Documentation

Client

- Connects to the Load Balancer via TCP on port 5059
- Sends and retrieves data to the Load Balancer via the Sender Thread
- Waits for responses via the Receiver Thread

Threads:

- Main thread
- Data receiver thread
- Data sender thread
- Input thread

Load Balancer

- Listens for client connections via the Client Listener Thread
- When a new client has connected borrows a Client Data Receiver Thread from the Client Thread Pool
- Publishes the clients request to a blocking Request Queue
- Worker-Client Request Dispatcher Thread subscribes to the Request Queue and when a new request appears it gets the next Worker (Round Robin algorithm) from the Worker List and sends the data to the Worker
- When a new Worker connects the Worker Listener thread registers it by adding it to the Worker List and borrows a Worker Listener Thread from the Worker Thread Pool
- When a new Worker is registered all other Workers are notified so they can open a TCP connection to the newly connected Worker, one of the notified workers also receives a request for full data export to the newly connected Worker
- When a Worker disconnects the Worker Manager thread unregisters it by removing it from the Worker List
- The Worker Data Receiver thread waits for Worker notifications and when it receives a notification from a Worker it puts it to a blocking Response Queue where the Client-Worker Response Dispatcher Thread delivers the response to the Client

Threads:

- Main thread
- Client listener thread
- N * Client data receiver thread
- Worker-client request dispatcher thread

- Worker listener thread
- N * Worker data receiver thread
- Client-worker response dispatcher thread
- Input thread

Data structures:

- Blocking queue for Client requests and responses (like a circular buffer but instead of overwriting data when it overflows, it blocks)
- Circular doubly linked list for Workers with a Round Robin pointer (so we can easily add/remove Workers)
- Thread pools for Client and Worker data receiver threads

Worker

- Connects to the Load Balancer and listens for data storage requests via the Receiver Thread
- When data is received on the Receiver Thread it inserts the data into a HashMap
- The Receiver Thread sends a notification to the Load Balancer when the data is stored and also broadcasts the data to its peers via the Peer Manager
- The Receiver Thread also gets notified about new peers by the Load Balancer and optionally the message may contain a flag that requests that the worker sends all of its data to the new peer
- A Peer Listener Thread listens for messages from its peers they can be full data exports when the worker is fresh or data sync while the worker is ready and running

Threads:

- Main thread
- Receiver thread
- Export thread
- Peer Listener thread
- Input thread

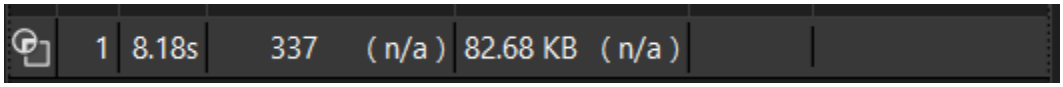
Data structures:

- A HashMap to store client data (simple key-value store)
- A static array to store data about peers
- A simple queue for storing export data requests

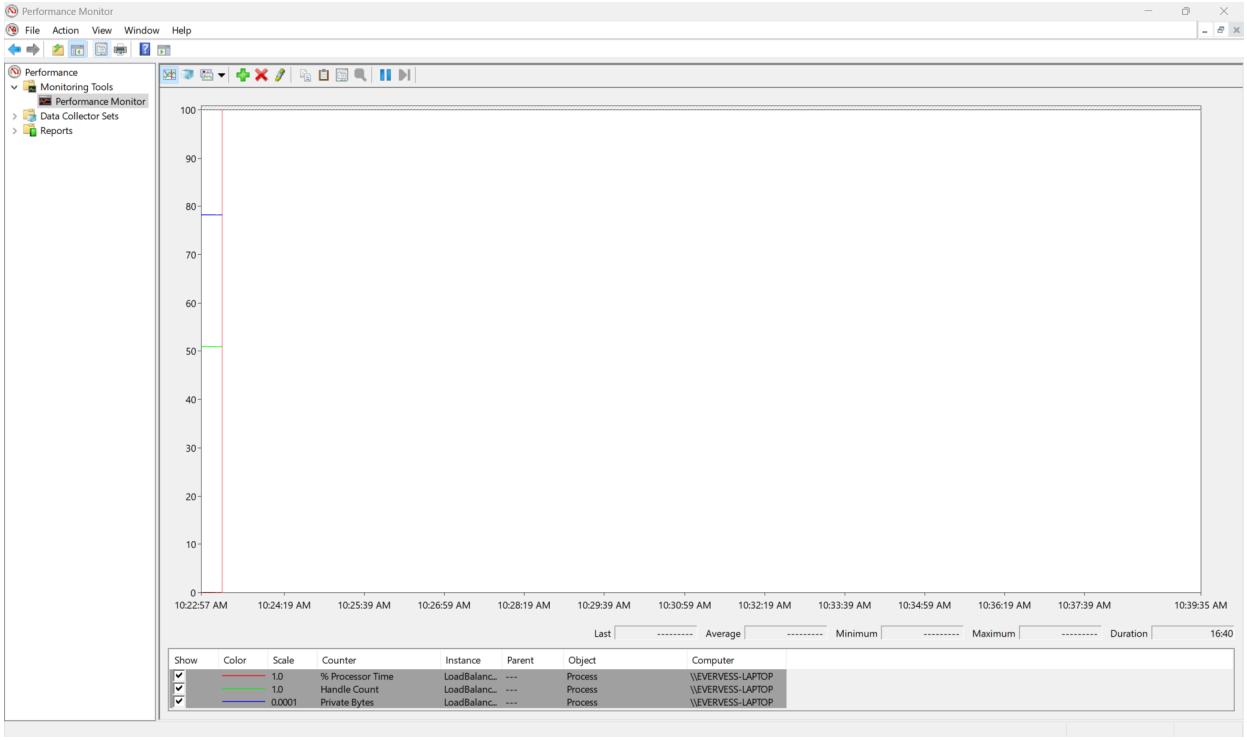
Testing

Step 1: Just the Load Balancer is started and waiting for a key press

Heap:



Process Monitor:



Step 2: After the memory allocations are done and threads are started

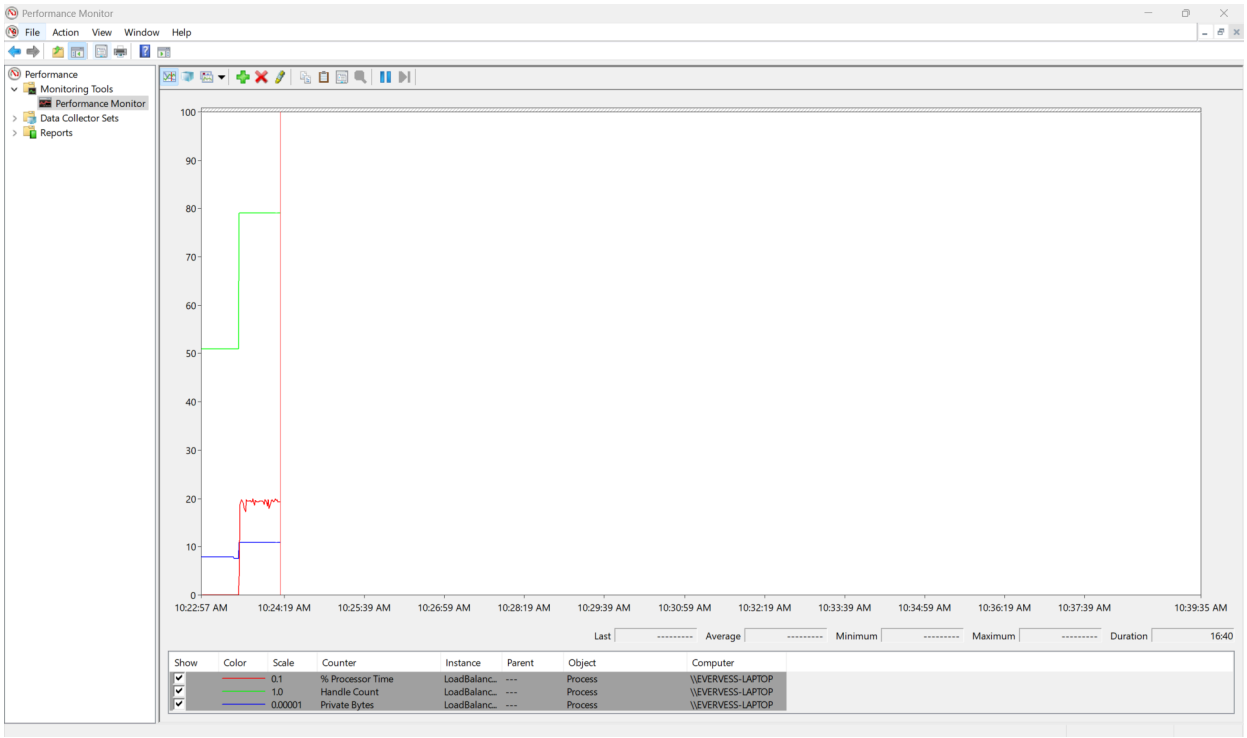
Heap:

1	8.18s	337	(n/a)	82.68 KB	(n/a)	
2	146.31s	423	(+86 ↑)	248.96 KB	(+166.28 KB ↑)	

Allocations:

LoadBalancer.exe!WorkerThreadPool		+1	+216	+1
LoadBalancer.exe!WorkerNode		+1	+304	+1
LoadBalancer.exe!ClientRequestQueue		+1	+67,144	+1
LoadBalancer.exe!WorkerResponseQueue		+1	+67,144	+1
LoadBalancer.exe!ClientThreadPool		+1	+248	+1
LoadBalancer.exe!WorkerResponse		+1	+1,048	+1
LoadBalancer.exe!WorkerList		+1	+80	+1
LoadBalancer.exe!ClientRequest		+1	+1,048	+1

Process Monitor:



Step 3: 2 workers are started and the Load Balancer is waiting for clients

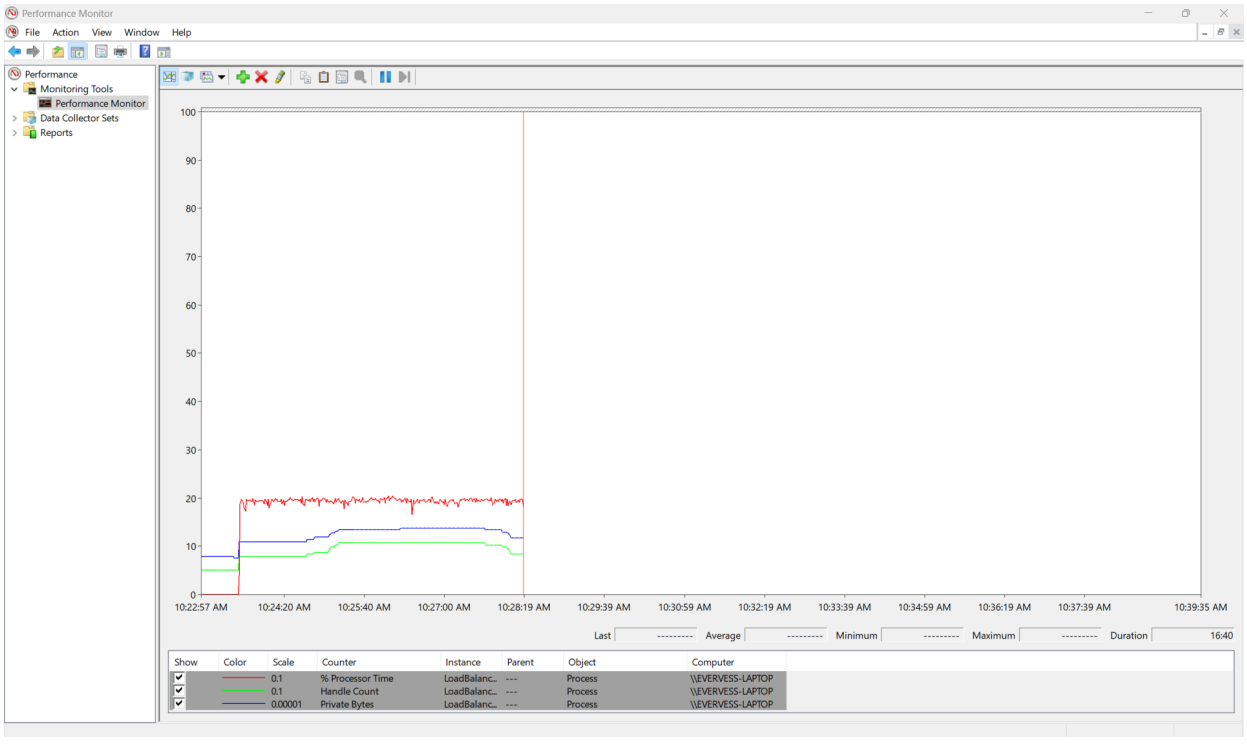
Heap:

1	8.18s	337	(n/a)	82.68 KB	(n/a)
2	146.31s	423	(+86 ↑)	248.96 KB	(+166.28 KB ↑)
3	244.94s	499	(+76 ↑)	269.24 KB	(+20.28 KB ↑)

Allocations:

LoadBalancer.exe!ClientDataReceiverThreadData		0	0	0
LoadBalancer.exe!WorkerThreadPool		0	0	0
LoadBalancer.exe!ClientRequest		0	0	0
LoadBalancer.exe!WorkerResponse		0	0	0
LoadBalancer.exe!WorkerResponseQueue		0	0	0
LoadBalancer.exe!WorkerNode		0	0	0
LoadBalancer.exe!ClientThreadPool		0	0	0
LoadBalancer.exe!WorkerDataReceiverThreadData		0	0	0
LoadBalancer.exe!WorkerList		0	0	0
LoadBalancer.exe!ClientRequestQueue		0	0	0

Process Monitor:



Step 4: 3 clients are connected and the Load Balancer is under stress distributing requests

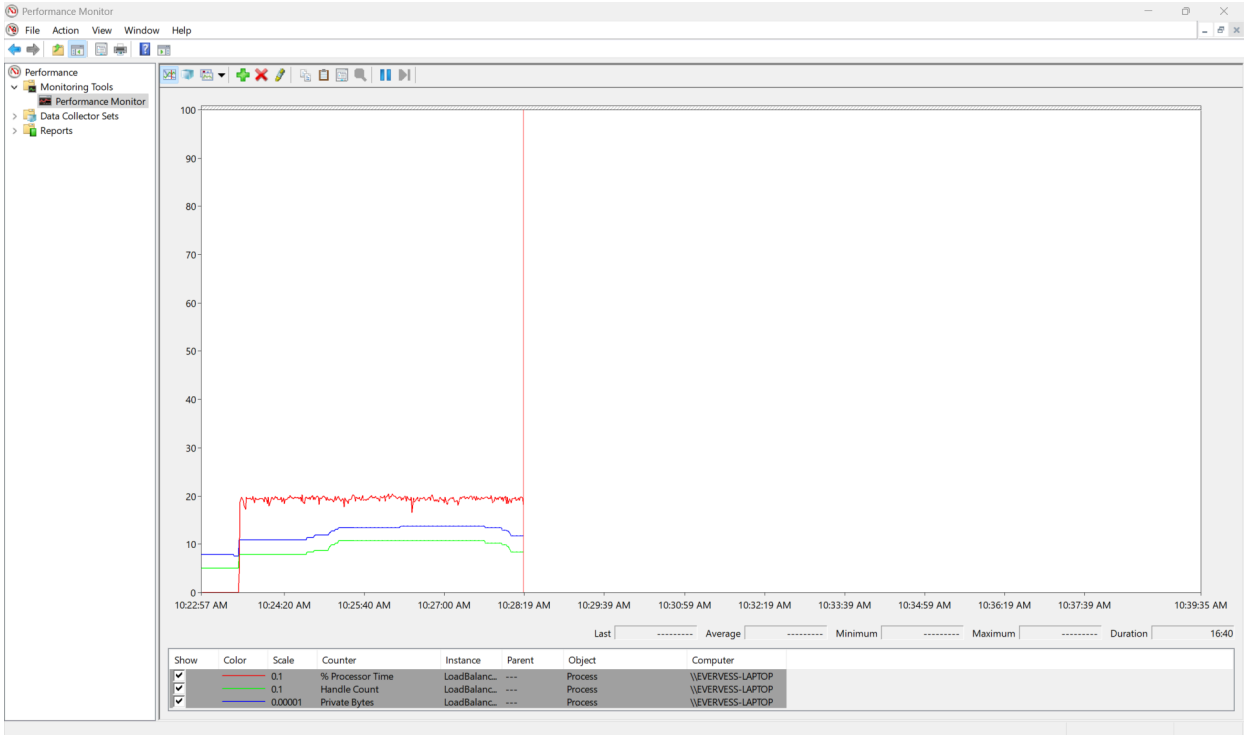
Heap:

1	8.18s	337	(n/a)	82.68 KB (n/a)
2	146.31s	423	(+86 ↑)	248.96 KB (+166.28 KB ↑)
3	244.94s	499	(+76 ↑)	269.24 KB (+20.28 KB ↑)
4	313.18s	507	(+8 ↑)	272.70 KB (+3.46 KB ↑)

Allocations:

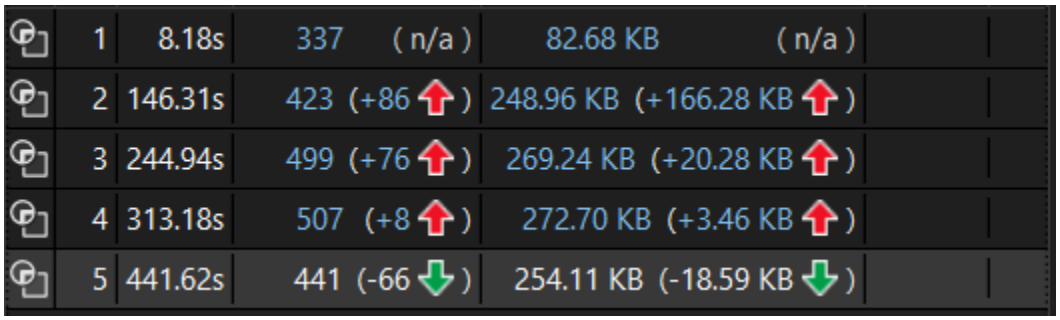
LoadBalancer.exe!ClientDataReceiverThreadData	0	0	0
LoadBalancer.exe!WorkerThreadPool	0	0	0
LoadBalancer.exe!ClientRequest	0	0	0
LoadBalancer.exe!WorkerResponse	0	0	0
LoadBalancer.exe!WorkerResponseQueue	0	0	0
LoadBalancer.exe!WorkerNode	0	0	0
LoadBalancer.exe!ClientThreadPool	0	0	0
LoadBalancer.exe!WorkerDataReceiverThreadData	0	0	0
LoadBalancer.exe!WorkerList	0	0	0
LoadBalancer.exe!ClientRequestQueue	0	0	0

Process Monitor:



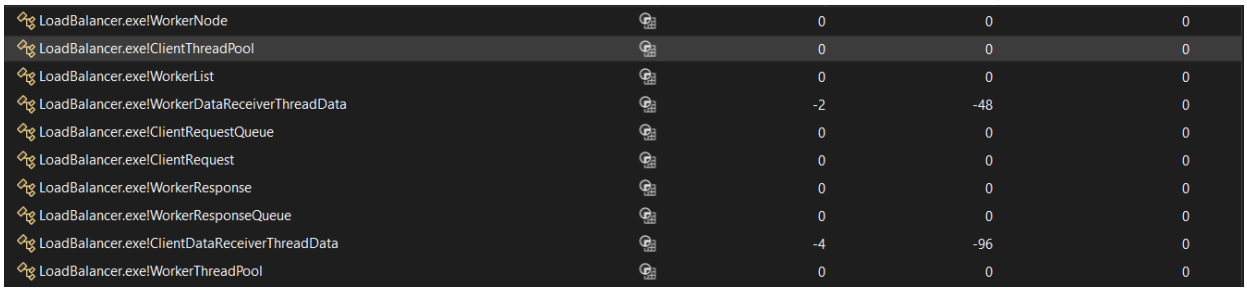
Step 5: The clients are disconnected and the Load Balancer is passive

Heap:



1	8.18s	337	(n/a)	82.68 KB (n/a)
2	146.31s	423	(+86 ↑)	248.96 KB (+166.28 KB ↑)
3	244.94s	499	(+76 ↑)	269.24 KB (+20.28 KB ↑)
4	313.18s	507	(+8 ↑)	272.70 KB (+3.46 KB ↑)
5	441.62s	441	(-66 ↓)	254.11 KB (-18.59 KB ↓)

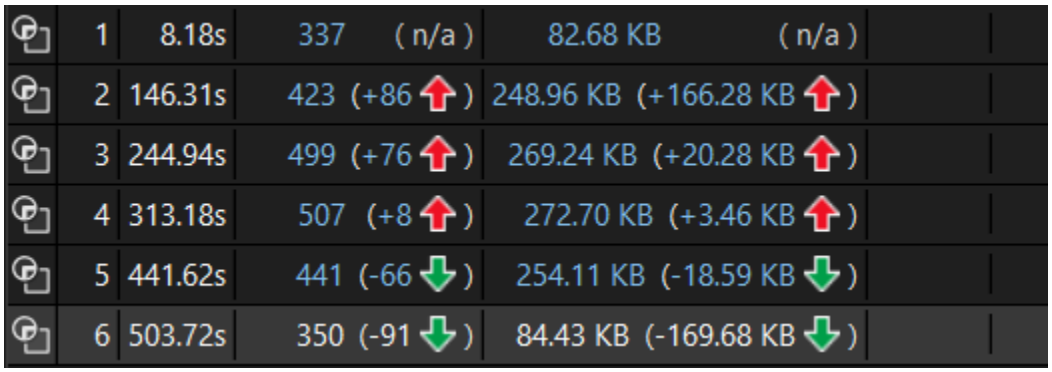
Allocations:



LoadBalancer.exe!WorkerNode	0	0	0
LoadBalancer.exe!ClientThreadPool	0	0	0
LoadBalancer.exe!WorkerList	0	0	0
LoadBalancer.exe!WorkerDataReceiverThreadData	-2	-48	0
LoadBalancer.exe!ClientRequestQueue	0	0	0
LoadBalancer.exe!ClientRequest	0	0	0
LoadBalancer.exe!WorkerResponse	0	0	0
LoadBalancer.exe!WorkerResponseQueue	0	0	0
LoadBalancer.exe!ClientDataReceiverThreadData	-4	-96	0
LoadBalancer.exe!WorkerThreadPool	0	0	0

Step 6: All workers are disconnected and the Load Balancer is stopped, memory deallocated and threads finished, waiting for a key press just before the final exit

Heap:

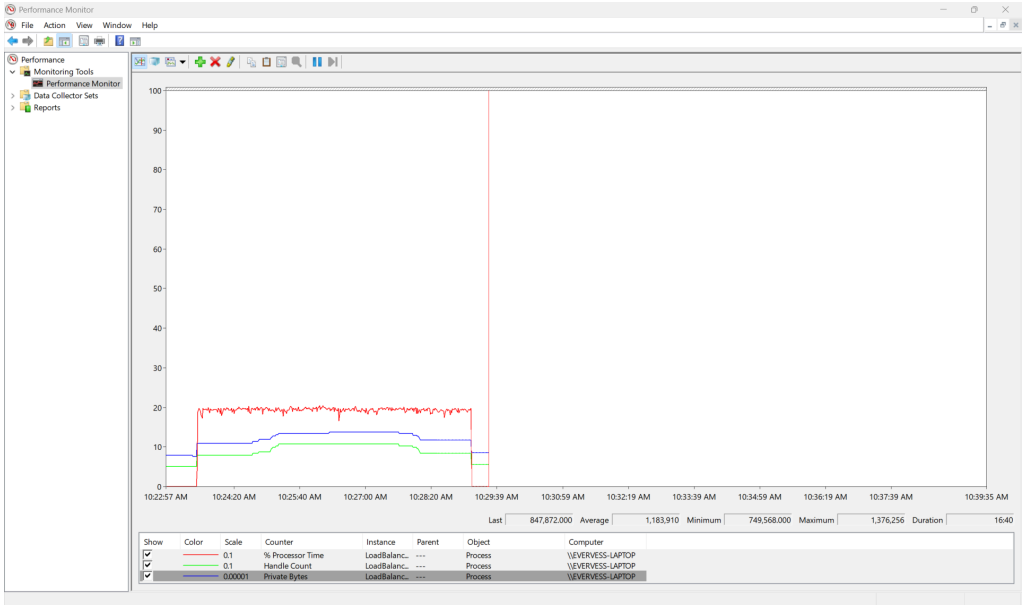


1	8.18s	337	(n/a)	82.68 KB (n/a)
2	146.31s	423	(+86 ↑)	248.96 KB (+166.28 KB ↑)
3	244.94s	499	(+76 ↑)	269.24 KB (+20.28 KB ↑)
4	313.18s	507	(+8 ↑)	272.70 KB (+3.46 KB ↑)
5	441.62s	441	(-66 ↓)	254.11 KB (-18.59 KB ↓)
6	503.72s	350	(-91 ↓)	84.43 KB (-169.68 KB ↓)

Allocations:

LoadBalancer.exe!WorkerResponseQueue		-1	-67,144	0
LoadBalancer.exe!WorkerList		-1	-80	0
LoadBalancer.exe!ClientRequest		-1	-1,048	0
LoadBalancer.exe!ClientThreadPool		-1	-248	0
LoadBalancer.exe!WorkerResponse		-1	-1,048	0
LoadBalancer.exe!ClientRequestQueue		-1	-67,144	0
LoadBalancer.exe!WorkerThreadPool		-1	-216	0
LoadBalancer.exe!WorkerNode		-3	-912	0

Process Monitor:



Protocol

All messages start with a header (packed to 3 bytes):

- type (1 byte, MessageType)
- length (2 bytes, payload size, not including header)

Message Type	Payload Fields
MSG_PUT	`keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen)

MSG_PUT_RESPONSE	`result` (1), `keyLen` (2), `key` (keyLen)
MSG_GET	`keyLen` (2), `key` (keyLen)
MSG_GET_RESPONSE	`result` (1), `keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen, if > 0)
MSG_STORE_REQUEST	`clientId` (4), `keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen)
MSG_STORE_RESPONSE	`result` (1), `clientId` (4), `keyLen` (2), `key` (keyLen)
MSG_RETRIEVE_REQUEST	`clientId` (4), `keyLen` (2), `key` (keyLen)
MSG_RETRIEVE_RESPONSE	`result` (1), `clientId` (4), `keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen, if > 0)
MSG_WORKER_REGISTRY_START	`totalWorkers` (4)
MSG_WORKER_ENTRY	`workerId` (4), `addrLen` (2), `address` (addrLen), `port` (2), `shouldExportData` (1)
MSG_WORKER_REGISTRY_END	(no payload)
MSG_DATA_EXPORT_START	`totalEntries` (4)
MSG_DATA_ENTRY	`keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen)
MSG_DATA_EXPORT_END	(no payload)
MSG_WORKER_READY	`workerId` (4), `peerPort` (2)
MSG_WORKER_NOT_READY	`workerId` (4)

MSG_PEER_NOTIFY	`keyLen` (2), `key` (keyLen), `valueLen` (2), `value` (valueLen)
MSG_SHUTDOWN	(no payload)
MSG_ERROR	`errorCode` (1), `messageLen` (2), `message` (messageLen, if > 0)