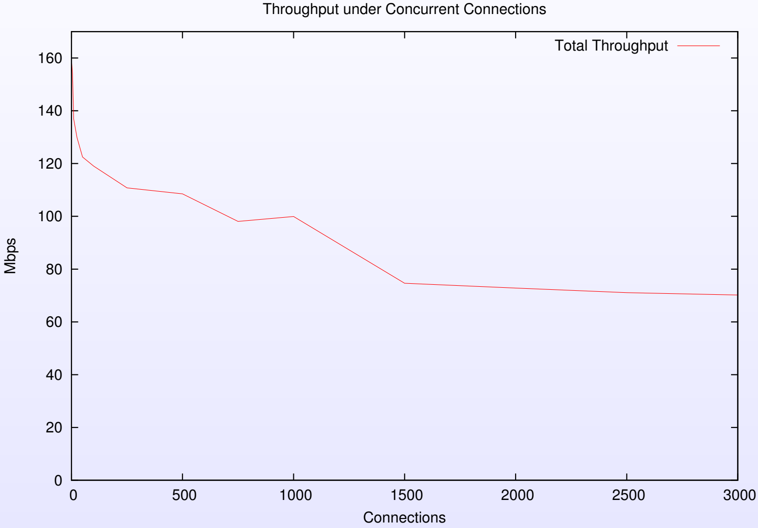
Throughput



Throughput Transfering a 1GB File
Sending
Receiving
Mbps
MTU
160
140
120
100
80
60
40
20
0
600
800
1000
1200
1400
1600

Concurrency



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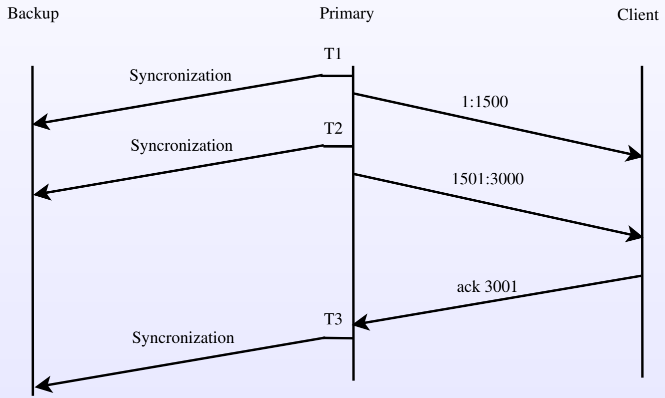
Distribution

- Aim: Make it possible to recover ongoing Tcp connections of failed machines in backup nodes.
- Erlang applications are often distributed => Try to take advantage of distributed information about the state to ease the cost.

Distribution: Sending Data

First Approach: Make a synchronization before everey packet sent and after every packet received.



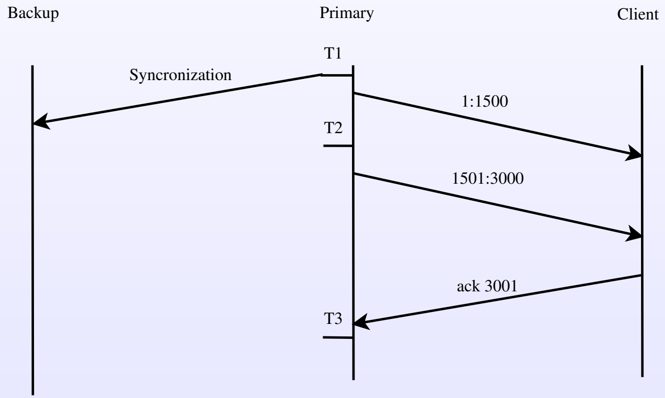
Distribution: Optimizing Send

Optimization:

- Data that must be synchronized at all times: Sequence Numbers and Window Information.
- Client also has this information at all times.
- An out of window packet must be answered with an ack (RFC 793) => The backup can recover this information by sending an out of window packet to the client.
- The client can use initial sequence number to generate an invalid sequence number. When the initial sequence number is about to enter window again the primary node must warn the backups => Forced Synchronization only every 4GB.

Distribution: Optimizing Send

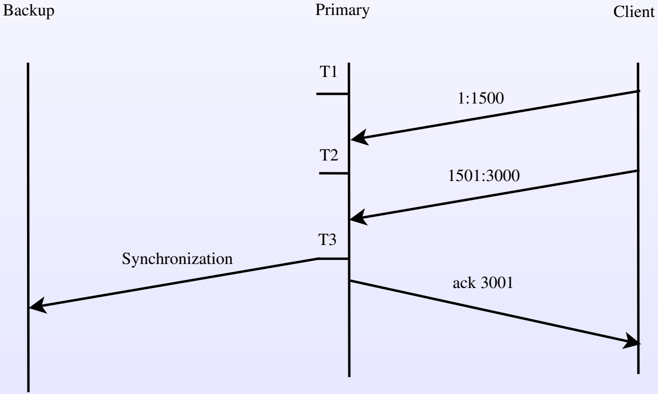
- The application must continue where it left in the failed node. The stack may help by saying how many bytes have been transmitted.



Distribution Reception

Harder to Optimize:

- Buffered received data cannot be recovered.
- Sincronization is needed every time an ack is received.



Distribution

Future Challenges:

- Failure detection and collision avoidance between master and slaves.
- How to physically distribute the servers.
- Support for load balancing in sidtributed by using connection migration.

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