Hardware Accelerated Decoding of FIX/FAST and Book Building of Market Data

Final Presentation

Danqing Hua, Junkang Ren, Chang Liu, Raghavan Santhanam

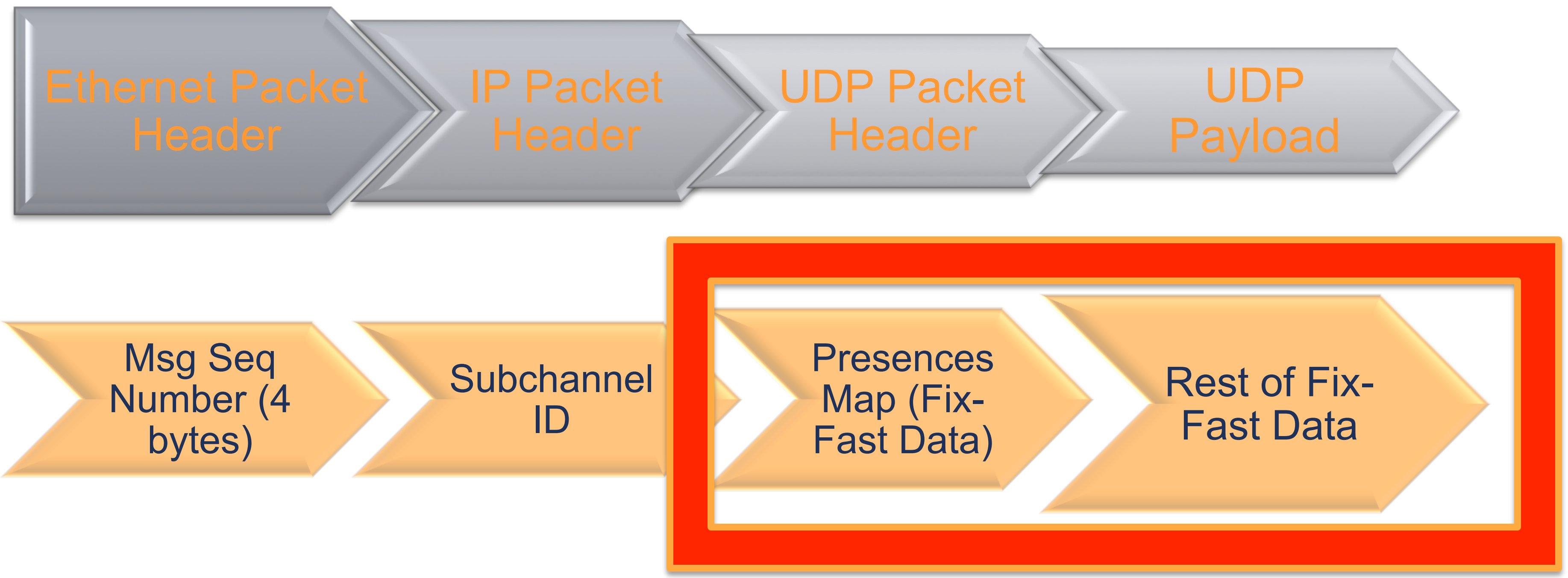
Outline

- Overview of Fix-fast protocol
- Overview of book builder.
- Work flow of the entire project.
- Software design
- Hardware design
- Demo on AOE board.

High Level Block Diagram

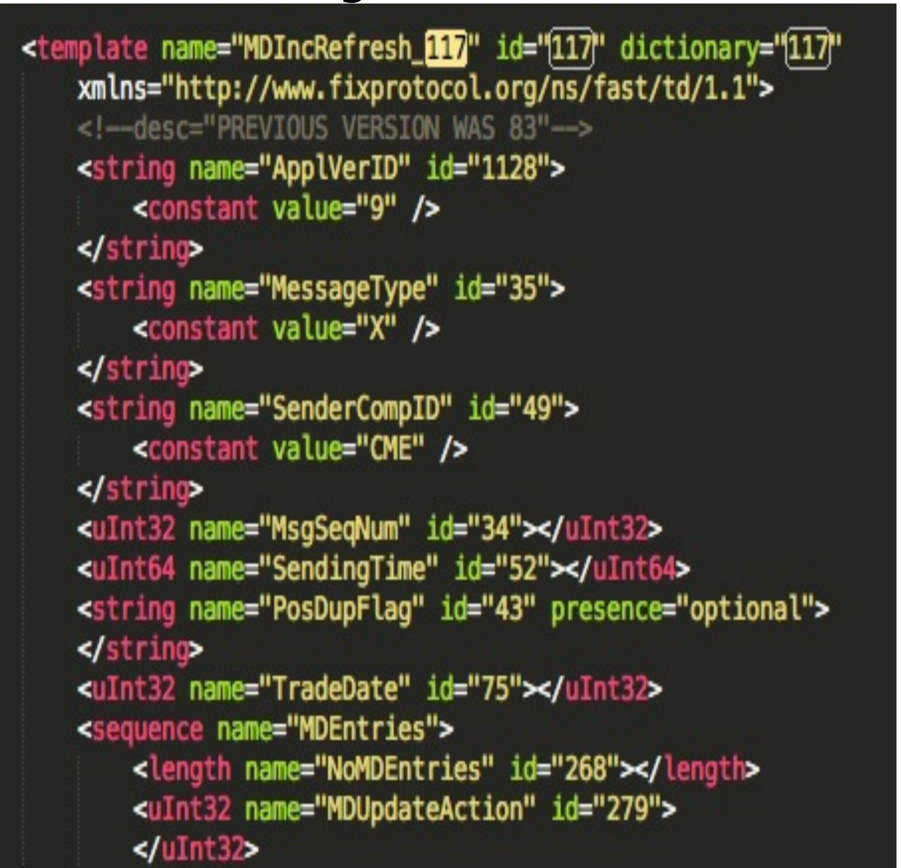
Fix-Fast Protocol

- 1. What is Fix-Fast?
  - FIX for financial information exchange.
  - It's a series of messaging specifications for electronic communication of trade related messages.
- 2. What's the protocol like?

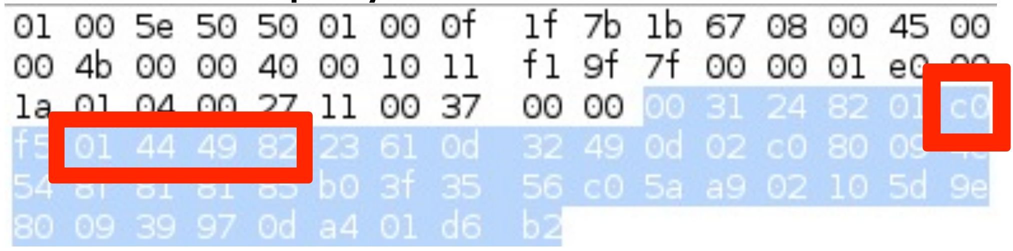


Fix-Fast Protocol

- 3. How to decode fix-fast message?
  - XML templates
  - Presence Map (PMap)
  - Big Endian
  - Most significant bit serve as indicator of stop byte.



```
<template name="MDIncRefresh_117" id="117" dictionary="117"
    xmlns="http://www.fixprotocol.org/ns/fast/td/1.1">
    <!--desc="PREVIOUS VERSION WAS 83"-->
    <string name="ApplVerID" id="1128">
        <constant value="9" />
    </string>
    <string name="MessageType" id="35">
        <constant value="X" />
    </string>
    <string name="SenderCompID" id="49">
        <constant value="CME" />
    </string>
    <uInt32 name="MsgSeqNum" id="34"></uInt32>
    <uInt64 name="SendingTime" id="52"></uInt64>
    <string name="PosDupFlag" id="43" presence="optional">
    </string>
    <uInt32 name="TradeDate" id="75"></uInt32>
    <sequence name="MDEntries">
        <length name="NoMDEntries" id="268"></length>
        <uInt32 name="MDUpdateAction" id="279">
        </uInt32>
```



```
01 00 5e 50 50 01 00 0f  1f 7b 1b 67 08 00 45 00
00 4b 00 00 40 00 10 11  f1 9f 7f 00 00 01 e0 00
1a 01 04 00 27 11 00 37  00 00 00 31 24 82 01 c0
f5 01 44 49 82 23 61 0d  32 49 0d 02 c0 80 09 4e
54 81 81 81 85 b0 3f 35  56 c0 5a a9 02 10 5d 9e
80 09 39 97 0d a4 01 d6  b2
```

Heximal:
01 44 49 82

Decimal:
0000 0001 0100 0100 0100 1001 1000 0010

After Decoding:
000 0001 100 0100 100 1001 000 0010

Book Builder

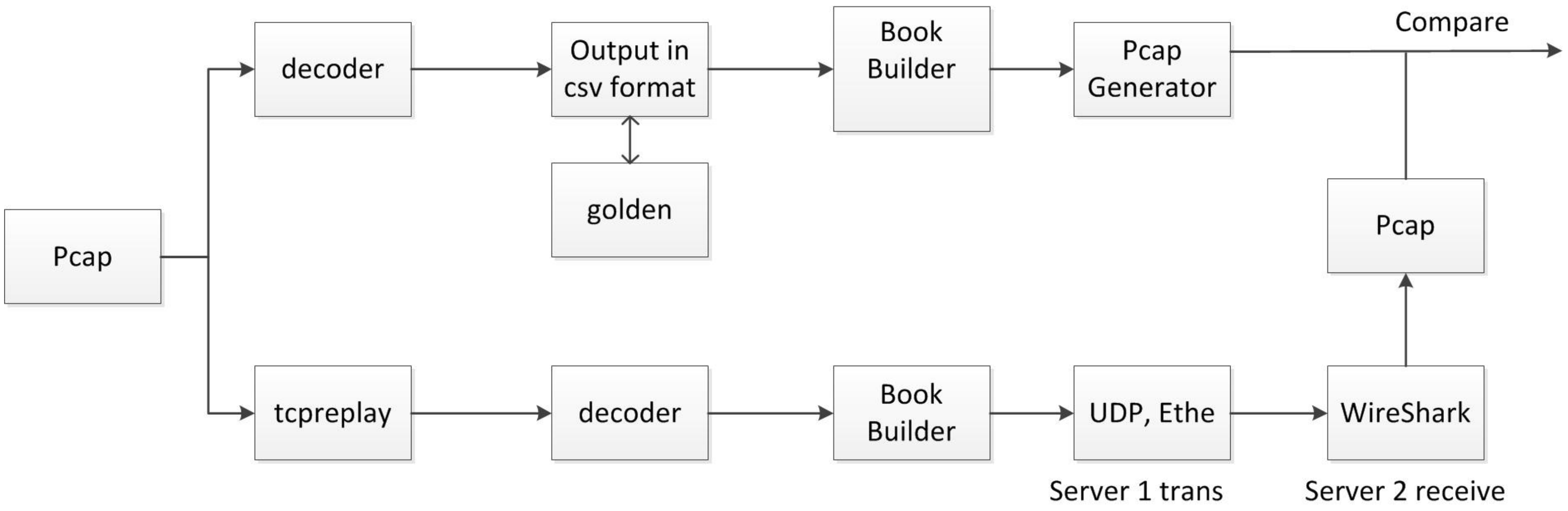
- What is Book in trading?
  - Records of bid and ask information in trading activity

- Important variables related to book builder
  - MDEntryType: Decides whether we are working on book with bidding information or on book with asking information. (0 for bid, 1 for ask)
  - MDUpdateAction: 3 actions in total. “0” means add a new level (item) in the book; “1” means modify a certain level in the book; “2” means delete an existing level in the book.
  - MDPriceLevel: Decides which item of the book we are working on.

  - MDEntryPx: Price of a stock
  - MDEntrySize: The amount of a certain stock
  - NumberOfOrders

Work Flow of The Project

- The flow on the top is software validation
- The flow on the bottom is hardware implementation

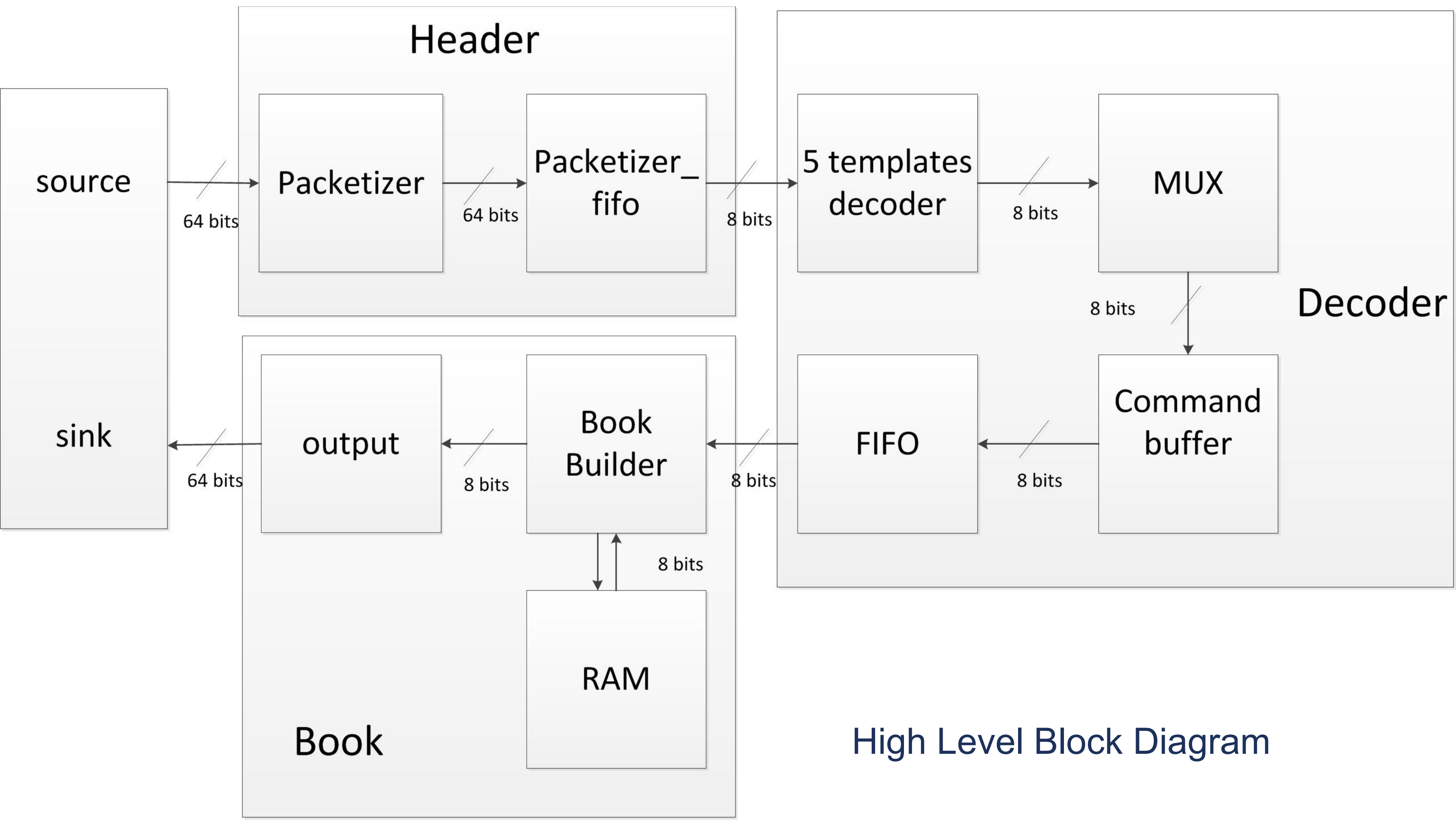


Software Design

- 1. Validation:
  - Decoder: Implementation of the template decoder in C.
  - Book builder: Implementation of the book builder in Python.
    - Parse the output file of csv format from Decoder
    - Generate the book as two separate list (one for bid, one for ask)
    - Output the snapshot of book through Ethernet packet. Packed all the packets into pcap format.

- 2. Software Support:
  - Using Perl to generate VHDL testbench for book builder.
  - Parsing the XML templates using Python to auto generate decoder for all templates.
  - Python and Shell script to compare output from decoder and golden output in simulation.
  - Tcl script to help compile run VHDL simulation in one command.

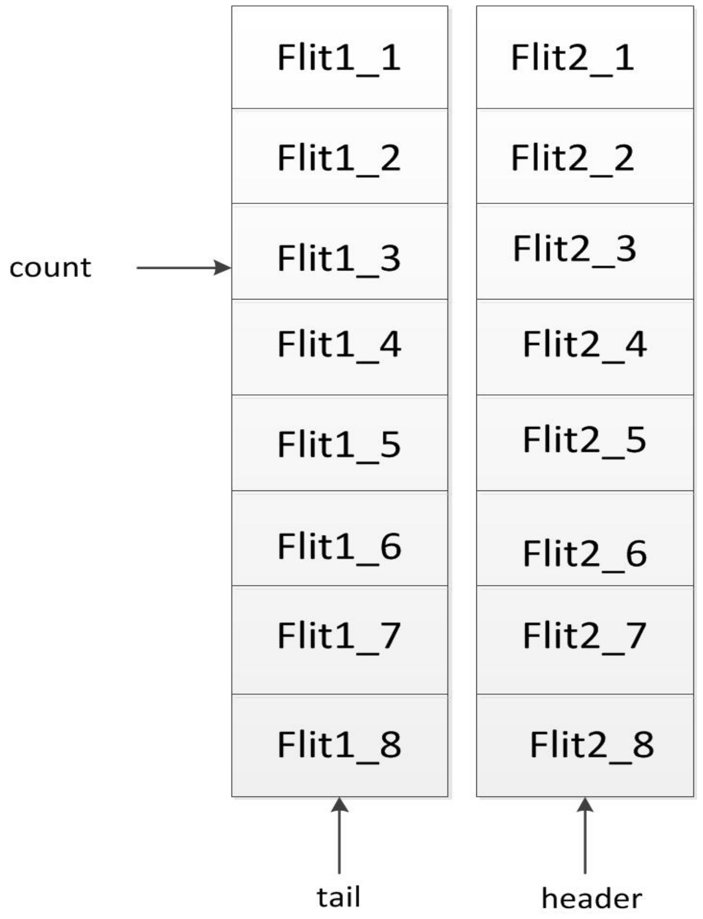
Hardware Design



High Level Block Diagram

Hardware Design

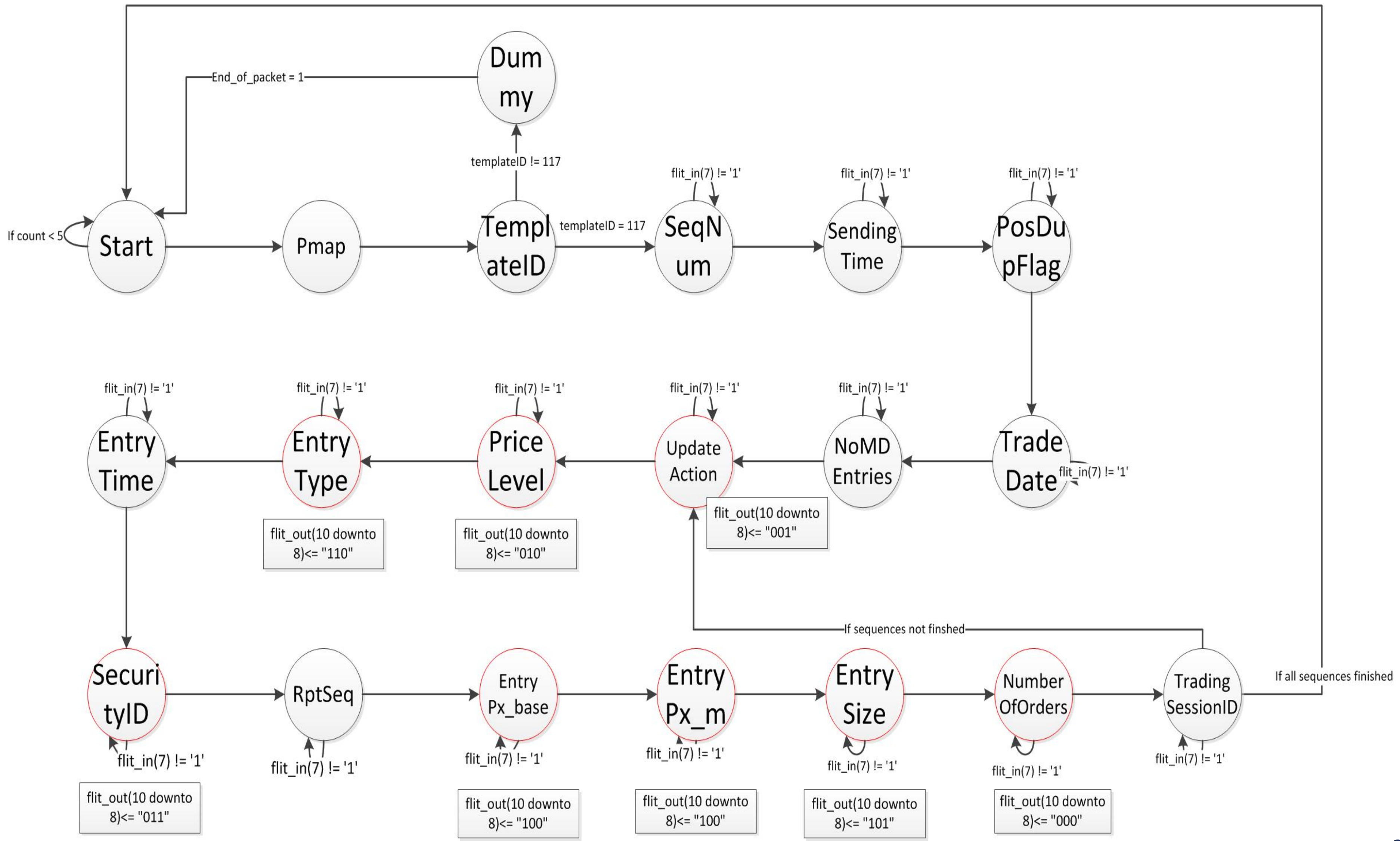
- Packetizer Module
  - passes along the UDP payload



- Packetizer_fifo Module
  - convert data to a 8-bits flit
  - store the data which hasn’t been processed

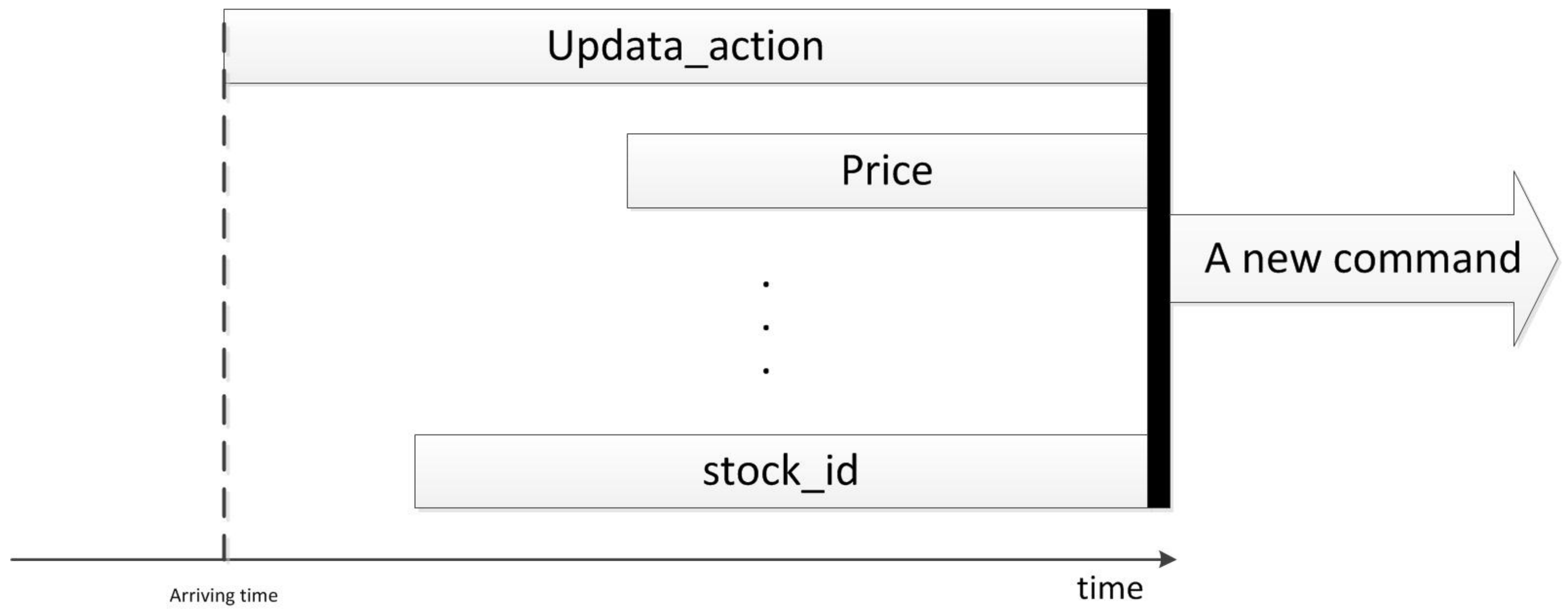
Hardware Design

- Template Decoder Module



Hardware Design

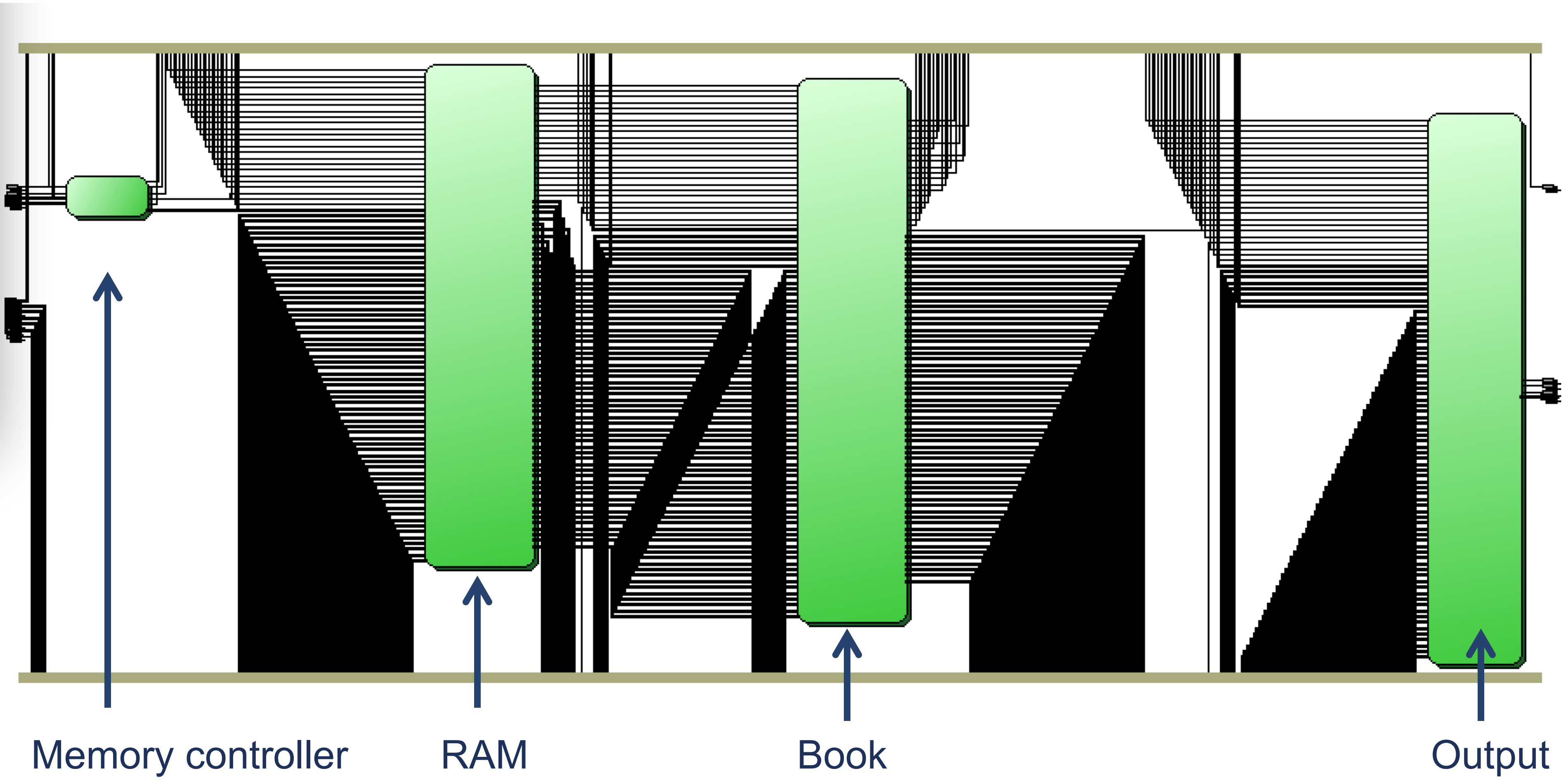
- Command Buffer Module



  - combines specified information to a piece of command

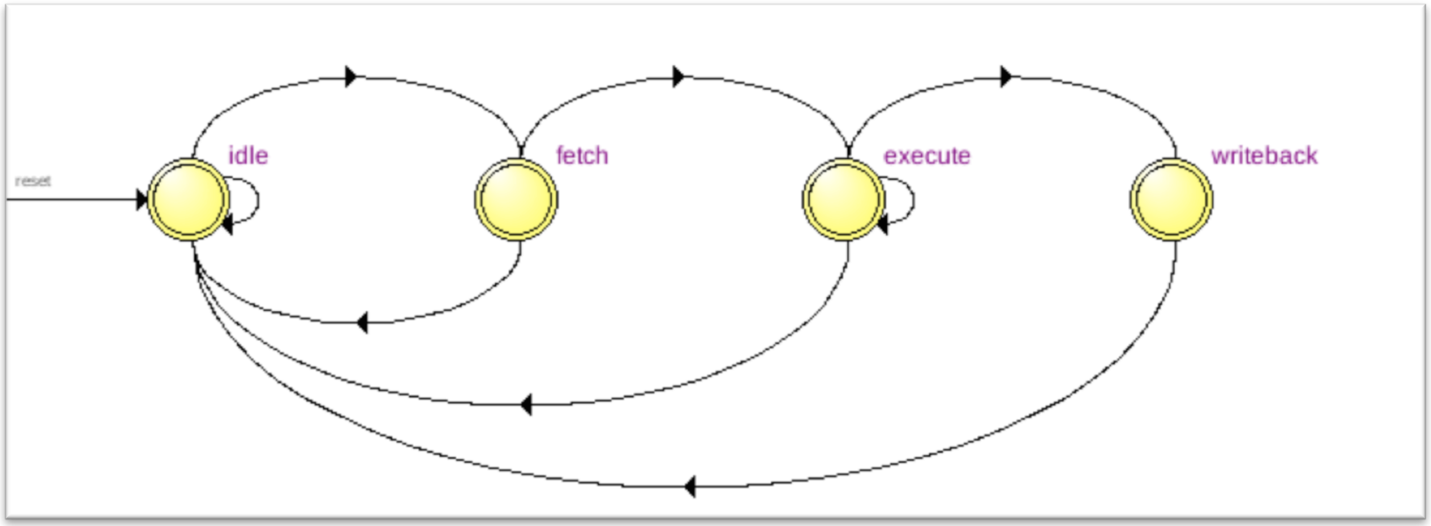
Hardware Design

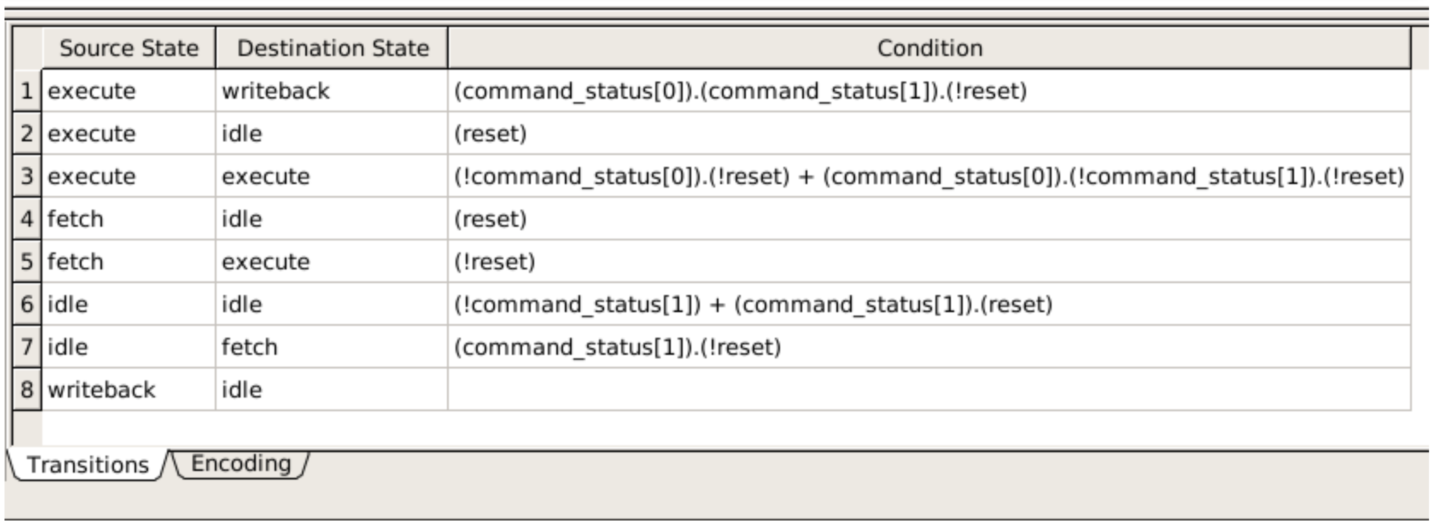
- Book Builder Module



Hardware Design

- Book Builder Module



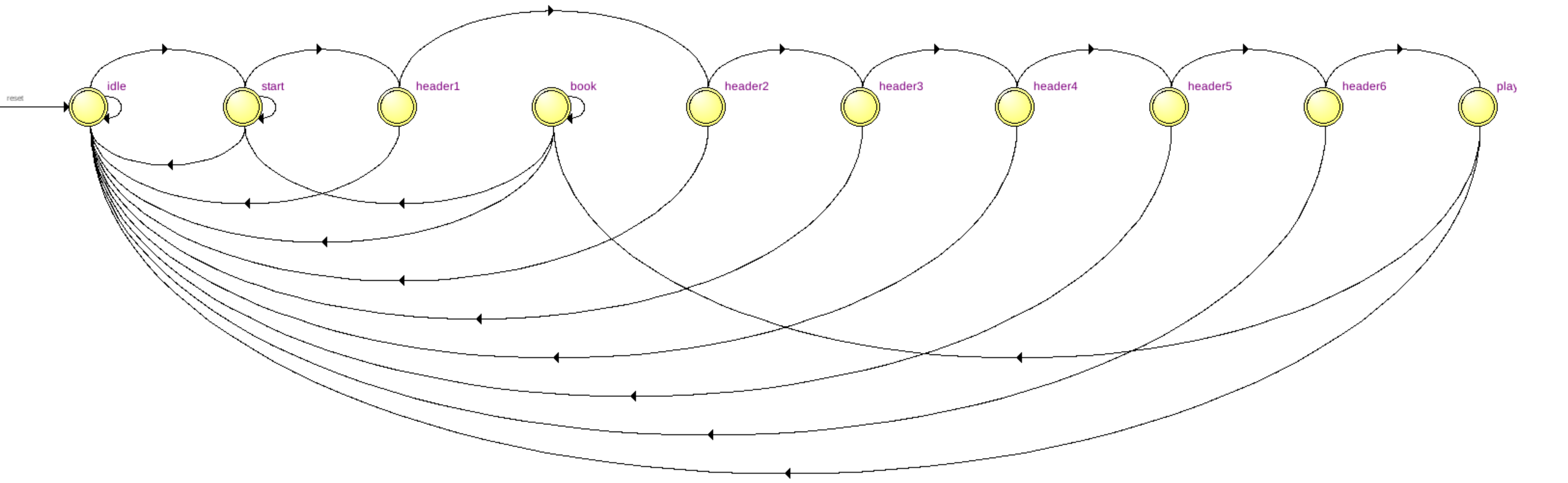


	Source State	Destination State	Condition
1	execute	writeback	(command_status[0]).(command_status[1]).(!reset)
2	execute	idle	(reset)
3	execute	execute	(!command_status[0]).(!reset) + (command_status[0]).(!command_status[1]).(!reset)
4	fetch	idle	(reset)
5	fetch	execute	(!reset)
6	idle	idle	(!command_status[1]) + (command_status[1]).(reset)
7	idle	fetch	(command_status[1]).(!reset)
8	writeback	idle	

Transitions / Encoding

Hardware Design

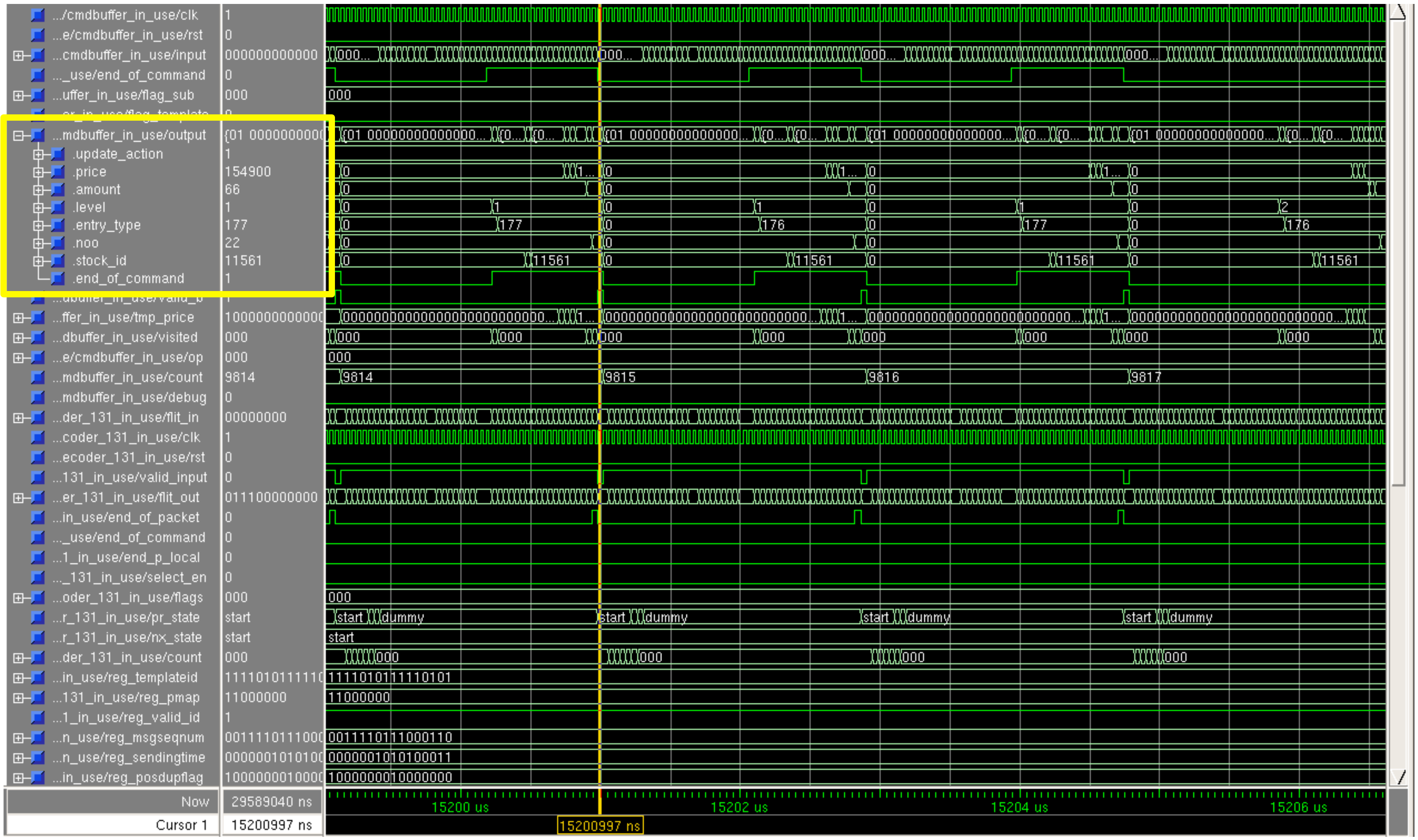
- Output Module



  - Output the snapshot of the book with whole book information
  - Equip with IP header and UDP header

Verification

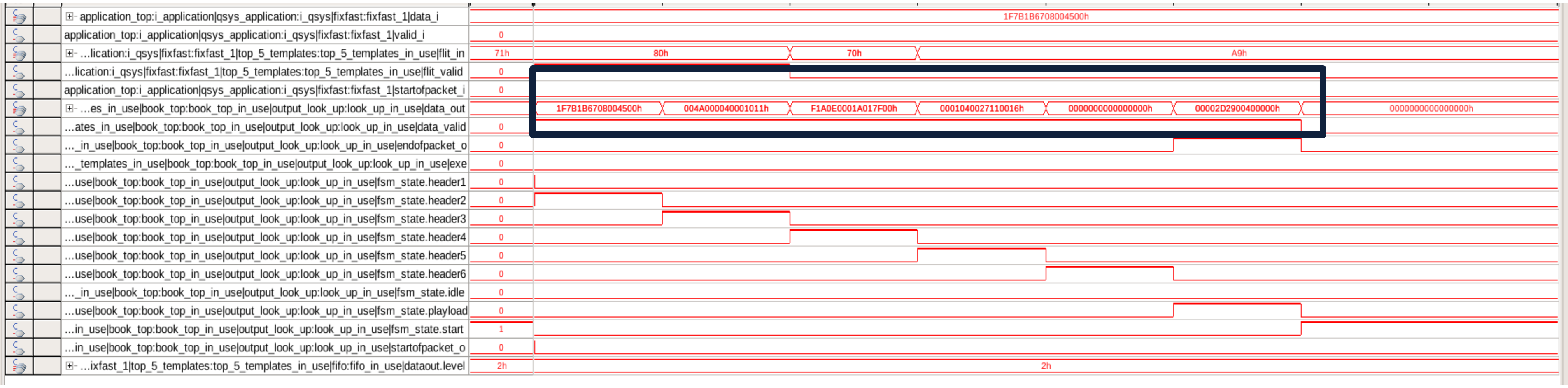
- Verification of Functionality



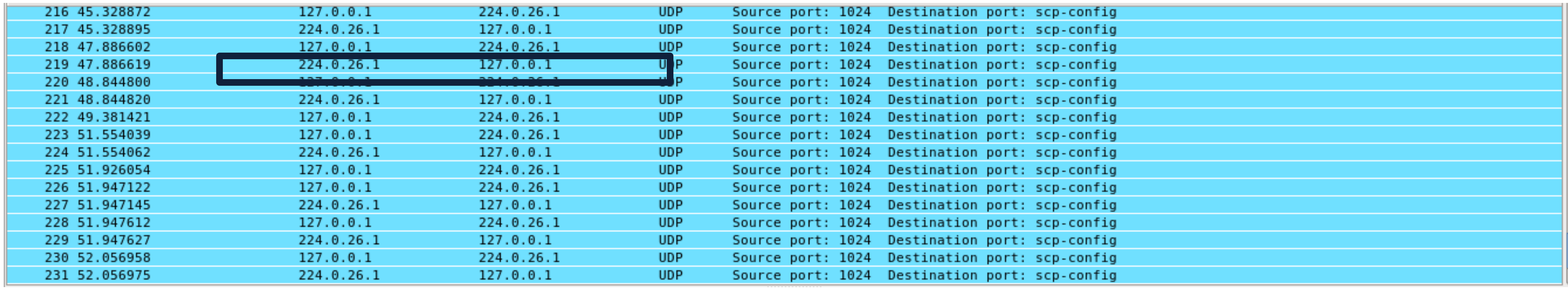
```
.../cmdbuffer_in_use/clk            1
...e/cmdbuffer_in_use/rst           0
...cmdbuffer_in_use/input           000000000000
..._use/end_of_command              0
...uffer_in_use/flag_sub            000
...er_in_use/flag_template          0
...mdbuffer_in_use/output           {01 0000000000
    .update_action                  1
    .price                          154900
    .amount                         66
    .level                          1
    .entry_type                     177
    .noo                            22
    .stock_id                       11561
    .end_of_command                 1
...buffer_in_use/valid_b            1
...ffer_in_use/tmp_price            1000000000000
...dbuffer_in_use/visited           000
...e/cmdbuffer_in_use/op            000
...mdbuffer_in_use/count            9814
...mdbuffer_in_use/debug            0
...der_131_in_use/flit_in           00000000
...coder_131_in_use/clk             1
...ecoder_131_in_use/rst            0
...131_in_use/valid_input           0
...er_131_in_use/flit_out           011100000000
...in_use/end_of_packet             0
..._use/end_of_command              0
...1_in_use/end_p_local             0
..._131_in_use/select_en            0
...oder_131_in_use/flags            000
...r_131_in_use/pr_state            start
...r_131_in_use/nx_state            start
...der_131_in_use/count             000
...in_use/reg_templateid            1111010111110
...131_in_use/reg_pmap              11000000
...1_in_use/reg_valid_id            1
...n_use/reg_msgseqnum              0011110111000
...n_use/reg_sendingtime            0000001010100
...in_use/reg_posdupflag            1000000010000

Now        29589040 ns
Cursor 1   15200997 ns
```

Verification

- Runtime Verification: Signal Tap



```
application_top:i_application|qsys_application:i_qsys|fixfast:fixfast_1|data_i                                          1F7B1B6708004500h
application_top:i_application|qsys_application:i_qsys|fixfast:fixfast_1|valid_i                          0
...lication:i_qsys|fixfast:fixfast_1|top_5_templates:top_5_templates_in_use|flit_in                      71h   80h  70h  A9h
...lication:i_qsys|fixfast:fixfast_1|top_5_templates:top_5_templates_in_use|flit_valid                   0
application_top:i_application|qsys_application:i_qsys|fixfast:fixfast_1|startofpacket_i                  0
...es_in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|data_out                                   1F7B1B6708004500h  004A000040001011h  F1A0E0001A017F00h  0001040027110016h  0000000000000000h  00002D2900400000h  0000000000000000h
...ates_in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|data_valid                         0
..._in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|endofpacket_o                          0
..._templates_in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|exe                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header1                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header2                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header3                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header4                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header5                          0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.header6                          0
..._in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.idle                         0
...use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.playload                         0
...in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|fsm_state.start                         1
...in_use|book_top:book_top_in_use|output_look_up:look_up_in_use|startofpacket_o                         0
...ixfast_1|top_5_templates:top_5_templates_in_use|fifo:fifo_in_use|dataout.level                        2h    2h
```



```
216 45.328872       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
217 45.328895       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
218 47.886602       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
219 47.886619       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
220 48.844800       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
221 48.844820       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
222 49.381421       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
223 51.554039       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
224 51.554062       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
225 51.926054       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
226 51.947122       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
227 51.947145       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
228 51.947612       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
229 51.947627       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
230 52.056958       127.0.0.1       224.0.26.1      UDP     Source port: 1024  Destination port: scp-config
231 52.056975       224.0.26.1      127.0.0.1       UDP     Source port: 1024  Destination port: scp-config
```