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
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.
Functionality

• MoldUDP Module contains two components
  – MoldUDPPacketizer_DataReg.vhd
    • Handles incoming data from the Packetizer module
    • Accumulates data until a single message is reached, 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 crops 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 $O(\log n)$ 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.
The ternary tree is parameterized, top level can recurse on it for different purposes.
L2 Book Builder - Design
Broadcast

• 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.