Performance Statistics AMI

September 12,2013

Overview

The primary objective of 3Forge AMI is to deliver maximum information to humans as fast as possible, allowing them to immediately sort, search and drill into data. Our latencies and related metrics are designed to match that of human user needs.

Requirements For User Experience

- **Latency Objective**: transmit data to the user at least as fast as the "the human visual system can process images". This is 12 FPS**,** or 80 milliseconds. [1]
- **Query Response Objective :** At least as fast as the "human cycle time". This is about 100 milliseconds. [2]

Objective For Data

- **Real time tables Objective :** 1 million records with full sorting, searching
- **Total data Objective** : 100 million+ records
- **Burst Throughput Objective :** 100,000 records per second

Results Overview (details on following pages)

Build Version: 2292

Test 1 – Sustained heavy load of new objects at 25,000/second. Single simulator creating 25,000 objects per second for 30 minutes sustained. The total is 45,000,000 objects being monitored.

Test Results:

- Avg. Latency from object creation to display: **19.49 milliseconds**
- Total objects in display: **45,000,000**
- Total memory used in Central Server**: 7.2gb**

Test 2 – Massive burst of new objects at 500,000/second. Five simulators each bursting 100,000 objects per second for 20 seconds. The total is 10,000,000 objects in just 20 seconds.

Test Results:

- Avg. Latency from creation to display: **84.17 milliseconds**
- Total objects in display: **10,000,000**

Test 3 – Massive real-time aggregation. This includes Real-time sorting on aggregate column with derived calculations .

Test Parameters:

- Underlying rows: **10,000,000** executions
- Grouping categories: **40,000** symbols
- Max underlying data in one group: **15,071** Executions for top Symbol

Test Results: No visible lag

Test 4 – Real-time search over massive data set. Data is auto-sorted by price. Query includes 4 symbols across **1 billion** entries.

Test Results

- Result set: **260,250** market data events
- Time to execute query: **698 milliseconds**

[1] Read, Paul; Meyer, Mark-Paul; Gamma Group (2000). Restoration of Motion Picture Film
[2] Card, Stuart; Moran, Thomas; Newell, Allen; Lawrence Erlbaum Associates, Inc (1983). The Psychology of Human-Computer Interaction

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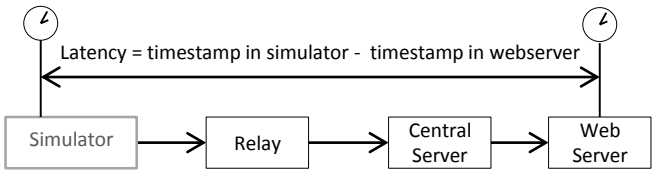
Measurement Approach

All tests are end to end, which include the creation, transmission, storage and format of an object at the front end. First, the simulator creates a new *"MarketTrade"* object which contains a timestamp reflecting current systime (see *"exectime"* in sample message). This object is passed to the AMI Relay. After the object passes through the Central Server and reaches it's final destination in the Web Server, the system time is compared against the object's timestamp to determine a latency. This , along with the number of objects, is aggregated and logged 1/sec. This latency will include (a) creation of the message in the simulator (b) transmission from simulator to the Relay (c) Relay processing (d) transmission from Relay to Central Server (e) storage of data in the Central Server (f) transmission from Central Server to Web Server (g) formatting in Web Server.



Message Format:

Each object contains (a) venue [enum], (b) symbol [enum], (c) price [float], (d) time [long], & (e) quantity [int].

Sample: `O|T="MarketTrade"|Venue='BATS'|Symbol='MSFT.O'|Price=27.32|exectime=1380479599421L|qty=20200`

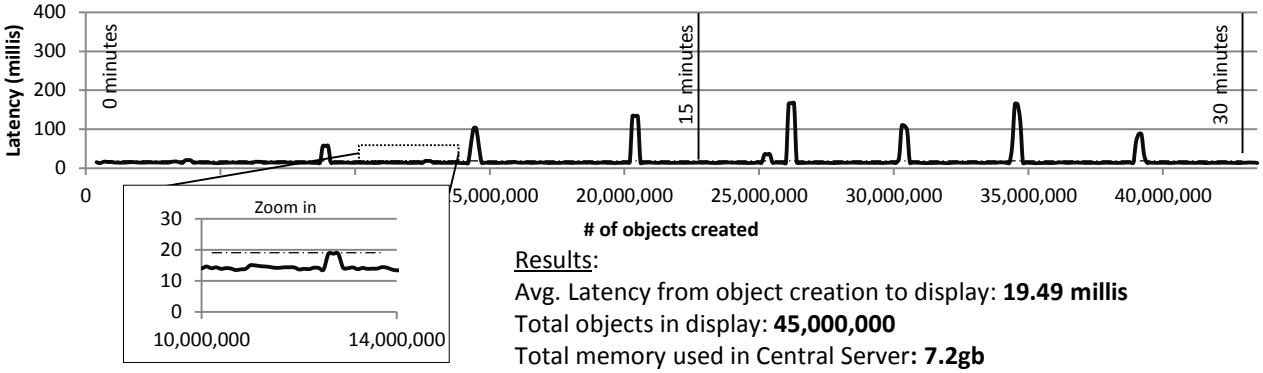
System Overview (test 1,2,3):

All Tests performed using openjdk 1.6 on a commodity server running centos with 48g & 12 x 3.06GHZ Intel Xeon processors. OS and java are default installations. Simulators, Central AMI server, Relay and Web Server are all running on this single machine, communicating via loopback.

JVM: java version 1.6.0_24 - OpenJDK 64-Bit Server VM (build 20.0-b12, mixed mode)
JVM MEM: 20GB for Central Server, 10GBfor Web Server. 1GB for Relay. 1gb for Simulator
OS :2.6.32-358.6.1.el6.centos.plus.x86_64
CPU: 2x Intel Xeon X5675 Westmere-EP 3.06GHz 256KB L2CH 12MB L3CH LGA 1366 95W 6-Core
RAM: 6 x Kingston 8GB 240-Pin DDR3 SDRAM ECC Registered DDR3 1333 Server Memory
MB: ASUS Z8NA-D6C Dual LGA 1366 Intel 5500 ATX Dual Intel Xeon 5500 and 5600 Series

Test 1 – Sustained heavy load of new objects at 25,000/second

Single simulator creating 25,000 objects per second for 30 minutes sustained. This totals 45,000,000 objects being monitored.

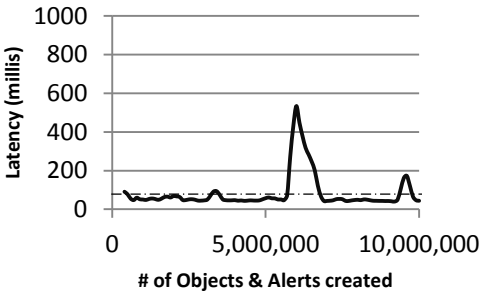


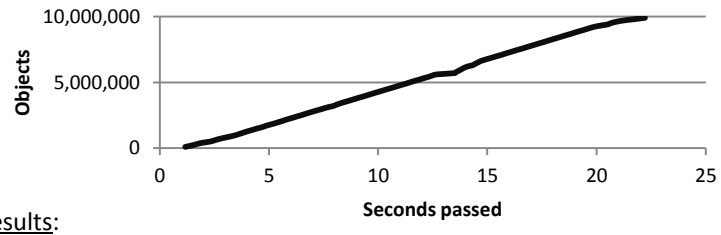
Results:

Avg. Latency from object creation to display: **19.49 millis**
Total objects in display: **45,000,000**
Total memory used in Central Server**: 7.2gb**

Test 2 – Massive burst of new objects at 500,000/second

Five simulators each bursting 100,000 objects per second for 20 seconds. This totals 10,000,000 objects in just 20 seconds





Results:

Avg. Latency from creation to display: **84.17 millis**
Total objects in display: **10,000,000**

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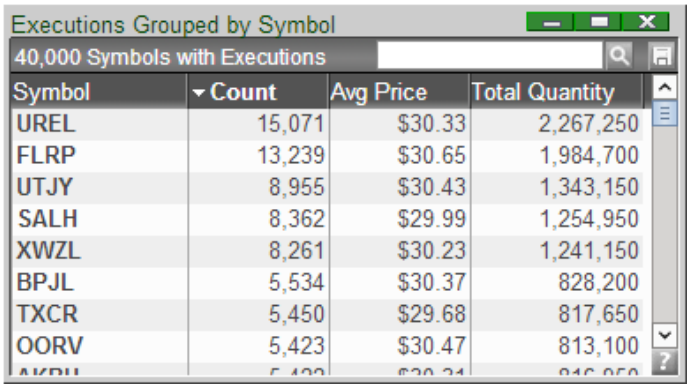
Test 3 – Massive real-time aggregation

- Real-time sorting on aggregate column
- Derived calculation for volume weighted Avg Px
- No visible lag when searching, sorting, filtering



Symbol	Count	Avg Price	Total Quantity
UREL	15,071	$30.33	2,267,250
FLRP	13,239	$30.65	1,984,700
UTJY	8,955	$30.43	1,343,150
SALH	8,362	$29.99	1,254,950
XWZL	8,261	$30.23	1,241,150
BPJL	5,534	$30.37	828,200
TXCR	5,450	$29.68	817,650
OORV	5,423	$30.47	813,100

Results

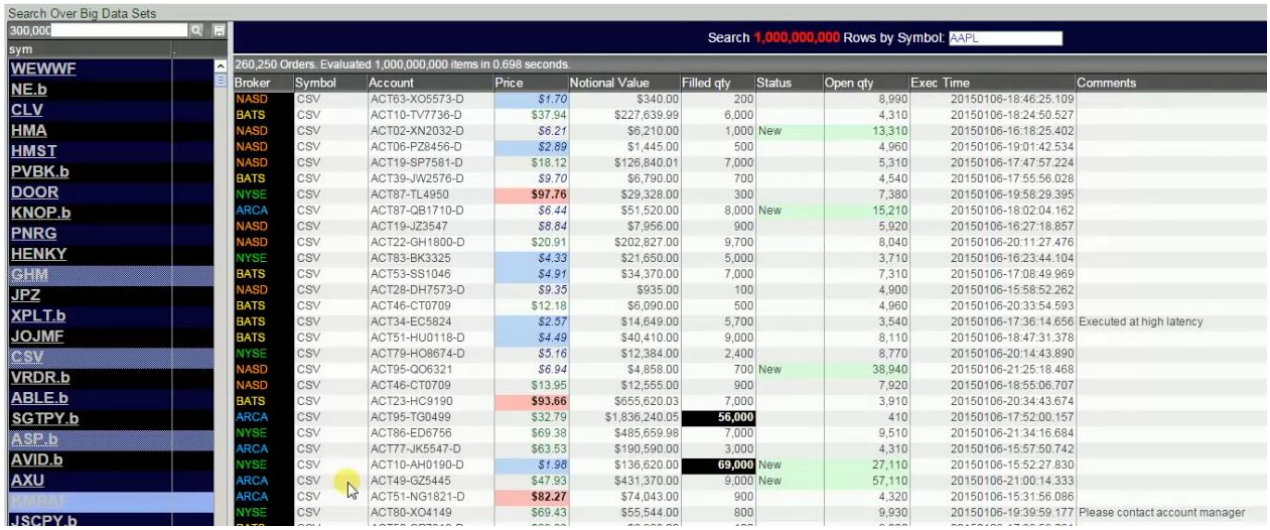
Underlying rows:
10,000,000 executions

Grouping categories:
40,000 symbols

Max underlying data in one group:
15,071 Executions for top Symbol

Test 4 – Real-time search over massive data set

- Results auto-sorted by price
- Query time includes request, index lookup, data retrieval ,sorting and display to front-end
- No visible lag when searching, sorting, filtering



Broker	Symbol	Account	Price	Notional Value	Filled qty	Status	Open qty	Exec Time	Comments
NASD	CSV	ACT63-XO5573-D	$1.70	$340.00	200		8,990	20150106-18:46:25.109	
BATS	CSV	ACT10-TV7736-D	$37.94	$227,639.99	6,000		4,310	20150106-18:24:50.527	
NASD	CSV	ACT02-XN2032-D	$6.21	$6,210.00	1,000	New	13,310	20150106-16:18:25.402	
NASD	CSV	ACT06-PZ8456-D	$2.89	$1,445.00	500		4,960	20150106-19:01:42.534	
NASD	CSV	ACT19-SP7581-D	$18.12	$126,840.01	7,000		5,310	20150106-17:47:57.224	
BATS	CSV	ACT39-JW2576-D	$9.70	$6,790.00	700		4,540	20150106-17:55:56.028	
NYSE	CSV	ACT87-TL4950	$97.76	$29,328.00	300		7,380	20150106-19:58:29.395	
ARCA	CSV	ACT87-QB1710-D	$6.44	$51,520.00	8,000	New	15,210	20150106-18:02:04.162	
NASD	CSV	ACT19-JZ3547	$8.84	$7,956.00	900		5,920	20150106-16:27:18.857	
NASD	CSV	ACT22-GH1800-D	$20.91	$202,827.00	9,700		8,040	20150106-20:11:27.476	
NYSE	CSV	ACT83-BK3325	$4.33	$21,650.00	5,000		3,710	20150106-16:23:44.104	
BATS	CSV	ACT53-SS1046	$4.91	$34,370.00	7,000		7,310	20150106-17:08:49.969	
NASD	CSV	ACT28-DH7573-D	$9.35	$935.00	100		4,900	20150106-15:58:52.262	
BATS	CSV	ACT46-CT0709	$12.18	$6,090.00	500		4,960	20150106-20:33:54.593	
BATS	CSV	ACT34-EC5824	$2.57	$14,649.00	5,700		3,540	20150106-17:36:14.656	Executed at high latency
BATS	CSV	ACT51-HU0118-D	$4.49	$40,410.00	9,000		8,110	20150106-18:47:31.378	
NYSE	CSV	ACT79-HO8674-D	$5.16	$12,384.00	2,400		8,770	20150106-20:14:43.890	
NASD	CSV	ACT95-QO6321	$6.94	$4,858.00	700	New	38,940	20150106-21:25:18.468	
NASD	CSV	ACT46-CT0709	$13.95	$12,555.00	900		7,920	20150106-18:55:06.707	
BATS	CSV	ACT23-HC9190	$93.66	$655,620.03	7,000		3,910	20150106-20:34:43.674	
ARCA	CSV	ACT95-TG0499	$32.79	$1,836,240.05	56,000		410	20150106-17:52:00.157	
NYSE	CSV	ACT86-ED6756	$69.38	$485,659.98	7,000		9,510	20150106-21:34:16.684	
ARCA	CSV	ACT77-JK5547-D	$63.53	$190,590.00	3,000		4,310	20150106-15:57:50.742	
NYSE	CSV	ACT10-AH0190-D	$1.98	$136,620.00	69,000	New	27,110	20150106-15:52:27.830	
ARCA	CSV	ACT49-GZ5445	$47.93	$431,370.00	9,000	New	57,110	20150106-21:00:14.333	
ARCA	CSV	ACT51-NG1821-D	$82.27	$74,043.00	900		4,320	20150106-15:31:56.086	
NYSE	CSV	ACT80-XO4149	$69.43	$55,544.00	800		9,930	20150106-19:39:59.177	Please contact account manager

Results

Size of Dataset at time of query:
1,000,000,000 market data events

Query includes:
4 symbols at once (selected in left panel)

Result set:
260,250 orders

Time to execute query:
0.698 seconds

Simulated Market data events inserted while query was running:
~50,000 per second.

Central Server Memory usage:
~200 GB used / 215.0 GB available

Server Location
Amazon Cloud (Virginia)

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