Nasdaq Itch Ticker Plant

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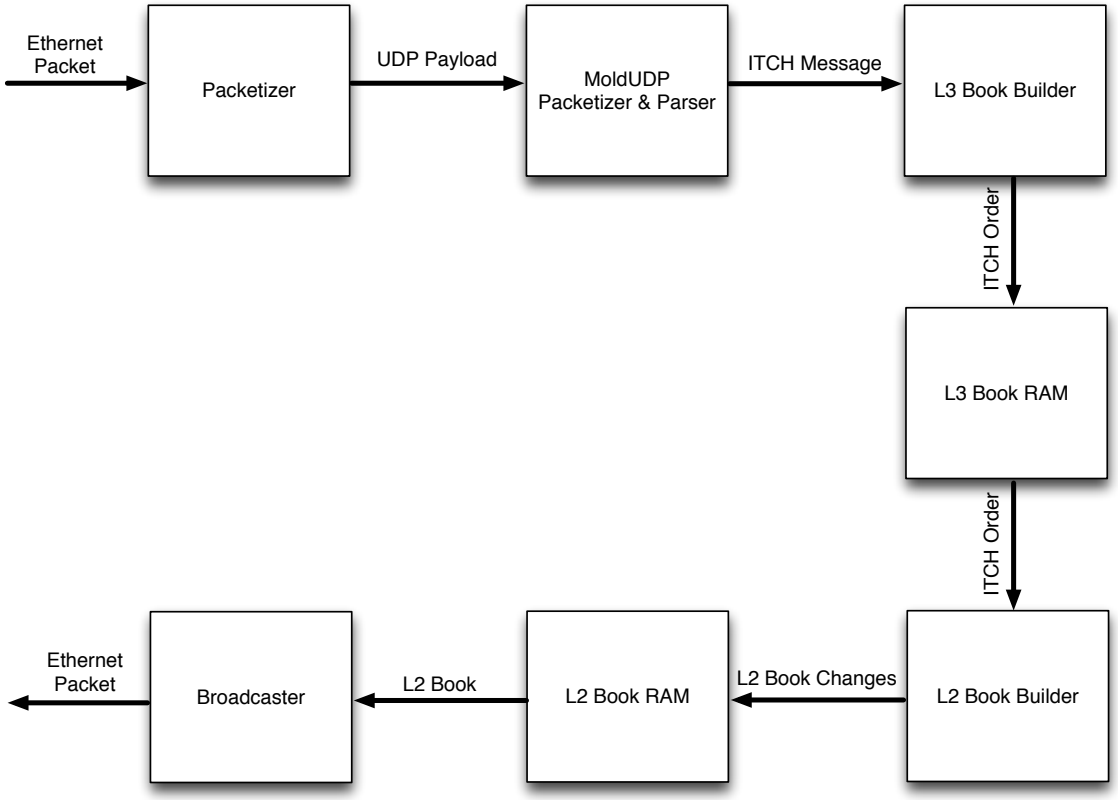
What is Itch? Why hardware?

- Itch is the Nasdaq's protocol for information transfer.
- Big firms require lowest latency. Time is money!
  - Traditional software methods work, but hardware can provide large decrease in latency.
- An untouched market.

The Concept


Ethernet Packet
Packetizer
UDP Payload
MoldUDP Packetizer & Parser
ITCH Message
L3 Book Builder
ITCH Order
L3 Book RAM
ITCH Order
Ethernet Packet
Broadcaster
L2 Book
L2 Book RAM
L2 Book Changes
L2 Book Builder

Module Level Descriptions

UDP Packetizer

When packets are being received, the payload is encapsulated within 3 headers:

1> Ethernet Header

2> IP Header

3> UDP Header

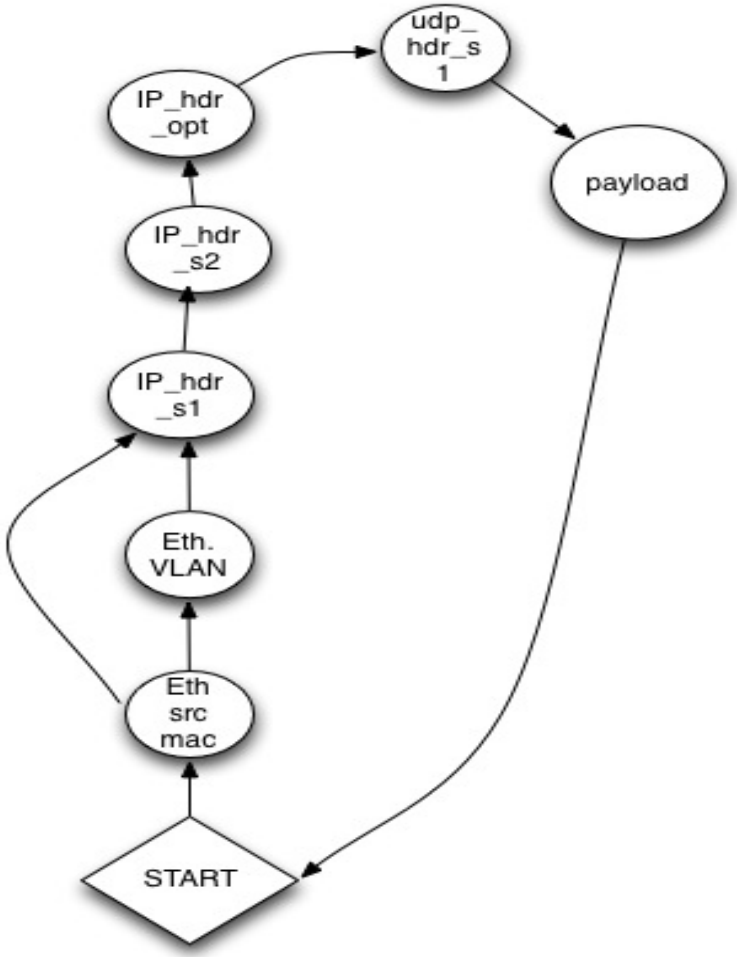
MoldUDP Packetizer & Parser

- Purpose
  - To receive and accumulate IP Payload data from the packetizer
  - Outputs full relevant messages to FIFO to be read by L3 book

UDP Packet Payload

- Upon reaching the payload of every packet, a data_valid_out signal is given to the next stage (MOLD_UDP), which is an indication this is the relevant data that needs to be read in.
- Payload data is given out in bursts of 8 bytes per clock cycle till the payload is exhausted.
- The FSM diagram on next slide makes it much more comprehensible.

UDP Packetizer FSM

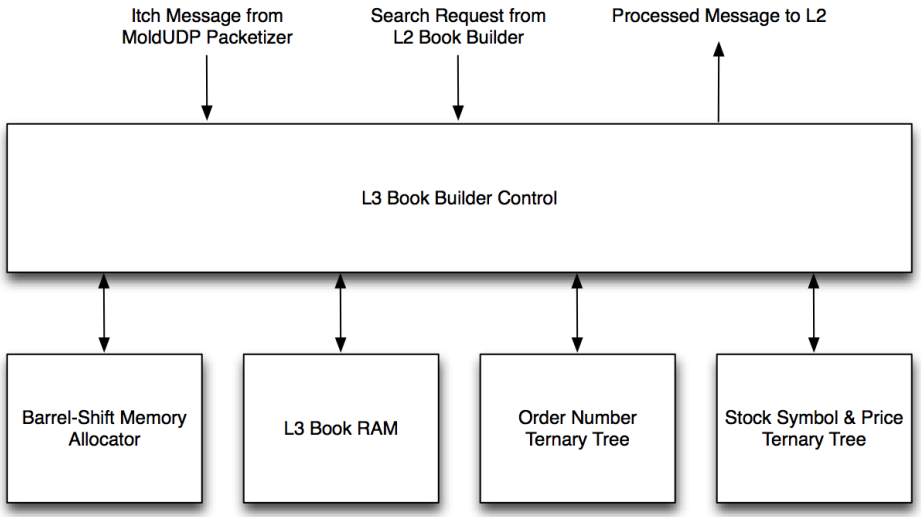


Functionality

- MoldUDP Module contains two components
  - MoldUDPPacketizer_DataReg.vhd
    - Handles incoming data from the Packetizer module
    - Accumulates data until a single message is reacheds, then sends out entire message to parser.
  - Msg_Parser.vhd
    - Serves to parse incoming messages from the Data Reg module.
    - Filters out irrelevant messages and crop unneeded portions of certain messages, then sends to FIFO

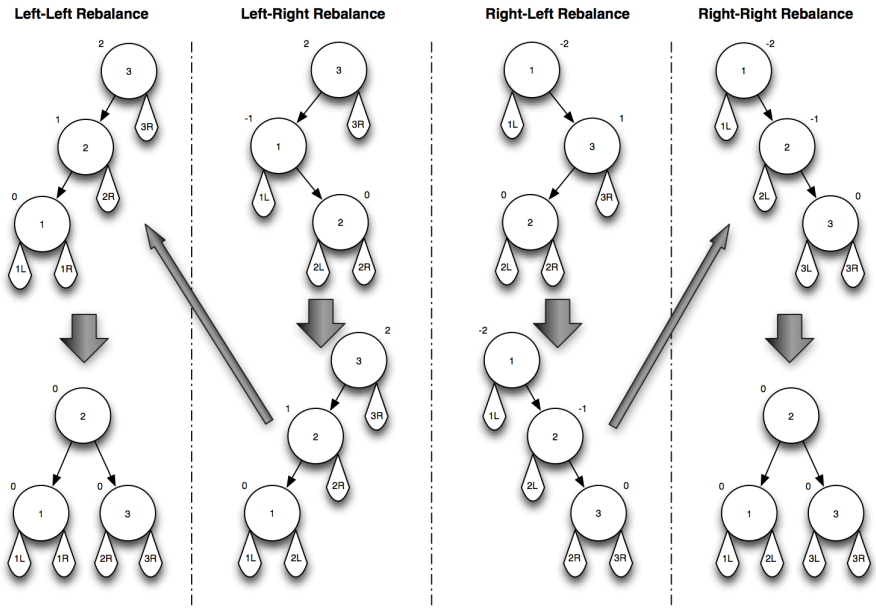
L3 Book Builder

- Large database controller.
- Extremely low latency requirements.
- Implemented using two ternary trees.



L3 Book Builder

- The ternary tree must stay rebalanced.
  - If successfully balanced at all time, a consistent O(logn) operation time is observed for lookups.



Ternary Tree

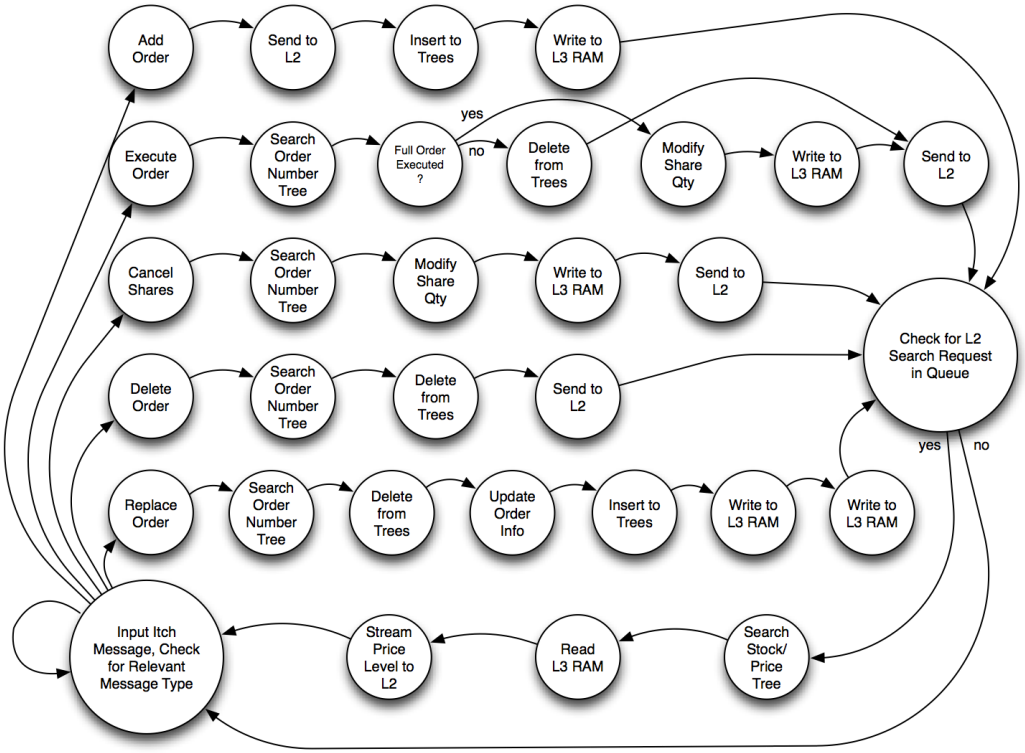
- Added functionality in the form of a center node. Not involved in rotation
- Address of node to be deleted is provided by the search module.
- Position of the node is checked in the tree, deleted and balance factors are updated
- Rotation done to balance tree if required
- Root Sharing.

Ternary Tree

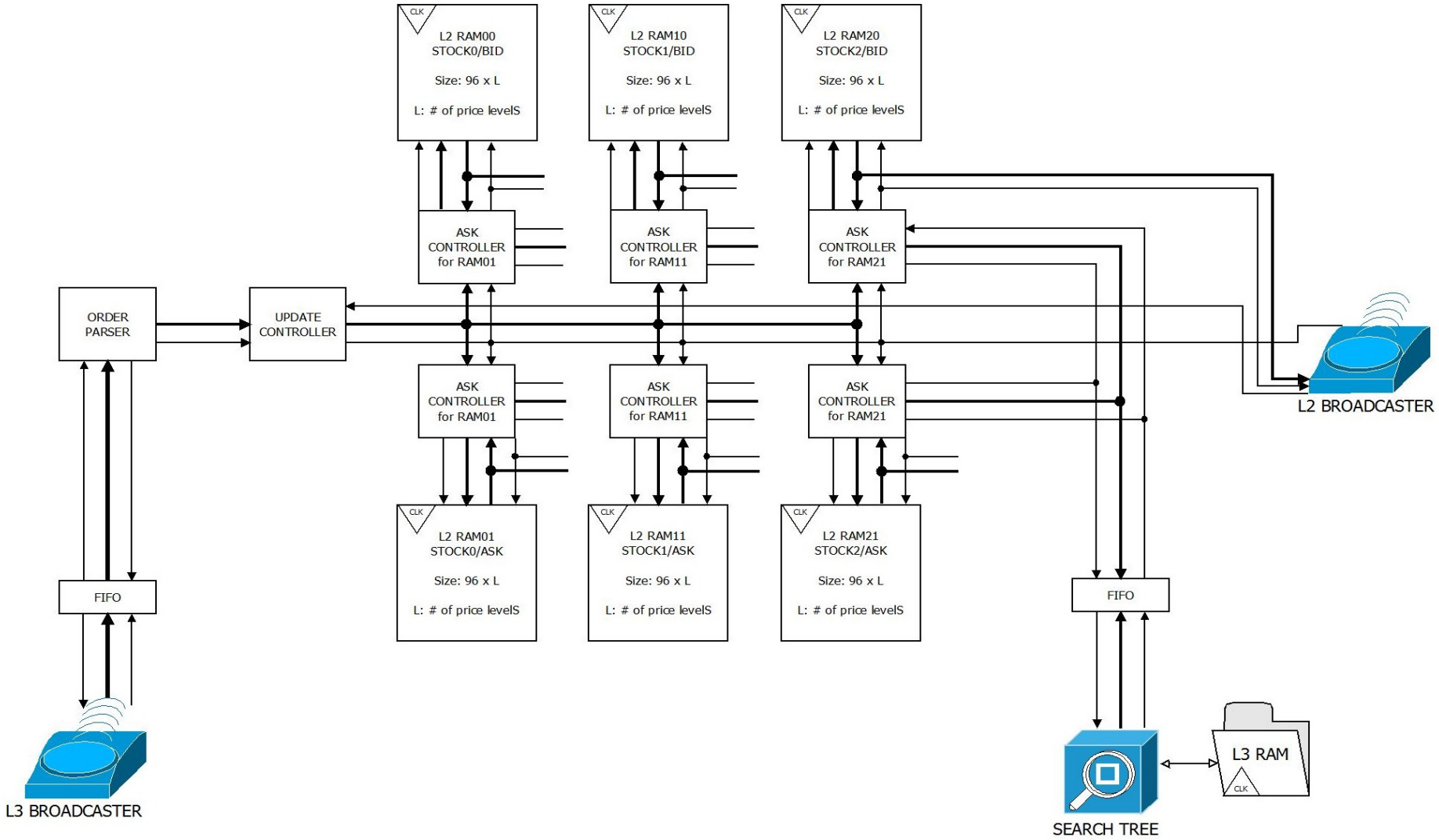
- Thoroughly validated with a 5 level deep tree.
- Validated with trees of 1000 randomly generated nodes.
- Encountered bugs after integration.

L3 Book Builder

- The ternary tree is parameterized, top level can recurse on it for different purposes.



L2 Book Builder - Design



Broadcaster

- Purpose
  - To send snapshots of the L2 books to a display every time there is an update.

Functionality

- L2 sends “update”, “execute” and “execute_data” signal to Broadcaster
- Broadcaster reads in data from the updated L2 RAM and stores it into a buffer.
- Buffer wrapped in UDP frame, then sent as output to ethernet port 64-bits at a time.

Top Level Functionality

Integration

- The system is functional in simulation and validated except for the L2 which must be integrated.
- The current system has a bug in the MoldUDP packetizer which requires a day or two to correct.
  - Packets are passing but the data is often incorrect.