Distributed Algorithms

Report

All the tests and examples were run on the following machine:

Architecture: x86\_64

CPU(s): 8

Thread(s) per core: 2

Core(s) per socket: 4

Model name: Intel(R) Core(TM) i7-6700HQ CPU @ 2.60GHz

RAM: 8GB

**System 1 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: All messages are delivered, which is to be expected as the number of messages is low.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

2: [{39151, 30563}, {39151, 11292}, {39151, 14082}, {39151, 14618}, {39151, 23931}]

3: [{32436, 58037}, {32436, 41957}, {32436, 38980}, {32436, 32353}, {32436, 57720}]

1: [{42113, 33197}, {42113, 12928}, {42113, 15399}, {42113, 15478}, {42113, 25086}]

0: [{58037, 55129}, {58037, 38224}, {58037, 36138}, {58037, 30622}, {58037, 54819}]

4: [{57895, 20128}, {57895, 7212}, {57895, 11722}, {57895, 12844}, {57895, 16520}]

Comments: We can notice a discrepancy between the send and received messages. This is mainly due to our implementation: a Peer spawns 2 processes, a Sender and a Receiver; they are not aware of eachother, so a message send by the Sender firsts gets to its parent, namely Peer, which redirects it to Receiver. Because of this extra step the number of received messeges is lower than the number of sent ones, even when a Peer sends a message to itself. Also, sending a messages is less computationally expansive because than receiving one. A process cand send a message without even checking that the receiving process exists or expects a message. On the receiving end, however, the process first saves the message in a mailbox and then takes it out if a pattern match is triggered, which results in a short latency.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

7: [{28493, 13900}, {28493, 7236}, {28493, 10266}, {28493, 5142}, {28493, 12575}, {28493, 3735}, {28493, 6666}, {28493, 28484}, {28493, 4801}, {28493, 7737}]

9: [{7745, 9195}, {7745, 5260}, {7745, 4695}, {7745, 3713}, {7745, 8874}, {7745, 2343}, {7745, 3527}, {7745, 24783}, {7745, 3526}, {7745, 3969}]

8: [{4817, 13644}, {4817, 7081}, {4817, 10130}, {4817, 5099}, {4817, 12421}, {4817, 3547}, {4817, 6410}, {4817, 28330}, {4817, 4666}, {4817, 7509}]

6: [{6681, 8118}, {6681, 5152}, {6681, 3974}, {6681, 3039}, {6681, 8047}, {6681, 2235}, {6681, 3354}, {6681, 23956}, {6681, 3353}, {6681, 3295}]

3: [{5143, 11190}, {5143, 5630}, {5143, 7090}, {5143, 4616}, {5143, 10339}, {5143, 2713}, {5143, 3957}, {5143, 26247}, {5143, 3608}, {5143, 4873}]

1: [{7244, 13914}, {7244, 7244}, {7244, 10281}, {7244, 5143}, {7244, 12584}, {7244, 3735}, {7244, 6680}, {7244, 28492}, {7244, 4816}, {7244, 7745}]

0: [{13914, 12352}, {13914, 6217}, {13914, 9137}, {13914, 4981}, {13914, 11557}, {13914, 3295}, {13914, 5119}, {13914, 27465}, {13914, 3672}, {13914, 6328}]

5: [{3735, 7870}, {3735, 4615}, {3735, 1972}, {3735, 1429}, {3735, 7715}, {3735, 1698}, {3735, 1129}, {3735, 20196}, {3735, 1129}, {3735, 1685}]

4: [{12584, 13906}, {12584, 7240}, {12584, 10272}, {12584, 5142}, {12584, 12580}, {12584, 3735}, {12584, 6673}, {12584, 28488}, {12584, 4808}, {12584, 7740}]

2: [{10281, 13909}, {10281, 7242}, {10281, 10277}, {10281, 5143}, {10281, 12582}, {10281, 3735}, {10281, 6676}, {10281, 28490}, {10281, 4813}, {10281, 7743}]

Comments: Same as for tests2.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Normal result.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000|

| 1: [{35878, 18867}, {35878, 31046}, {35878, 11476}, {35878, 6884}, {35878, 10618}]

| 3: [{28147, 14099}, {28147, 19541}, {28147, 16206}, {28147, 24598}, {28147, 13043}]

| 0: [{23959, 20507}, {23959, 9342}, {23959, 15391}, {23959, 7542}, {23959, 10815}]

| 4: [{32530, 19060}, {32530, 16295}, {32530, 12151}, {32530, 8877}, {32530, 31391}]

| 2: [{34391, 15820}, {34391, 6635}, {34391, 34391}, {34391, 13234}, {34391, 7825}]

Comments: Again we notice the discrepancy between sent and received messages. Another observation would be that the total number of messages is lower compared to when we ran it locally. This is due to the extra cost of sending messages over the docker network.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

|

| 7: [{17659, 11573}, {17659, 9309}, {17659, 11769}, {17659, 8013}, {17659, 6328}, {17659, 5658}, {17659, 4283}, {17659, 6928}, {17659, 3645}, {17659, 5296}]

| 5: [{17553, 8340}, {17553, 15000}, {17553, 7927}, {17553, 11086}, {17553, 8149}, {17553, 10080}, {17553, 3673}, {17553, 2633}, {17553, 6575}, {17553, 1429}]

| 2: [{30627, 7935}, {30627, 4044}, {30627, 20190}, {30627, 5424}, {30627, 1281}, {30627, 8822}, {30627, 1599}, {30627, 4218}, {30627, 5371}, {30627, 5576}]

| 9: [{19586, 9673}, {19586, 6892}, {19586, 12383}, {19586, 8291}, {19586, 6191}, {19586, 4068}, {19586, 3294}, {19586, 3777}, {19586, 2565}, {19586, 4487}]

| 6: [{18612, 9610}, {18612, 11494}, {18612, 7718}, {18612, 8339}, {18612, 6151}, {18612, 5394}, {18612, 3254}, {18612, 5192}, {18612, 3406}, {18612, 4154}]

| 3: [{25354, 11252}, {25354, 5873}, {25354, 14586}, {25354, 15453}, {25354, 7649}, {25354, 6536}, {25354, 5242}, {25354, 6328}, {25354, 2832}, {25354, 3453}]

| 1: [{24170, 11741}, {24170, 13875}, {24170, 5176}, {24170, 9629}, {24170, 5793}, {24170, 7258}, {24170, 4853}, {24170, 5486}, {24170, 2167}, {24170, 4321}]

| 0: [{22905, 9080}, {22905, 6915}, {22905, 5440}, {22905, 4596}, {22905, 5505}, {22905, 3870}, {22905, 1376}, {22905, 3389}, {22905, 1982}, {22905, 1705}]

| 4: [{17516, 7416}, {17516, 6790}, {17516, 5290}, {17516, 5805}, {17516, 5923}, {17516, 4187}, {17516, 2864}, {17516, 3926}, {17516, 2951}, {17516, 1541}]

| 8: [{18132, 9424}, {18132, 10176}, {18132, 14126}, {18132, 12604}, {18132, 7733}, {18132, 3950}, {18132, 5042}, {18132, 2327}, {18132, 10998}, {18132, 746}]

Comments: Here we can observe that some Peers, take 8 for example, have way less messages received than delivered in some cases. This is due to all the factors described in previous sections. In addition to those we have to take into account the “input” of both the process scheduler running on the host OS and the Erlang/Elixir scheduler. Firstly, there are 10 containers running, but only 8 CPUs, so each container will get limited CPU time. Secondly, inside each container we have an Erlang Scheduler which alocates a limited amount of time to the Receive process (remember that in our implementation each Peer spawns a Send and Receive process). The combination of these two extra factors results in Peer 8 having very few received messages in some cases.

**System 2 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Same as System1.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000}]

0: [{133079, 44684}, {133079, 33811}, {133079, 40707}, {133079, 34407}, {133079, 29632}]

2: [{197232, 38540}, {197232, 28074}, {197232, 36248}, {197232, 28956}, {197232, 25732}]

4: [{161770, 25452}, {161770, 19506}, {161770, 20372}, {161770, 17425}, {161770, 17444}]

3: [{154284, 36133}, {154284, 26971}, {154284, 34832}, {154284, 27423}, {154284, 23480}]

1: [{190887, 38540}, {190887, 28040}, {190887, 36064}, {190887, 28957}, {190887, 25412}]

Comments: The discrepancy between sent and receive is even larger, due to the extra steps a message has to take in order reach its destination.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

8: [{24465, 11605}, {24465, 13848}, {24465, 10568}, {24465, 9698}, {24465, 10280}, {24465, 9287}, {24465, 13345}, {24465, 9948}, {24465, 12334}, {24465, 22135}]

9: [{32592, 11236}, {32592, 13438}, {32592, 10049}, {32592, 9698}, {32592, 10178}, {32592, 9242}, {32592, 12953}, {32592, 9724}, {32592, 12226}, {32592, 21634}]

7: [{25103, 7696}, {25103, 9885}, {25103, 7833}, {25103, 7584}, {25103, 6539}, {25103, 6643}, {25103, 8425}, {25103, 7152}, {25103, 7953}, {25103, 15938}]

1: [{30634, 7139}, {30634, 8953}, {30634, 7254}, {30634, 6869}, {30634, 6049}, {30634, 6269}, {30634, 7360}, {30634, 6781}, {30634, 7359}, {30634, 14552}]

5: [{29445, 6175}, {29445, 7762}, {29445, 6077}, {29445, 5681}, {29445, 4934}, {29445, 4920}, {29445, 5178}, {29445, 5619}, {29445, 6493}, {29445, 10200}]

0: [{28659, 7563}, {28659, 9744}, {28659, 7733}, {28659, 7476}, {28659, 6500}, {28659, 6531}, {28659, 8246}, {28659, 7138}, {28659, 7808}, {28659, 15760}]

6: [{34046, 8452}, {34046, 10643}, {34046, 8377}, {34046, 8200}, {34046, 6786}, {34046, 7114}, {34046, 9482}, {34046, 7430}, {34046, 8821}, {34046, 16929}]

4: [{38884, 4820}, {38884, 6083}, {38884, 4202}, {38884, 3911}, {38884, 4037}, {38884, 3778}, {38884, 3633}, {38884, 4378}, {38884, 5012}, {38884, 7108}]

2: [{44018, 3902}, {44018, 4982}, {44018, 3680}, {44018, 3393}, {44018, 3175}, {44018, 2897}, {44018, 2999}, {44018, 3453}, {44018, 4113}, {44018, 5092}]

3: [{45024, 3554}, {45024, 4242}, {45024, 3329}, {45024, 2986}, {45024, 2689}, {45024, 2340}, {45024, 2742}, {45024, 3015}, {45024, 3705}, {45024, 4030}]

Comments: Similar to System1, but lower number of received messages due to the extra steps the a sent message takes.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Normal behaviour.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

|

| 0: [{91770, 37697}, {91770, 31424}, {91770, 28441}, {91770, 28404}, {91770, 33967}]

| 1: [{117549, 25438}, {117549, 30850}, {117549, 20095}, {117549, 22506}, {117549, 27403}]

| 4: [{104738, 28063}, {104738, 28177}, {104738, 21544}, {104738, 22311}, {104738, 32163}]

| 2: [{125187, 17698}, {125187, 19020}, {125187, 19039}, {125187, 15493}, {125187, 23729}]

| 3: [{88776, 25231}, {88776, 27116}, {88776, 20823}, {88776, 20481}, {88776, 27604}]

Comments: Behaves similar to when ran locally, except numbers are a bit lower due to docker network latency.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

|

| 8: [{33843, 3315}, {33843, 3046}, {33843, 1}, {33843, 1}, {33843, 0}, {33843, 0}, {33843, 0}, {33843, 0}, {33843, 0}, {33843, 0}]

| 7: [{41267, 1890}, {41267, 704}, {41267, 0}, {41267, 0}, {41267, 0}, {41267, 0}, {41267, 0}, {41267, 0}, {41267, 0}, {41267, 0}]

| 4: [{34901, 5462}, {34901, 5305}, {34901, 2050}, {34901, 1515}, {34901, 1}, {34901, 896}, {34901, 259}, {34901, 522}, {34901, 1}, {34901, 0}]

| 3: [{26210, 6504}, {26210, 6213}, {26210, 3044}, {26210, 2508}, {26210, 657}, {26210, 1065}, {26210, 1298}, {26210, 1066}, {26210, 705}, {26210, 833}]

| 9: [{27768, 5082}, {27768, 4560}, {27768, 1591}, {27768, 199}, {27768, 0}, {27768, 0}, {27768, 0}, {27768, 0}, {27768, 0}, {27768, 0}]

| 6: [{43723, 1639}, {43723, 703}, {43723, 0}, {43723, 0}, {43723, 0}, {43723, 0}, {43723, 0}, {43723, 0}, {43723, 0}, {43723, 0}]

| 2: [{33918, 5137}, {33918, 5021}, {33918, 1879}, {33918, 605}, {33918, 1}, {33918, 451}, {33918, 1}, {33918, 92}, {33918, 1}, {33918, 1}]

| 1: [{28702, 6082}, {28702, 7691}, {28702, 2992}, {28702, 1987}, {28702, 902}, {28702, 1365}, {28702, 789}, {28702, 1243}, {28702, 916}, {28702, 41}]

| 0: [{28904, 14186}, {28904, 8346}, {28904, 2433}, {28904, 2173}, {28904, 4281}, {28904, 2266}, {28904, 3201}, {28904, 779}, {28904, 1277}, {28904, 1847}]

| 5: [{33793, 4252}, {33793, 3900}, {33793, 407}, {33793, 199}, {33793, 1}, {33793, 1}, {33793, 1}, {33793, 0}, {33793, 0}, {33793, 0}]

Comments: Similar to when ran locally + docker latency.

**System 3 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Normal behaviour.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

4: [{476406, 3351}, {476406, 5413}, {476406, 5101}, {476406, 3713}, {476406, 7939}]

1: [{475810, 2236}, {475810, 3138}, {475810, 4436}, {475810, 2498}, {475810, 6133}]

2: [{408411, 1595}, {408411, 2061}, {408411, 3982}, {408411, 1300}, {408411, 4591}]

0: [{427664, 4921}, {427664, 8207}, {427664, 7189}, {427664, 5511}, {427664, 9849}]

3: [{710972, 2606}, {710972, 3794}, {710972, 4697}, {710972, 2907}, {710972, 6703}]

Comments: The rate between send and received is even lower due to the extra component. Also, number of sent messages is significantly higher because now instead of sending each message to a specific Peer we broadcast every message.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

8: [{214117, 484}, {214117, 332}, {214117, 326}, {214117, 306}, {214117, 315}, {214117, 110}, {214117, 142}, {214117, 364}, {214117, 299}, {214117, 317}]

1: [{188125, 1132}, {188125, 740}, {188125, 699}, {188125, 446}, {188125, 603}, {188125, 451}, {188125, 578}, {188125, 831}, {188125, 651}, {188125, 661}]

2: [{174687, 791}, {174687, 532}, {174687, 567}, {174687, 425}, {174687, 505}, {174687, 256}, {174687, 352}, {174687, 618}, {174687, 491}, {174687, 512}]

4: [{189808, 819}, {189808, 548}, {189808, 575}, {189808, 427}, {189808, 515}, {189808, 263}, {189808, 361}, {189808, 619}, {189808, 502}, {189808, 520}]

5: [{151733, 997}, {151733, 655}, {151733, 662}, {151733, 436}, {151733, 536}, {151733, 364}, {151733, 480}, {151733, 745}, {151733, 579}, {151733, 595}]

9: [{156926, 780}, {156926, 524}, {156926, 561}, {156926, 423}, {156926, 503}, {156926, 251}, {156926, 346}, {156926, 617}, {156926, 485}, {156926, 506}]

7: [{174386, 726}, {174386, 478}, {174386, 484}, {174386, 407}, {174386, 452}, {174386, 208}, {174386, 284}, {174386, 530}, {174386, 417}, {174386, 432}]

3: [{169335, 308}, {169335, 218}, {169335, 214}, {169335, 170}, {169335, 196}, {169335, 67}, {169335, 80}, {169335, 204}, {169335, 195}, {169335, 207}]

6: [{198569, 247}, {198569, 179}, {198569, 174}, {198569, 118}, {198569, 151}, {198569, 51}, {198569, 57}, {198569, 145}, {198569, 151}, {198569, 164}]

0: [{230283, 10}, {230283, 9}, {230283, 9}, {230283, 10}, {230283, 9}, {230283, 9}, {230283, 10}, {230283, 9}, {230283, 8}, {230283, 9}]

Comments: Much lower receive rate due to all factors previously discussed.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Normal behaviour.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

|

| 3: [{200961, 10610}, {200961, 14418}, {200961, 13013}, {200961, 12666}, {200961, 13013}]

| 4: [{282910, 17800}, {282910, 16759}, {282910, 15087}, {282910, 14475}, {282910, 18648}]

| 1: [{227954, 18314}, {227954, 20711}, {227954, 16239}, {227954, 15969}, {227954, 19157}]

| 0: [{233122, 11912}, {233122, 14043}, {233122, 7720}, {233122, 11230}, {233122, 12328}]

| 2: [{204326, 5807}, {204326, 10838}, {204326, 11646}, {204326, 6272}, {204326, 8743}]

Comments: Same as previous System + many more sent messages due to broadcast.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

| 3: [{67119, 1}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}, {67119, 0}]

| 0: [{68962, 1154}, {68962, 5}, {68962, 1}, {68962, 1}, {68962, 1}, {68962, 1}, {68962, 1}, {68962, 1}, {68962, 1}, {68962, 1}]

| 2: [{75469, 1}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}, {75469, 0}]

| 4: [{78427, 1}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}, {78427, 0}]

| 6: [{103948, 1}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}, {103948, 0}]

| 8: [{97025, 1}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}, {97025, 0}]

| 5: [{80061, 1}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}, {80061, 0}]

| 9: [{83039, 1}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}, {83039, 0}]

| 7: [{96110, 1}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}, {96110, 0}]

| 1: [{105524, 0}, {105524, 1}, {105524, 0}, {105524, 0}, {105524, 0}, {105524, 0}, {105524, 0}, {105524, 0}, {105524, 0}, {105524, 0}]

Comments:

**System 4 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 0

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

0: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

4: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

2: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

1: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

3: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

Comments: Normal behaviour.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 0

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 0

1: [{120540, 0}, {120540, 0}, {120540, 0}, {120540, 0}, {120540, 0}]

2: [{140979, 0}, {140979, 0}, {140979, 0}, {140979, 0}, {140979, 0}]

4: [{108885, 0}, {108885, 0}, {108885, 0}, {108885, 0}, {108885, 0}]

3: [{116263, 0}, {116263, 0}, {116263, 0}, {116263, 0}, {116263, 0}]

0: [{119391, 0}, {119391, 0}, {119391, 0}, {119391, 0}, {119391, 0}]

Comments: Normal behaviour.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 0

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 0

0: [{48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}, {48678, 0}]

6: [{21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}, {21381, 0}]

7: [{16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}, {16378, 0}]

5: [{42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}, {42580, 0}]

9: [{14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}, {14905, 0}]

1: [{41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}, {41308, 0}]

8: [{34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}, {34685, 0}]

3: [{40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}, {40790, 0}]

2: [{38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}, {38742, 0}]

4: [{44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}, {44637, 0}]

Comments: Normal behaviour.

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

0: [{1000, 499}, {1000, 489}, {1000, 506}, {1000, 479}, {1000, 525}]

1: [{1000, 521}, {1000, 525}, {1000, 535}, {1000, 508}, {1000, 518}]

2: [{1000, 481}, {1000, 476}, {1000, 492}, {1000, 527}, {1000, 481}]

4: [{1000, 532}, {1000, 516}, {1000, 489}, {1000, 486}, {1000, 500}]

3: [{1000, 489}, {1000, 500}, {1000, 487}, {1000, 497}, {1000, 502}]

Comments: To be expected, the number of received messages is 50% that of the previous system.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

1: [{482323, 4027}, {482323, 4451}, {482323, 5166}, {482323, 3560}, {482323, 4176}]

3: [{437848, 6875}, {437848, 5935}, {437848, 6663}, {437848, 5458}, {437848, 5732}]

0: [{350852, 7263}, {350852, 5889}, {350852, 6826}, {350852, 5600}, {350852, 5974}]

2: [{514788, 4675}, {514788, 4621}, {514788, 5621}, {514788, 3760}, {514788, 4356}]

4: [{556451, 2796}, {556451, 3775}, {556451, 3981}, {556451, 2737}, {556451, 3587}]

Comments: If we compare this result with the previous system we can see that only about 50% of the messages have been received.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

8: [{141249, 1000}, {141249, 439}, {141249, 518}, {141249, 987}, {141249, 1060}, {141249, 688}, {141249, 534}, {141249, 88}, {141249, 425}, {141249, 1059}]

6: [{158627, 1801}, {158627, 888}, {158627, 863}, {158627, 1833}, {158627, 1426}, {158627, 1455}, {158627, 965}, {158627, 705}, {158627, 749}, {158627, 1455}]

2: [{174209, 558}, {174209, 252}, {174209, 364}, {174209, 454}, {174209, 562}, {174209, 412}, {174209, 266}, {174209, 64}, {174209, 269}, {174209, 633}]

4: [{167391, 1000}, {167391, 418}, {167391, 535}, {167391, 998}, {167391, 1051}, {167391, 646}, {167391, 523}, {167391, 87}, {167391, 418}, {167391, 1031}]

1: [{157954, 2441}, {157954, 1003}, {157954, 1026}, {157954, 2099}, {157954, 1569}, {157954, 1847}, {157954, 1279}, {157954, 1273}, {157954, 832}, {157954, 1555}]

3: [{146328, 1043}, {146328, 478}, {146328, 558}, {146328, 1023}, {146328, 1046}, {146328, 762}, {146328, 536}, {146328, 105}, {146328, 422}, {146328, 1119}]

0: [{173182, 2382}, {173182, 1017}, {173182, 1026}, {173182, 2050}, {173182, 1529}, {173182, 1921}, {173182, 1276}, {173182, 1236}, {173182, 827}, {173182, 1567}]

5: [{146428, 1121}, {146428, 516}, {146428, 605}, {146428, 1300}, {146428, 1178}, {146428, 882}, {146428, 600}, {146428, 183}, {146428, 466}, {146428, 1173}]

7: [{145441, 1027}, {145441, 455}, {145441, 508}, {145441, 1054}, {145441, 1040}, {145441, 697}, {145441, 543}, {145441, 101}, {145441, 433}, {145441, 1050}]

9: [{229741, 1047}, {229741, 461}, {229741, 539}, {229741, 1126}, {229741, 1147}, {229741, 825}, {229741, 580}, {229741, 140}, {229741, 435}, {229741, 1102}]

Comments: Same as for previous System, but we notice that only 50% of messages are received.

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 100

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: The results are identical to the previous system.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 100

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

4: [{191605, 1613}, {191605, 2437}, {191605, 2467}, {191605, 2876}, {191605, 2466}]

2: [{188441, 1977}, {188441, 2898}, {188441, 2962}, {188441, 3302}, {188441, 2914}]

3: [{158487, 1670}, {158487, 2484}, {158487, 2526}, {158487, 2915}, {158487, 2511}]

1: [{208811, 1120}, {208811, 1777}, {208811, 1873}, {208811, 2198}, {208811, 1876}]

0: [{175643, 103}, {175643, 90}, {175643, 90}, {175643, 302}, {175643, 102}]

Comments: The received messages seem to be lower than those of the previous System with the same parameters. The only difference is the random function written. The function might be a bit too computationally expensive as we have used Enum.random(0..10000) which generates a list and then chooses a random index every time we try to send a message.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 100

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

9: [{59273, 63}, {59273, 63}, {59273, 1247}, {59273, 62}, {59273, 51}, {59273, 67}, {59273, 56}, {59273, 61}, {59273, 62}, {59273, 52}]

8: [{62434, 99}, {62434, 99}, {62434, 1486}, {62434, 84}, {62434, 64}, {62434, 228}, {62434, 85}, {62434, 97}, {62434, 98}, {62434, 65}]

6: [{62476, 98}, {62476, 98}, {62476, 1485}, {62476, 83}, {62476, 64}, {62476, 226}, {62476, 84}, {62476, 96}, {62476, 97}, {62476, 65}]

0: [{53015, 144}, {53015, 143}, {53015, 1547}, {53015, 118}, {53015, 74}, {53015, 298}, {53015, 121}, {53015, 142}, {53015, 143}, {53015, 75}]

7: [{60344, 90}, {60344, 90}, {60344, 1448}, {60344, 78}, {60344, 62}, {60344, 195}, {60344, 77}, {60344, 87}, {60344, 89}, {60344, 63}]

3: [{64629, 99}, {64629, 99}, {64629, 1486}, {64629, 84}, {64629, 65}, {64629, 228}, {64629, 85}, {64629, 97}, {64629, 98}, {64629, 65}]

4: [{74077, 119}, {74077, 119}, {74077, 1518}, {74077, 99}, {74077, 68}, {74077, 263}, {74077, 98}, {74077, 116}, {74077, 119}, {74077, 69}]

2: [{79495, 141}, {79495, 141}, {79495, 1546}, {79495, 116}, {79495, 73}, {79495, 295}, {79495, 119}, {79495, 139}, {79495, 140}, {79495, 74}]

1: [{76740, 89}, {76740, 89}, {76740, 1443}, {76740, 78}, {76740, 63}, {76740, 193}, {76740, 77}, {76740, 86}, {76740, 88}, {76740, 63}]p

5: [{78448, 12}, {78448, 12}, {78448, 12}, {78448, 12}, {78448, 12}, {78448, 11}, {78448, 11}, {78448, 11}, {78448, 11}, {78448, 12}]

Comments: Same as previous System + latency due to our function.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 0

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000, send\_percentage: 0

|

| 0: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 1: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 2: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 3: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 4: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

Comments: Normal behaviour.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 0

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 0

|

| 0: [{415615, 0}, {415615, 0}, {415615, 0}, {415615, 0}, {415615, 0}]

| 2: [{355529, 0}, {355529, 0}, {355529, 0}, {355529, 0}, {355529, 0}]

| 4: [{404413, 0}, {404413, 0}, {404413, 0}, {404413, 0}, {404413, 0}]

| 1: [{381507, 0}, {381507, 0}, {381507, 0}, {381507, 0}, {381507, 0}]

| 3: [{399625, 0}, {399625, 0}, {399625, 0}, {399625, 0}, {399625, 0}]

Comments: Normal behaviour.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 0

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 0

|

| 2: [{99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}, {99963, 0}]

| 6: [{104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}, {104209, 0}]

| 9: [{88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}, {88139, 0}]

| 1: [{134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}, {134481, 0}]

| 3: [{91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}, {91642, 0}]

| 0: [{111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}, {111327, 0}]

| 4: [{94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}, {94190, 0}]

| 7: [{100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}, {100130, 0}]

| 5: [{99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}, {99652, 0}]

| 8: [{122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}, {122740, 0}]

Comments: Normal behaviour.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

| 4: [{1000, 492}, {1000, 487}, {1000, 506}, {1000, 511}, {1000, 510}]

| 1: [{1000, 500}, {1000, 485}, {1000, 500}, {1000, 498}, {1000, 530}]

| 3: [{1000, 486}, {1000, 510}, {1000, 501}, {1000, 483}, {1000, 512}]

| 0: [{1000, 516}, {1000, 493}, {1000, 519}, {1000, 485}, {1000, 496}]

| 2: [{1000, 495}, {1000, 492}, {1000, 522}, {1000, 504}, {1000, 510}]

Comments: Normal behaviour

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

|

| 3: [{297183, 3482}, {297183, 1212}, {297183, 2201}, {297183, 1145}, {297183, 1552}]

| 0: [{304959, 5675}, {304959, 5660}, {304959, 5591}, {304959, 3356}, {304959, 6335}]

| 4: [{294064, 4541}, {294064, 3896}, {294064, 1819}, {294064, 2503}, {294064, 5397}]

| 2: [{351152, 5538}, {351152, 6052}, {351152, 6326}, {351152, 3421}, {351152, 5278}]

| 1: [{270853, 4376}, {270853, 3946}, {270853, 4314}, {270853, 2498}, {270853, 5147}]

Comments: Normal behaviour considering all factors previously discussed.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

|

| 8: [{139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}, {139534, 0}]

| 9: [{86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}, {86586, 0}]

| 0: [{92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}, {92650, 0}]

| 2: [{101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}, {101962, 0}]

| 7: [{103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}, {103950, 0}]

| 6: [{78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}, {78299, 0}]

| 3: [{121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}, {121419, 0}]

| 5: [{104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}, {104595, 0}]

| 4: [{84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}, {84661, 0}]

| 1: [{97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}, {97339, 0}]

Comments: There seems to be an issue with message passing when increasing the number of containers from 5 to 10.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 100

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

3: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

1: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

0: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

4: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

2: [{1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}, {1000, 1000}]

Comments: Normal behaviour.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 100

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 100

|

| 2: [{301890, 6632}, {301890, 4664}, {301890, 5997}, {301890, 4688}, {301890, 1142}]

| 3: [{277818, 6241}, {277818, 3927}, {277818, 2731}, {277818, 4688}, {277818, 1575}]

| 1: [{283105, 3907}, {283105, 3028}, {283105, 41}, {283105, 821}, {283105, 372}]

| 0: [{284312, 5082}, {284312, 2139}, {284312, 1900}, {284312, 3205}, {284312, 396}]

| 4: [{305775, 4580}, {305775, 1634}, {305775, 1223}, {305775, 1066}, {305775, 371}]

Comments: Normal behaviouor considering all factors.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 100

Output:

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 100

|

| 0: [{110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}, {110625, 0}]

| 6: [{114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}, {114465, 0}]

| 7: [{123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}, {123790, 0}]

| 3: [{119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}, {119877, 0}]

| 1: [{104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}, {104932, 0}]

| 8: [{112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}, {112170, 0}]

| 5: [{89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}, {89850, 0}]

| 2: [{106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}, {106202, 0}]

| 4: [{107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}, {107961, 0}]

| 9: [{130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}, {130484, 0}]

Comments: There seems to be an issue with message passing when increasing the number of containers from 5 to 10.

**System 5 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

1: [{1000, 519}, {1000, 524}, {1000, 469}, {1000, 0}, {1000, 482}]

2: [{1000, 525}, {1000, 510}, {1000, 524}, {1000, 0}, {1000, 501}]

0: [{1000, 490}, {1000, 478}, {1000, 500}, {1000, 0}, {1000, 533}]

4: [{1000, 512}, {1000, 506}, {1000, 510}, {1000, 0}, {1000, 479}]

Comments: We can see that everything is similar to the previous System except for the fact that Peer3 crashed and didn’t get to receive any messages. He might still have sent some messages in the time it was active, but his input is not noticeble sincer with or without him there are many more sent messages compared to received messages.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

1: [{161506, 3945}, {161506, 4202}, {161506, 3265}, {161506, 0}, {161506, 6976}]

4: [{166389, 7331}, {166389, 6101}, {166389, 5339}, {166389, 0}, {166389, 9560}]

2: [{249511, 5280}, {249511, 5179}, {249511, 4345}, {249511, 0}, {249511, 8403}]

0: [{170958, 3605}, {170958, 4093}, {170958, 3163}, {170958, 0}, {170958, 6785}]

Comments: Normal behaviour.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

7: [{141404, 661}, {141404, 964}, {141404, 903}, {141404, 53}, {141404, 312}, {141404, 541}, {141404, 723}, {141404, 885}, {141404, 313}, {141404, 846}]

5: [{231044, 638}, {231044, 776}, {231044, 584}, {231044, 58}, {231044, 257}, {231044, 480}, {231044, 594}, {231044, 559}, {231044, 240}, {231044, 540}]

1: [{235446, 445}, {235446, 288}, {235446, 210}, {235446, 59}, {235446, 115}, {235446, 270}, {235446, 361}, {235446, 213}, {235446, 146}, {235446, 251}]

4: [{133157, 615}, {133157, 770}, {133157, 583}, {133157, 58}, {133157, 272}, {133157, 492}, {133157, 586}, {133157, 574}, {133157, 251}, {133157, 569}]

8: [{201557, 723}, {201557, 1089}, {201557, 1039}, {201557, 51}, {201557, 375}, {201557, 605}, {201557, 777}, {201557, 965}, {201557, 349}, {201557, 1162}]

0: [{290268, 544}, {290268, 610}, {290268, 362}, {290268, 61}, {290268, 199}, {290268, 370}, {290268, 487}, {290268, 386}, {290268, 196}, {290268, 366}]

9: [{194973, 701}, {194973, 967}, {194973, 848}, {194973, 52}, {194973, 336}, {194973, 575}, {194973, 745}, {194973, 889}, {194973, 295}, {194973, 847}]

2: [{187178, 532}, {187178, 569}, {187178, 415}, {187178, 52}, {187178, 179}, {187178, 355}, {187178, 507}, {187178, 383}, {187178, 223}, {187178, 370}]

6: [{226488, 574}, {226488, 719}, {226488, 425}, {226488, 67}, {226488, 227}, {226488, 398}, {226488, 505}, {226488, 431}, {226488, 234}, {226488, 433}]

Comments: Normal behaviour considering the previously discussed factors.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000, send\_percentage: 50

| 0: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 1: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 2: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

| 4: [{1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}, {1000, 0}]

Comments: -

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

|

| 2: [{495741, 0}, {495741, 0}, {495741, 0}, {495741, 0}, {495741, 0}]

| 0: [{469569, 0}, {469569, 0}, {469569, 0}, {469569, 0}, {469569, 0}]

| 1: [{500539, 0}, {500539, 0}, {500539, 0}, {500539, 0}, {500539, 0}]

| 4: [{511090, 0}, {511090, 0}, {511090, 0}, {511090, 0}, {511090, 0}]

Comments: -

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

| 2: [{107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}]

| 0: [{116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}]

| 4: [{90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}]

| 6: [{120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}]

| 5: [{142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}]

| 8: [{105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}]

| 9: [{104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}]

| 7: [{109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}]

| 1: [{97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}]

Comments: -

**System 6 Tests**

Test 1 Local - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000

0: [{1000, 860}, {1000, 848}, {1000, 856}, {1000, 0}, {1000, 851}]

2: [{1000, 868}, {1000, 854}, {1000, 841}, {1000, 0}, {1000, 869}]

1: [{1000, 868}, {1000, 850}, {1000, 851}, {1000, 0}, {1000, 865}]

4: [{1000, 868}, {1000, 865}, {1000, 839}, {1000, 0}, {1000, 864}]

Comments: We can observe that the ERB component improved our send rate from 50% to 85%.

Test 2 Local - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

4: [{140402, 3837}, {140402, 4323}, {140402, 4413}, {140402, 0}, {140402, 6628}]

1: [{174690, 1751}, {174690, 901}, {174690, 2526}, {174690, 0}, {174690, 2498}]

0: [{148727, 1962}, {148727, 1008}, {148727, 2829}, {148727, 0}, {148727, 2919}]

2: [{184709, 1902}, {184709, 990}, {184709, 2808}, {184709, 0}, {184709, 2880}]

Comments: Similar result.

Test 3 Local - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000

1: [{68215, 233}, {68215, 553}, {68215, 550}, {68215, 9}, {68215, 563}, {68215, 263}, {68215, 268}, {68215, 395}, {68215, 520}, {68215, 666}]

7: [{64553, 182}, {64553, 485}, {64553, 477}, {64553, 10}, {64553, 477}, {64553, 240}, {64553, 212}, {64553, 289}, {64553, 465}, {64553, 620}]

8: [{66232, 88}, {66232, 298}, {66232, 311}, {66232, 7}, {66232, 290}, {66232, 83}, {66232, 102}, {66232, 147}, {66232, 325}, {66232, 323}]

4: [{72869, 204}, {72869, 484}, {72869, 511}, {72869, 11}, {72869, 460}, {72869, 256}, {72869, 238}, {72869, 311}, {72869, 480}, {72869, 619}]

6: [{65513, 129}, {65513, 425}, {65513, 447}, {65513, 10}, {65513, 396}, {65513, 201}, {65513, 197}, {65513, 235}, {65513, 410}, {65513, 533}]

2: [{68243, 107}, {68243, 351}, {68243, 348}, {68243, 9}, {68243, 351}, {68243, 142}, {68243, 141}, {68243, 183}, {68243, 402}, {68243, 441}]

0: [{64860, 117}, {64860, 350}, {64860, 365}, {64860, 7}, {64860, 363}, {64860, 136}, {64860, 144}, {64860, 155}, {64860, 393}, {64860, 431}]

9: [{68102, 19}, {68102, 25}, {68102, 19}, {68102, 5}, {68102, 20}, {68102, 20}, {68102, 21}, {68102, 20}, {68102, 228}, {68102, 39}]

5: [{82767, 62}, {82767, 162}, {82767, 141}, {82767, 9}, {82767, 140}, {82767, 64}, {82767, 65}, {82767, 68}, {82767, 310}, {82767, 164}]

Comments: Similar result.

Test 1 Docker - nr\_of\_peers = 5, max\_broadcasts = 1000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 1000, timeout: 3000, send\_percentage: 50

| 0: [{1000, 855}, {1000, 864}, {1000, 860}, {1000, 0}, {1000, 862}]

| 1: [{1000, 842}, {1000, 870}, {1000, 868}, {1000, 0}, {1000, 835}]

| 2: [{1000, 863}, {1000, 864}, {1000, 849}, {1000, 0}, {1000, 857}]

| 4: [{1000, 873}, {1000, 869}, {1000, 859}, {1000, 0}, {1000, 845}]

Comments: We can observe that the ERB component improved our send rate from 50% to 85%.

Test 2 Docker - nr\_of\_peers = 5, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

| Starting on docker with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50|

| 2: [{360683, 1}, {360683, 2}, {360683, 2}, {360683, 0}, {360683, 88}]

| 0: [{334387, 1984}, {334387, 2568}, {334387, 1281}, {334387, 0}, {334387, 1403}]

| 1: [{364392, 2949}, {364392, 3693}, {364392, 2594}, {364392, 0}, {364392, 3055}]

| 4: [{351717, 2320}, {351717, 3647}, {351717, 1865}, {351717, 0}, {351717, 2778}]

Comments: Similar result.

Test 3 Docker - nr\_of\_peers = 10, max\_broadcasts = 10\_000\_000, timeout = 3000, send\_percentage = 50

Output:

Starting local with nr\_of\_peers: 5, max\_broadcasts: 10000000, timeout: 3000

| Starting on docker with nr\_of\_peers: 10, max\_broadcasts: 10000000, timeout: 3000, send\_percentage: 50

| 1: [{97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}, {97499, 0}]

| 0: [{116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}, {116050, 0}]

| 7: [{109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}, {109091, 0}]

| 4: [{90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}, {90061, 0}]

| 6: [{120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}, {120345, 0}]

| 5: [{142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}, {142533, 0}]

| 2: [{107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}, {107812, 0}]

| 8: [{105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}, {105850, 0}]

| 9: [{104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}, {104797, 0}]

Comments: There seems to be an issue with message passing when increasing the number of containers from 5 to 10.