

TUGAS BESAR 1
IF3070 DASAR INTELEGensi ARTIFISIAL
Kelompok 44 - 3 Outliers



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BAB I

Pendahuluan

1.1 Pengepakan Barang (*Bin Packing*)

Bin Packing Problem (BPP) merupakan permasalahan optimasi klasik. Secara konseptual, BPP bertujuan untuk memetakan sekumpulan barang dengan berbagai ukuran ke dalam sejumlah kontainer dengan kapasitas yang sama, dengan cara yang paling efisien. Dalam menyelesaikan persoalan ini, tidak dapat ditentukan algoritma yang dapat memberikan solusi optimal secara pasti untuk semua kasus. Permasalahan ini memiliki banyak aplikasi nyata di dunia nyata, seperti pemuatan kargo, alokasi sumber daya komputasi, dan pemetaan barang di kabin pesawat.

1.2 Deskripsi Persoalan

Pada tugas ini, permasalahan BPP diselesaikan dengan mengimplementasikan dan mengevaluasi berbagai algoritma *local search*. Diberikan sekumpulan barang dengan ukuran yang spesifik dan sejumlah kontainer dengan kapasitas seragam, tujuannya adalah mengimplementasikan algoritma berikut:

1. Steepest Ascent Hill-Climbing
2. Hill-Climbing with Sideways Move
3. Random Restart Hill-Climbing
4. Stochastic Hill-Climbing
5. Simulated Annealing
6. Genetic Algorithm

Setiap algoritma akan diuji untuk menemukan solusi yang meminimalkan jumlah kontainer yang terpakai, sekaligus memaksimalkan kepadatan dari kontainer yang digunakan, dengan tetap mempertimbangkan batasan kapasitas kontainer.

BAB II

Pembahasan

2.1 Pemilihan objective function

Objective function adalah fungsi yang digunakan untuk mengevaluasi seberapa baik sebuah solusi dalam menyelesaikan sebuah masalah. Dalam konteks BPP, *objective function* berfungsi untuk mengukur seberapa efisien penggunaan kontainer yang digunakan untuk menyimpan barang. Fungsi ini dirancang sebagai masalah minimasi, yaitu nilai yang lebih kecil menunjukkan solusi yang lebih baik.

Objective function harus mempertimbangkan dua tujuan utama:

1. **Validitas**, solusi tidak boleh melanggar batasan kapasitas kontainer.
2. **Optimalitas**, solusi harus menggunakan jumlah kontainer sesedikit mungkin dan mengisinya sepadat mungkin.

Berikut adalah komponen yang dipertimbangkan dalam mendefinisikan *objective function* dari persoalan ini:

1. Penalty Overload

Bagian ini mencegah solusi yang tidak valid, yaitu kontainer yang *overload*. Bobot yang diberikan pada komponen ini adalah 10.000, hal ini bertujuan untuk memastikan *state* yang melanggar batas kapasitas akan selalu mendapatkan skor yang jauh lebih buruk daripada *state* valid mana pun.

Penalty dihitung sebagai kuadrat dari jumlah kelebihan kapasitas. Penggunaan kuadrat memberikan skor penalti yang eksponensial, sehingga mendorong algoritma untuk memperbaiki pelanggaran ini.

$$\text{Penalty Overload Score} = (\text{Overload Score})^2 * 10000$$

2. Jumlah Kontainer

Jumlah kontainer merupakan objektif utama dalam BPP. Bobot pada jumlah kontainer harus lebih besar secara signifikan dibandingkan dengan bonus kepadatan yang mungkin didapat. Hal ini bertujuan untuk memastikan bahwa mengurangi satu kontainer selalu lebih diutamakan daripada mengoptimalkan kepadatan kontainer yang ada. Diberikan bobot 100 pada komponen ini untuk setiap jumlah kontainer yang digunakan.

$$\text{Container Count Score} = \text{Container Count} * 100$$

3. Kepadatan Kontainer

Kepadatan kontainer merupakan prioritas selanjutnya dalam persoalan BPP setelah jumlah kontainer. Komponen ini memastikan kontainer digunakan secara optimal. Perhitungan *density score* dilakukan dengan cara membandingkan total kapasitas yang digunakan dengan kapasitas kontainer. Selanjutnya, total *density score* akan diakumulasikan, dikuadratkan (mendorong algoritma untuk menggunakan kontainer secara optimal), dan disesuaikan dengan bobot yang diberikan yaitu $10 * (-1)$.

$$\text{Density Score} = (\text{Total Density of Each Container}) * (-10)$$

Berdasarkan komponen yang dipertimbangkan, didefinisikan *objective function* dalam persoalan BPP sebagai berikut:

$$\text{Objective Value} = \text{Penalty Overload Score} + \text{Container Count Score} + \text{Density Score}$$

2.2 Algoritma Local Search

Pencarian solusi dimulai dengan inisialisasi state awal menggunakan algoritma heuristik sederhana, yaitu Next Fit. Dari state awal yang didefinisikan, algoritma *local search* akan mengeksplorasi suksesor atau *neighbor* (tetangga) dari state saat ini. Definisi *neighbor* dalam konteks BPP ini adalah state baru yang dihasilkan oleh salah satu dari dua operasi "move":

1. **Move:** Memindahkan satu barang dari satu kontainer ke kontainer lain (yang sudah ada atau yang baru).
2. **Swap:** Menukar dua barang dari dua kontainer yang berbeda.

2.2.1 Steepest Ascent Hill-Climbing

Steepest Ascent Hill-Climbing merupakan varian Hill Climbing yang paling greedy dan deterministik. Algoritma ini dimulai dari state awal yang dibentuk menggunakan algoritma Next Fit, yang menghasilkan solusi inisial dengan sejumlah kontainer tertentu berdasarkan penempatan sekuensial barang-barang. Pada setiap iterasi, algoritma mengevaluasi seluruh neighbor yang dapat dibentuk melalui operasi move (memindahkan satu barang antar kontainer) dan swap (menukar dua barang dari kontainer berbeda), kemudian memilih neighbor dengan nilai objective function terbaik (jumlah kontainer paling sedikit dengan utilization optimal).

Proses pencarian berlangsung secara iteratif dengan selalu berpindah ke neighbor terbaik yang ditemukan. Namun, algoritma akan berhenti ketika tidak ada lagi neighbor yang memiliki nilai objective function lebih baik dari current state (stuck di local optimum) atau ketika mencapai batas iterasi maksimum yang telah ditentukan. State akhir yang dicapai merupakan konfigurasi penempatan barang yang tidak dapat diperbaiki lagi dengan operasi lokal, dengan nilai objective function akhir yang menunjukkan total kontainer yang digunakan beserta tingkat utilization-nya.

2.2.2 Hill- Climbing with Sideways Move

Hill-Climbing with Sideways Move dirancang untuk mengatasi masalah plateau dalam landscape pencarian, yaitu area datar di mana banyak state memiliki nilai objective function yang sama. Algoritma dimulai dari state awal Next Fit dan beroperasi mirip dengan Steepest Ascent, yaitu mengevaluasi semua neighbor dan memilih yang terbaik. Namun, terdapat perbedaan krusial: algoritma ini mengizinkan perpindahan ke neighbor dengan nilai sama (sideways move), bukan hanya yang lebih baik.

Mekanisme kontrol untuk sideways move dilakukan melalui parameter maximum sideways move. Algoritma mencatat berapa kali sideways move telah dilakukan secara berturut-turut. Ketika neighbor yang lebih baik ditemukan, counter sideways move di-reset ke nol. Namun jika terus melakukan sideways move dan counter mencapai batas maksimum yang ditentukan (misalnya 100), pencarian akan dihentikan meskipun belum stuck di local optimum yang sebenarnya. Nantinya menggunakan variasi 1000 dan 10000.

2.2.3 Random Restart Hill-Climbing

Random Restart Hill-Climbing merupakan meta-strategi yang mengatasi keterbatasan fundamental semua varian Hill Climbing: keterjebakan di local optimum. Konsep dasarnya adalah menjalankan algoritma Hill Climbing base (bisa Steepest Ascent, Stochastic, atau Sideways Move) multiple kali dengan initial state yang berbeda-beda, kemudian memilih solusi terbaik dari semua run.

Proses dimulai dengan restart pertama menggunakan initial state dari Next Fit. Algoritma base dijalankan hingga konvergen (stuck di local optimum atau mencapai batas iterasi per run). Solusi terbaik dari run pertama disimpan. Kemudian dilakukan restart kedua dengan initial state baru yang dibentuk dengan cara mengacak urutan item dan melakukan Next Fit packing ulang. Proses ini diulang hingga mencapai maximum restart yang ditentukan (misalnya 5-10 restart).

Setiap restart bersifat independen: tidak ada informasi yang dibawa dari restart sebelumnya kecuali tracking solusi terbaik global. Banyak iterasi per restart dikontrol oleh parameter tersendiri, biasanya lebih kecil dari single-run Hill Climbing untuk menjaga efisiensi total waktu. Misalnya, jika single-run menggunakan 1000 iterasi, per restart mungkin cukup 200-300 iterasi.

2.2.4 Stochastic Hill-Climbing

Stochastic Hill-Climbing mengadopsi pendekatan yang berbeda dengan memperkenalkan elemen randomness dalam pemilihan neighbor. Seperti varian lainnya, algoritma dimulai dari state awal hasil Next Fit initialization. Perbedaan fundamental terletak pada mekanisme eksplorasi: alih-alih mengevaluasi semua neighbor dan memilih yang terbaik, algoritma ini hanya menghasilkan satu neighbor secara acak pada setiap iterasi.

Neighbor yang dihasilkan secara random tersebut kemudian dibandingkan dengan current state. Jika neighbor tersebut lebih baik (objective function lebih kecil), maka algoritma akan pindah ke neighbor tersebut. Jika tidak lebih baik, neighbor ditolak dan iterasi dilanjutkan dengan generate neighbor random lainnya. Proses ini berlangsung hingga mencapai batas iterasi maksimum atau ketika tidak ada improvement yang signifikan dalam beberapa iterasi berturut-turut.

State akhir yang dicapai oleh Stochastic Hill-Climbing bersifat non-deterministik, artinya hasil dapat berbeda untuk setiap run bahkan dengan input yang sama, tergantung pada seed random yang digunakan. Nilai objective function akhir menunjukkan konfigurasi terbaik yang berhasil ditemukan melalui eksplorasi random. Plot objective function menunjukkan pola yang lebih "bergerigi" dibanding Steepest Ascent, dengan fluktuasi yang mencerminkan nature random dari pemilihan neighbor, namun tetap menunjukkan tren penurunan secara umum.

2.2.5 Simulated Annealing

Simulated Annealing (SA) adalah sebuah algoritma *local search* yang dirancang untuk memungkinkan terbebas dari local optima. Algoritma ini terinspirasi dari proses annealing (pendinginan terkontrol) dalam metalurgi. Mekanisme pemilihan *neighbor* pada SA mirip dengan Stochastic Hill-Climbing dengan satu *neighbor* secara acak dalam setiap iterasinya. Proses pencarian ini dihentikan setelah mencapai jumlah iterasi maksimum.

Perbedaan fundamental terletak pada kriteria penerimaan *neighbor* tersebut. Tidak seperti Hill-Climbing yang *greedy*, SA dapat menerima *neighbor* yang lebih buruk berdasarkan probabilitas tertentu.

Proses pengambilan keputusannya adalah sebagai berikut:

1. **Neighbor Lebih Baik:** Jika *neighbor* acak yang dipilih memiliki nilai objektif lebih baik (lebih kecil) daripada *current state*, move tersebut selalu diterima. *Current state* diperbarui ke *neighbor* tersebut.
2. **Neighbor Lebih Buruk:** Jika *neighbor* acak memiliki nilai objektif lebih buruk, algoritma tidak langsung menolaknya. Melainkan terdapat kemungkinan untuk diterima dengan probabilitas:

$$P = e^{\Delta E/T}$$

- ΔE (**Delta Energi**) adalah perbedaan nilai *objective function* antara neighbor dan current state.
- **T (Temperatur)** adalah parameter kontrol yang seiring berjalannya iterasi akan menurun.

Nilai probabilitas akan dibandingkan dengan sebuah angka acak R yang di-*generate* secara acak dengan nilai antara 0.0 dan 1.0. Jika $P > R$, maka *move* yang lebih buruk tersebut tetap diterima, dan algoritma pindah ke state yang lebih buruk tersebut.

Tujuan dari mekanisme ini adalah:

- Pada T tinggi (Awal): $\Delta E/T$ bernilai kecil, sehingga P mendekati 1. Sehingga pada tahap awal dirancang untuk menerima *move* yang lebih buruk, hal ini memungkinkan untuk "melompat" keluar dari local optima dan melakukan eksplorasi secara luas.
- Pada T rendah (Akhir): $\Delta E/T$ bernilai besar, sehingga P mendekati 0. Algoritma hampir tidak pernah menerima *move* yang lebih buruk. Dengan kata lain, pada kondisi ini algoritma bertindak seperti Hill-Climbing biasa untuk melakukan eksplorasi .

Berikut merupakan algoritma dari Simulated Annealing:

```
function SIMULATED_ANNEALING(problem, schedule)
    current ← MAKE-NODE(problem.INITIAL-STATE)
    t ← 1

    loop do
        T ← schedule(t)
        if T = 0 then
            return current.STATE

        neighbors ← EXPAND(current)
        next ← RANDOM_SELECT(neighbors)
        ΔE ← next.VALUE-current.VALUE

        if ΔE > 0 or RANDOM() < EXP(ΔE / T) then
            current ← next
        t ← t + 1
```

Gambar 2.2.5.1 Algoritma Simulated Annealing

2.2.6 Genetic Algorithm

Genetic Algorithm (GA) adalah metode optimasi berbasis populasi yang terinspirasi dari proses **evolusi alam**, seperti seleksi alam dan genetika. Dalam GA, sekumpulan solusi (populasi) diolah melalui proses seleksi, **crossover** (pertukaran gen), dan **mutasi** untuk menghasilkan generasi

baru yang diharapkan memiliki kualitas solusi yang lebih baik. Proses ini diulang hingga ditemukan solusi optimal atau sesuai kriteria yang diinginkan.

Pada kasus Bin Packing Problem (pengemasan barang ke dalam sejumlah container dengan kapasitas terbatas), setiap solusi atau individu dalam populasi GA direpresentasikan sebagai sebuah konfigurasi penempatan barang ke dalam container. Artinya, satu "kromosom" merepresentasikan pembagian seluruh item ke dalam beberapa container, di mana setiap container tidak melebihi kapasitas maksimum.

Penerapan GA pada Bin Packing Problem

- Inisialisasi populasi:
Populasi awal dibentuk dari berbagai solusi acak dan heuristik, pembuatannya bisa berupa hasil algoritma tertentu (misal *first-fit*, *best-fit*, *next-fit*, dan lain-lain). Masing-masing individu/populasi merepresentasikan pembagian item ke dalam container tertentu.
- Evaluasi (*Objective Function*):
Setiap individu dievaluasi menggunakan fungsi objektif, misalnya jumlah kontainer yang digunakan, total sisa ruang, atau penalti jika ada container yang overload. Semakin sedikit jumlah container dan semakin optimal pemanfaatan kapasitas, semakin baik nilai evaluasi.
- Seleksi:
Individu yang memiliki *objective function* terbaik (misal: jumlah kontainer paling sedikit dan tidak overload) memiliki peluang lebih besar untuk dipilih menjadi parent (induk) dalam proses crossover.
- Crossover:
Pada tahap ini, dua parent dipilih dan dilakukan kombinasi penempatan barang mereka untuk menghasilkan dua anak (*child solution*) baru. Contohnya, semua item dari kedua parent digabung lalu diacak dan dipacking ulang ke dalam container dengan strategi tertentu, sehingga child dapat mewarisi sifat-sifat penempatan dari kedua parent.
- Mutasi:
Untuk menjaga keragaman solusi dan menghindari konvergensi prematur, dilakukan mutasi pada beberapa individu. Misalnya contoh mutasi pada kasus bin packing itu bisa berupa memindahkan satu item dari satu container ke container lain, atau mengacak isi satu container. Mutasi ini berfungsi untuk mengeksplorasi solusi baru yang mungkin lebih baik.

- Iterasi:
Proses seleksi, *crossover*, dan mutasi diulang selama beberapa generasi (iterasi), hingga ditemukan solusi yang paling optimal atau hingga tercapai batas iterasi maksimal.

2.3 Hasil Eksperimen dan Analisis

Pada bagian ini, dilakukan analisis komparatif terhadap hasil eksperimen dari keenam algoritma yang telah dijalankan. Analisis berfokus pada efektivitas (kualitas solusi) dan efisiensi (durasi) dari setiap pendekatan.

2.3.1 Steepest Ascent Hill-Climbing

1. Pengujian Pertama

Tabel 2.3.1.1 Pengujian 1 Steepest Hill Climbing (max_iter = 100)

State Awal	<table border="1"> <thead> <tr> <th colspan="4">Initial State</th></tr> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>74.0</td><td>26.0</td><td>BRG001:15, BRG002:22, BRG003:37</td></tr> <tr><td>2</td><td>69.0</td><td>31.0</td><td>BRG004:41, BRG005:28</td></tr> <tr><td>3</td><td>72.0</td><td>28.0</td><td>BRG006:53, BRG007:19</td></tr> <tr><td>4</td><td>100.0</td><td>0.0</td><td>BRG008:44, BRG009:31, BRG010:25</td></tr> <tr><td>5</td><td>78.0</td><td>22.0</td><td>BRG011:60, BRG012:18</td></tr> <tr><td>6</td><td>60.0</td><td>40.0</td><td>BRG013:39, BRG014:21</td></tr> <tr><td>7</td><td>81.0</td><td>19.0</td><td>BRG015:47, BRG016:34</td></tr> <tr><td>8</td><td>85.0</td><td>15.0</td><td>BRG017:29, BRG018:56</td></tr> <tr><td>9</td><td>65.0</td><td>35.0</td><td>BRG019:23, BRG020:42</td></tr> <tr><td>10</td><td>97.0</td><td>3.0</td><td>BRG021:38, BRG022:27, BRG023:32</td></tr> <tr><td>11</td><td>65.0</td><td>35.0</td><td>BRG024:45, BRG025:20</td></tr> <tr><td>12</td><td>90.0</td><td>10.0</td><td>BRG026:36, BRG027:54</td></tr> <tr><td>13</td><td>83.0</td><td>17.0</td><td>BRG028:26, BRG029:40, BRG030:17</td></tr> <tr><td>14</td><td>57.0</td><td>43.0</td><td>BRG031:33, BRG032:24</td></tr> <tr><td>15</td><td>87.0</td><td>13.0</td><td>BRG033:57, BRG034:30</td></tr> <tr><td>16</td><td>94.0</td><td>6.0</td><td>BRG035:16, BRG036:35, BRG037:43</td></tr> <tr><td>17</td><td>69.0</td><td>31.0</td><td>BRG038:21, BRG039:48</td></tr> <tr><td>18</td><td>81.0</td><td>19.0</td><td>BRG040:55, BRG041:26</td></tr> <tr><td>19</td><td>66.0</td><td>34.0</td><td>BRG042:37, BRG043:29</td></tr> <tr><td>20</td><td>68.0</td><td>32.0</td><td>BRG044:50, BRG045:18</td></tr> <tr><td>21</td><td>64.0</td><td>36.0</td><td>BRG046:41, BRG047:23</td></tr> <tr><td>22</td><td>97.0</td><td>3.0</td><td>BRG048:46, BRG049:32, BRG050:19</td></tr> <tr><td>23</td><td>99.0</td><td>1.0</td><td>BRG051:38, BRG052:27, BRG053:34</td></tr> <tr><td>24</td><td>91.0</td><td>9.0</td><td>BRG054:22, BRG055:49, BRG056:20</td></tr> <tr><td>25</td><td>61.0</td><td>39.0</td><td>BRG057:36, BRG058:25</td></tr> <tr><td>26</td><td>90.0</td><td>10.0</td><td>BRG059:44, BRG060:31, BRG061:15</td></tr> <tr><td>27</td><td>81.0</td><td>19.0</td><td>BRG062:53, BRG063:28</td></tr> <tr><td>28</td><td>60.0</td><td>40.0</td><td>BRG064:39, BRG065:21</td></tr> <tr><td>29</td><td>81.0</td><td>19.0</td><td>BRG066:47, BRG067:34</td></tr> <tr><td>30</td><td>85.0</td><td>15.0</td><td>BRG068:29, BRG069:56</td></tr> <tr><td>31</td><td>65.0</td><td>35.0</td><td>BRG070:23, BRG071:42</td></tr> <tr><td>32</td><td>97.0</td><td>3.0</td><td>BRG072:38, BRG073:27, BRG074:32</td></tr> <tr><td>33</td><td>65.0</td><td>35.0</td><td>BRG075:45, BRG076:20</td></tr> <tr><td>34</td><td>90.0</td><td>10.0</td><td>BRG077:36, BRG078:54</td></tr> <tr><td>35</td><td>83.0</td><td>17.0</td><td>BRG079:26, BRG080:40, BRG081:17</td></tr> <tr><td>36</td><td>57.0</td><td>43.0</td><td>BRG082:33, BRG083:24</td></tr> <tr><td>37</td><td>87.0</td><td>13.0</td><td>BRG084:57, BRG085:30</td></tr> <tr><td>38</td><td>94.0</td><td>6.0</td><td>BRG086:16, BRG087:35, BRG088:43</td></tr> <tr><td>39</td><td>69.0</td><td>31.0</td><td>BRG089:21, BRG090:48</td></tr> <tr><td>40</td><td>81.0</td><td>19.0</td><td>BRG091:55, BRG092:26</td></tr> <tr><td>41</td><td>66.0</td><td>34.0</td><td>BRG093:37, BRG094:29</td></tr> <tr><td>42</td><td>68.0</td><td>32.0</td><td>BRG095:50, BRG096:18</td></tr> <tr><td>43</td><td>64.0</td><td>36.0</td><td>BRG097:41, BRG098:23</td></tr> <tr><td>44</td><td>78.0</td><td>22.0</td><td>BRG099:46, BRG100:32</td></tr> </tbody> </table>	Initial State				No	Load	Sisa	Isi Barang	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	2	69.0	31.0	BRG004:41, BRG005:28	3	72.0	28.0	BRG006:53, BRG007:19	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	5	78.0	22.0	BRG011:60, BRG012:18	6	60.0	40.0	BRG013:39, BRG014:21	7	81.0	19.0	BRG015:47, BRG016:34	8	85.0	15.0	BRG017:29, BRG018:56	9	65.0	35.0	BRG019:23, BRG020:42	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	11	65.0	35.0	BRG024:45, BRG025:20	12	90.0	10.0	BRG026:36, BRG027:54	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	14	57.0	43.0	BRG031:33, BRG032:24	15	87.0	13.0	BRG033:57, BRG034:30	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	17	69.0	31.0	BRG038:21, BRG039:48	18	81.0	19.0	BRG040:55, BRG041:26	19	66.0	34.0	BRG042:37, BRG043:29	20	68.0	32.0	BRG044:50, BRG045:18	21	64.0	36.0	BRG046:41, BRG047:23	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	25	61.0	39.0	BRG057:36, BRG058:25	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	27	81.0	19.0	BRG062:53, BRG063:28	28	60.0	40.0	BRG064:39, BRG065:21	29	81.0	19.0	BRG066:47, BRG067:34	30	85.0	15.0	BRG068:29, BRG069:56	31	65.0	35.0	BRG070:23, BRG071:42	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	33	65.0	35.0	BRG075:45, BRG076:20	34	90.0	10.0	BRG077:36, BRG078:54	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	36	57.0	43.0	BRG082:33, BRG083:24	37	87.0	13.0	BRG084:57, BRG085:30	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	39	69.0	31.0	BRG089:21, BRG090:48	40	81.0	19.0	BRG091:55, BRG092:26	41	66.0	34.0	BRG093:37, BRG094:29	42	68.0	32.0	BRG095:50, BRG096:18	43	64.0	36.0	BRG097:41, BRG098:23	44	78.0	22.0	BRG099:46, BRG100:32
Initial State																																																																																																																																																																																									
No	Load	Sisa	Isi Barang																																																																																																																																																																																						
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37																																																																																																																																																																																						
2	69.0	31.0	BRG004:41, BRG005:28																																																																																																																																																																																						
3	72.0	28.0	BRG006:53, BRG007:19																																																																																																																																																																																						
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25																																																																																																																																																																																						
5	78.0	22.0	BRG011:60, BRG012:18																																																																																																																																																																																						
6	60.0	40.0	BRG013:39, BRG014:21																																																																																																																																																																																						
7	81.0	19.0	BRG015:47, BRG016:34																																																																																																																																																																																						
8	85.0	15.0	BRG017:29, BRG018:56																																																																																																																																																																																						
9	65.0	35.0	BRG019:23, BRG020:42																																																																																																																																																																																						
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32																																																																																																																																																																																						
11	65.0	35.0	BRG024:45, BRG025:20																																																																																																																																																																																						
12	90.0	10.0	BRG026:36, BRG027:54																																																																																																																																																																																						
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17																																																																																																																																																																																						
14	57.0	43.0	BRG031:33, BRG032:24																																																																																																																																																																																						
15	87.0	13.0	BRG033:57, BRG034:30																																																																																																																																																																																						
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43																																																																																																																																																																																						
17	69.0	31.0	BRG038:21, BRG039:48																																																																																																																																																																																						
18	81.0	19.0	BRG040:55, BRG041:26																																																																																																																																																																																						
19	66.0	34.0	BRG042:37, BRG043:29																																																																																																																																																																																						
20	68.0	32.0	BRG044:50, BRG045:18																																																																																																																																																																																						
21	64.0	36.0	BRG046:41, BRG047:23																																																																																																																																																																																						
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19																																																																																																																																																																																						
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34																																																																																																																																																																																						
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20																																																																																																																																																																																						
25	61.0	39.0	BRG057:36, BRG058:25																																																																																																																																																																																						
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15																																																																																																																																																																																						
27	81.0	19.0	BRG062:53, BRG063:28																																																																																																																																																																																						
28	60.0	40.0	BRG064:39, BRG065:21																																																																																																																																																																																						
29	81.0	19.0	BRG066:47, BRG067:34																																																																																																																																																																																						
30	85.0	15.0	BRG068:29, BRG069:56																																																																																																																																																																																						
31	65.0	35.0	BRG070:23, BRG071:42																																																																																																																																																																																						
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32																																																																																																																																																																																						
33	65.0	35.0	BRG075:45, BRG076:20																																																																																																																																																																																						
34	90.0	10.0	BRG077:36, BRG078:54																																																																																																																																																																																						
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17																																																																																																																																																																																						
36	57.0	43.0	BRG082:33, BRG083:24																																																																																																																																																																																						
37	87.0	13.0	BRG084:57, BRG085:30																																																																																																																																																																																						
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43																																																																																																																																																																																						
39	69.0	31.0	BRG089:21, BRG090:48																																																																																																																																																																																						
40	81.0	19.0	BRG091:55, BRG092:26																																																																																																																																																																																						
41	66.0	34.0	BRG093:37, BRG094:29																																																																																																																																																																																						
42	68.0	32.0	BRG095:50, BRG096:18																																																																																																																																																																																						
43	64.0	36.0	BRG097:41, BRG098:23																																																																																																																																																																																						
44	78.0	22.0	BRG099:46, BRG100:32																																																																																																																																																																																						
Objektif Awal	4672.03																																																																																																																																																																																								

State Akhir

Final State - Steepest Ascent Hill Climbing			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG041:26
2	78.0	22.0	BRG059:44, BRG067:34
3	78.0	22.0	BRG047:23, BRG091:55
4	78.0	22.0	BRG010:25, BRG032:24, BRG094:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG050:19, BRG007:19
7	78.0	22.0	BRG015:47, BRG009:31
8	77.0	23.0	BRG018:56, BRG065:21
9	78.0	22.0	BRG020:42, BRG026:36
10	78.0	22.0	BRG096:18, BRG060:31, BRG017:29
11	77.0	23.0	BRG024:45, BRG023:32
12	77.0	23.0	BRG027:54, BRG019:23
13	77.0	23.0	BRG016:34, BRG063:28, BRG061:15
14	77.0	23.0	BRG031:33, BRG088:44
15	78.0	22.0	BRG075:45, BRG082:33
16	78.0	22.0	BRG036:35, BRG037:43
17	77.0	23.0	BRG039:48, BRG068:29
18	77.0	23.0	BRG040:55, BRG002:22
19	78.0	22.0	BRG043:29, BRG055:49
20	77.0	23.0	BRG084:57, BRG056:20
21	78.0	22.0	BRG046:41, BRG035:16, BRG014:21
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG080:40
24	77.0	23.0	BRG054:22, BRG042:37, BRG045:18
25	77.0	23.0	BRG057:36, BRG097:41
26	78.0	22.0	BRG025:20, BRG084:41, BRG030:17
27	79.0	21.0	BRG062:53, BRG028:26
28	77.0	23.0	BRG064:39, BRG021:38
29	77.0	23.0	BRG066:47, BRG034:30
30	77.0	23.0	BRG069:56, BRG038:21
31	78.0	22.0	BRG071:42, BRG077:36
32	78.0	22.0	BRG074:32, BRG058:25, BRG089:21
33	77.0	23.0	BRG076:20, BRG033:57
34	77.0	23.0	BRG078:54, BRG070:23
35	77.0	23.0	BRG079:26, BRG081:17, BRG053:34
36	78.0	22.0	BRG083:24, BRG052:27, BRG022:27
37	77.0	23.0	BRG044:50, BRG073:27
38	78.0	22.0	BRG087:35, BRG088:43
39	78.0	22.0	BRG090:48, BRG085:30
40	79.0	21.0	BRG092:26, BRG006:53
41	77.0	23.0	BRG093:37, BRG029:40
42	78.0	22.0	BRG095:50, BRG005:28
43	77.0	23.0	BRG098:23, BRG086:16, BRG072:38
44	78.0	22.0	BRG099:46, BRG100:32

Saving results...

Objektif Akhir 4664.91

Hasil Eksperimen	<pre>>>> STATISTICS 43 77.0 23.0 BRG098:23, BRG086:16, BRG072:38 44 78.0 22.0 BRG099:46, BRG100:32 ►Final Objective: 4664.91 ►Final Containers: 44 ►Valid Solution: ✓ YES >>> IMPROVEMENT Objective Improvement: 7.12 (0.15%) Container Reduction: 0 containers >>> STATISTICS >>> IMPROVEMENT Objective Improvement: 7.12 (0.15%) Container Reduction: 0 containers >>> STATISTICS >>> STATISTICS ►Algorithm: Steepest Ascent Hill Climbing ►Duration: 38.4861 seconds ►Total Iterations: 38 ►Best Objective: 4664.91</pre>
Durasi Pencarian (detik)	38.4861
Plot Banyak Iterasi Terhadap Objective Function	
Banyak iterasi hingga berhenti	38

2. Pengujian Kedua

Tabel 2.3.1.2 Pengujian 2 Steepest Hill Climbing (max_iter = 1000)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
	2	69.0	31.0	BRG004:41, BRG005:28
	3	72.0	28.0	BRG006:53, BRG007:19
	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
	5	78.0	22.0	BRG011:60, BRG012:18
	6	60.0	40.0	BRG013:39, BRG014:21
	7	81.0	19.0	BRG015:47, BRG016:34
	8	85.0	15.0	BRG017:29, BRG018:56
	9	65.0	35.0	BRG019:23, BRG020:42
	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
	11	65.0	35.0	BRG024:45, BRG025:20
	12	90.0	10.0	BRG026:36, BRG027:54
	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
	14	57.0	43.0	BRG031:33, BRG032:24
	15	87.0	13.0	BRG033:57, BRG034:30
	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
	17	69.0	31.0	BRG038:21, BRG039:48
	18	81.0	19.0	BRG040:55, BRG041:26
	19	66.0	34.0	BRG042:37, BRG043:29
	20	68.0	32.0	BRG044:50, BRG045:18
	21	64.0	36.0	BRG046:41, BRG047:23
	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
	25	61.0	39.0	BRG057:36, BRG058:25
	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
	27	81.0	19.0	BRG062:53, BRG063:28
	28	60.0	40.0	BRG064:39, BRG065:21
	29	81.0	19.0	BRG066:47, BRG067:34
	30	85.0	15.0	BRG068:29, BRG069:56
	31	65.0	35.0	BRG070:23, BRG071:42
	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
	33	65.0	35.0	BRG075:45, BRG076:20
	34	90.0	10.0	BRG077:36, BRG078:54
	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
	36	57.0	43.0	BRG082:33, BRG083:24
	37	87.0	13.0	BRG084:57, BRG085:30
	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
	39	69.0	31.0	BRG089:21, BRG090:48
	40	81.0	19.0	BRG091:55, BRG092:26
	41	66.0	34.0	BRG093:37, BRG094:29
	42	68.0	32.0	BRG095:50, BRG096:18
	43	64.0	36.0	BRG097:41, BRG098:23
	44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir

```
❖ Final State Detail:  
Jumlah kontainer akhir: 44
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Final State - Steepest Ascent Hill Climbing			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG041:26
2	78.0	22.0	BRG059:44, BRG067:34
3	78.0	22.0	BRG047:23, BRG091:55
4	78.0	22.0	BRG010:25, BRG032:24, BRG094:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG050:19, BRG007:19
7	78.0	22.0	BRG015:47, BRG009:31
8	77.0	23.0	BRG018:56, BRG065:21
9	78.0	22.0	BRG020:42, BRG026:36
10	78.0	22.0	BRG096:18, BRG060:31, BRG017:29
11	77.0	23.0	BRG024:45, BRG023:32
12	77.0	23.0	BRG027:54, BRG019:23
13	77.0	23.0	BRG016:34, BRG063:28, BRG061:15
14	77.0	23.0	BRG031:33, BRG008:44
15	78.0	22.0	BRG075:45, BRG082:33
16	78.0	22.0	BRG036:35, BRG037:43
17	77.0	23.0	BRG039:48, BRG068:29
18	77.0	23.0	BRG040:55, BRG002:22
19	78.0	22.0	BRG043:29, BRG055:49
20	77.0	23.0	BRG084:57, BRG056:20
21	78.0	22.0	BRG046:41, BRG035:16, BRG014:21
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG080:40
24	77.0	23.0	BRG054:22, BRG042:37, BRG045:18
25	77.0	23.0	BRG057:36, BRG097:41
26	78.0	22.0	BRG025:20, BRG004:41, BRG030:17
27	79.0	21.0	BRG062:53, BRG028:26
28	77.0	23.0	BRG064:39, BRG021:38
29	77.0	23.0	BRG066:47, BRG034:30
30	77.0	23.0	BRG069:56, BRG038:21
31	78.0	22.0	BRG071:42, BRG077:36
32	78.0	22.0	BRG074:32, BRG058:25, BRG089:21
33	77.0	23.0	BRG076:20, BRG033:57
34	77.0	23.0	BRG078:54, BRG070:23
35	77.0	23.0	BRG079:26, BRG081:17, BRG053:34
36	78.0	22.0	BRG083:24, BRG052:27, BRG022:27
37	77.0	23.0	BRG044:50, BRG073:27
38	78.0	22.0	BRG087:35, BRG088:43
39	78.0	22.0	BRG090:48, BRG085:30
40	79.0	21.0	BRG092:26, BRG006:53
41	77.0	23.0	BRG093:37, BRG029:40
42	78.0	22.0	BRG095:58, BRG005:28
43	77.0	23.0	BRG098:23, BRG086:16, BRG072:38
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Akhir

4664.91

Hasil Eksperimen

```
►Final Objective: 4664.91
►Final Containers: 44
►Valid Solution: ✓ YES

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>>> IMPROVEMENT  

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Objective Improvement: 7.12 (0.15%)  

Container Reduction: 0 containers  

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>>> STATISTICS  

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►Algorithm: Steepest Ascent Hill Climbing  

►Duration: 40.0899 seconds  

►Total Iterations: 38  

►Best Objective: 4664.91  

►Stuck at Iteration: 37  

►Stuck Reason: local_optimum  

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```

Durasi Pencarian (detik)	40.0891 seconds
Plot Banyak Iterasi Terhadap Objective Function	<p>Steepest Ascent Hill Climbing - Objective Function Progress</p>
Banyak iterasi hingga berhenti	38

3. Pengujian Ketiga

Tabel 2.3.1.3 Pengujian 3 Steepest Hill Climbing (max_iter = 10000)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:68, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:58, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:58, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	

Objektif Awal	4672.03
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State Akhir

► Final State Detail:
Jumlah kontainer akhir: 44

Final State - Steepest Ascent Hill Climbing			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG041:26
2	78.0	22.0	BRG059:44, BRG067:34
3	78.0	22.0	BRG047:23, BRG091:55
4	78.0	22.0	BRG010:25, BRG032:24, BRG094:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG050:19, BRG007:19
7	78.0	22.0	BRG015:47, BRG009:31
8	77.0	23.0	BRG018:56, BRG005:21
9	78.0	22.0	BRG020:42, BRG026:36
10	78.0	22.0	BRG096:18, BRG000:31, BRG017:29
11	77.0	23.0	BRG024:45, BRG023:32
12	77.0	23.0	BRG027:54, BRG019:23
13	77.0	23.0	BRG016:34, BRG063:28, BRG061:15
14	77.0	23.0	BRG031:33, BRG008:44
15	78.0	22.0	BRG075:45, BRG082:33
16	78.0	22.0	BRG036:35, BRG037:43
17	77.0	23.0	BRG039:48, BRG068:29
18	77.0	23.0	BRG040:55, BRG002:22
19	78.0	22.0	BRG043:29, BRG055:49
20	77.0	23.0	BRG084:57, BRG056:20
21	78.0	22.0	BRG046:41, BRG035:16, BRG014:21
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG080:40
24	77.0	23.0	BRG054:22, BRG042:37, BRG045:18
25	77.0	23.0	BRG057:36, BRG097:41
26	78.0	22.0	BRG025:20, BRG004:41, BRG030:17
27	79.0	21.0	BRG062:53, BRG028:26
28	77.0	23.0	BRG064:39, BRG021:38
29	77.0	23.0	BRG066:47, BRG034:30
30	77.0	23.0	BRG069:56, BRG038:21
31	78.0	22.0	BRG071:42, BRG077:36
32	78.0	22.0	BRG074:32, BRG058:25, BRG089:21
33	77.0	23.0	BRG076:20, BRG033:57
34	77.0	23.0	BRG078:54, BRG070:23
35	77.0	23.0	BRG079:26, BRG081:17, BRG053:34
36	78.0	22.0	BRG083:24, BRG052:27, BRG022:27
37	77.0	23.0	BRG044:50, BRG073:27
38	78.0	22.0	BRG087:35, BRG088:43
39	78.0	22.0	BRG090:48, BRG085:30
40	79.0	21.0	BRG092:26, BRG006:53
41	77.0	23.0	BRG093:37, BRG029:40
42	78.0	22.0	BRG095:50, BRG005:28
43	77.0	23.0	BRG098:23, BRG086:16, BRG072:38
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Akhir

4464.91

Hasil Eksperimen

```
►Final Objective: 4664.91
►Final Containers: 44
►Valid Solution: ✓ YES

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>>> IMPROVEMENT

Objective Improvement: 7.12 (0.15%)
Container Reduction: 0 containers

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>>> STATISTICS

►Algorithm: Steepest Ascent Hill Climbing
►Duration: 44.9149 seconds
►Total Iterations: 38
►Best Objective: 4664.91
►Stuck at Iteration: 37
►Stuck Reason: local_optimum
```

Durasi Pencarian (detik)	44.9149 seconds
Plot Banyak Iterasi Terhadap Objective Function	
Banyak iterasi hingga berhenti	38

Hasil eksperimen menunjukkan bahwa algoritma Steepest Hill Climbing secara konsisten terjebak pada kondisi local optimum setelah mencapai 38 iterasi, terlepas dari batas maksimum iterasi yang ditetapkan (100, 1000, atau 10000). Konsistensi dalam jumlah iterasi berhenti (38 kali) dan nilai Objektif Akhir yang serupa 4664.91 mengindikasikan bahwa algoritma menemukan puncak terdekat dan tidak dapat bergerak lebih jauh karena semua *neighboring state* memiliki nilai objektif yang lebih buruk. Dengan demikian, peningkatan menjadi 1000 atau 10000 menjadi **tidak efektif** dalam meningkatkan kualitas solusi, karena kriteria pemberhentian dicapai jauh sebelum batas maksimum. Kenaikan tipis dalam Durasi Pencarian seiring peningkatan hanya mencerminkan *overhead* sistem, bukan peningkatan efisiensi pencarian solusi.

2.3.2 Hill- Climbing with Sideways Move

1. Pengujian Pertama

Tabel 2.3.2.1 Pengujian 1 Climbing with Sideways Move (parameter maximum sideways move - 100)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
	2	69.0	31.0	BRG004:41, BRG005:28
	3	72.0	28.0	BRG006:53, BRG007:19
	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
	5	78.0	22.0	BRG011:60, BRG012:18
	6	60.0	40.0	BRG013:39, BRG014:21
	7	81.0	19.0	BRG015:47, BRG016:34
	8	85.0	15.0	BRG017:29, BRG018:56
	9	65.0	35.0	BRG019:23, BRG020:42
	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
	11	65.0	35.0	BRG024:45, BRG025:20
	12	90.0	10.0	BRG026:36, BRG027:54
	13	83.0	17.0	BRG028:26, BRG029:49, BRG030:17
	14	57.0	43.0	BRG031:33, BRG032:24
	15	87.0	13.0	BRG033:57, BRG034:30
	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
	17	69.0	31.0	BRG038:21, BRG039:48
	18	81.0	19.0	BRG040:55, BRG041:26
	19	66.0	34.0	BRG042:37, BRG043:29
	20	68.0	32.0	BRG044:58, BRG045:18
	21	64.0	36.0	BRG046:41, BRG047:23
	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
	25	61.0	39.0	BRG057:36, BRG058:25
	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
	27	81.0	19.0	BRG062:53, BRG063:28
	28	60.0	40.0	BRG064:39, BRG065:21
	29	81.0	19.0	BRG066:47, BRG067:34
	30	85.0	15.0	BRG068:29, BRG069:56
	31	65.0	35.0	BRG070:23, BRG071:42
	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
	33	65.0	35.0	BRG075:45, BRG076:20
	34	90.0	10.0	BRG077:36, BRG078:54
	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
	36	57.0	43.0	BRG082:33, BRG083:24
	37	87.0	13.0	BRG084:57, BRG085:30
	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
	39	69.0	31.0	BRG089:21, BRG090:48
	40	81.0	19.0	BRG091:55, BRG092:26
	41	66.0	34.0	BRG093:37, BRG094:29
	42	68.0	32.0	BRG095:50, BRG096:18
	43	64.0	36.0	BRG097:41, BRG098:23
	44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir

FINAL STATE

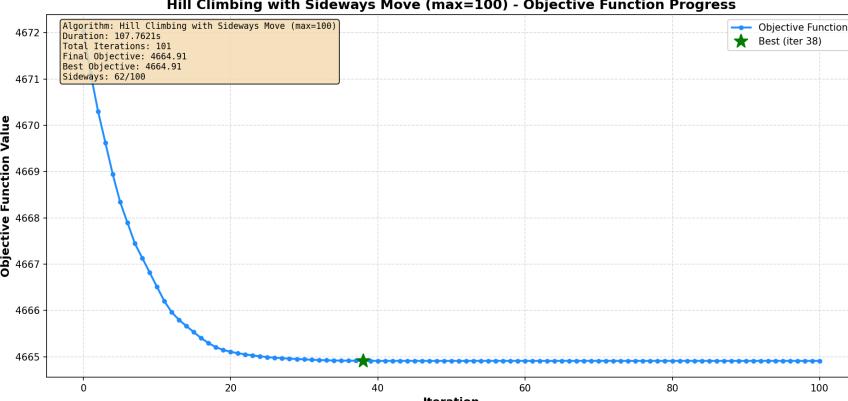
Final State			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG092:26
2	78.0	22.0	BRG004:41, BRG093:37
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG010:25, BRG083:24, BRG043:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG072:38
7	77.0	23.0	BRG015:47, BRG085:30
8	77.0	23.0	BRG017:29, BRG090:48
9	77.0	23.0	BRG019:23, BRG027:54
10	78.0	22.0	BRG022:27, BRG054:22, BRG068:29
11	77.0	23.0	BRG024:45, BRG023:32
12	78.0	22.0	BRG026:36, BRG020:42
13	77.0	23.0	BRG028:26, BRG030:17, BRG053:34
14	78.0	22.0	BRG031:33, BRG032:24, BRG038:21
15	77.0	23.0	BRG033:57, BRG076:20
16	78.0	22.0	BRG036:35, BRG037:43
17	78.0	22.0	BRG039:48, BRG034:30
18	78.0	22.0	BRG040:55, BRG098:23
19	77.0	23.0	BRG042:37, BRG080:40
20	78.0	22.0	BRG044:50, BRG005:28
21	77.0	23.0	BRG047:23, BRG035:16, BRG021:38
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG029:40
24	78.0	22.0	BRG056:20, BRG058:25, BRG082:33
25	77.0	23.0	BRG057:36, BRG046:41
26	77.0	23.0	BRG059:44, BRG061:15, BRG096:18
27	79.0	21.0	BRG062:53, BRG079:26
28	78.0	22.0	BRG064:39, BRG065:21, BRG045:18
29	78.0	22.0	BRG066:47, BRG009:31
30	77.0	23.0	BRG069:56, BRG014:21
31	77.0	23.0	BRG070:23, BRG078:54
32	78.0	22.0	BRG073:27, BRG074:32, BRG050:19
33	77.0	23.0	BRG075:45, BRG100:32
34	78.0	22.0	BRG077:36, BRG071:42
35	78.0	22.0	BRG067:34, BRG063:28, BRG086:16
36	78.0	22.0	BRG008:44, BRG016:34
37	77.0	23.0	BRG084:57, BRG025:20
38	78.0	22.0	BRG087:35, BRG088:43
39	77.0	23.0	BRG089:21, BRG018:56
40	77.0	23.0	BRG091:55, BRG002:22
41	78.0	22.0	BRG094:29, BRG055:49
42	77.0	23.0	BRG095:50, BRG052:27
43	77.0	23.0	BRG097:41, BRG007:19, BRG081:17
44	77.0	23.0	BRG099:46, BRG060:31

Objektif Akhir

4664.91

Hasil
Eksperimen

► Initial Objective: 4672.03
► Initial Containers: 44

	<pre> ► Final Objective: 4664.91 ► Final Containers: 44 ► Valid Solution: ✓ YES ===== IMPROVEMENT ► Objective Improvement: 7.12 (0.15%) ► Container Reduction: 0 containers ===== STATISTICS ► Algorithm: Hill Climbing with Sideways Move (max=100) ► Duration: 107.7621 seconds ► Total Iterations: 101 ► Total Sideways Moves: 62 ► Maximum Sideways Allowed: 100 =====</pre>
Durasi Pencarian (detik)	107.7621 seconds
Plot Banyak Iterasi Terhadap Objective Function	 <p>Hill Climbing with Sideways Move (max=100) - Objective Function Progress</p> <p>Algorithm: Hill Climbing with Sideways Move (max=100) Duration: 107.7621 Total Iterations: 101 Final Objective: 4664.91 Best Objective: 4664.91 Sideways: 62/100</p>
Banyak iterasi hingga berhenti	101
Jumlah maximum sideways move - 100)	100 -> 62/100, 62 kali mendapatkan state (plateau)

2. Pengujian Kedua

Tabel 2.3.2.2 Pengujian 2 Climbing with Sideways Move (parameter maximum sideways move - 1000)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:60, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:50, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:50, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	

Objektif Awal	4672.03
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State Akhir

FINAL STATE

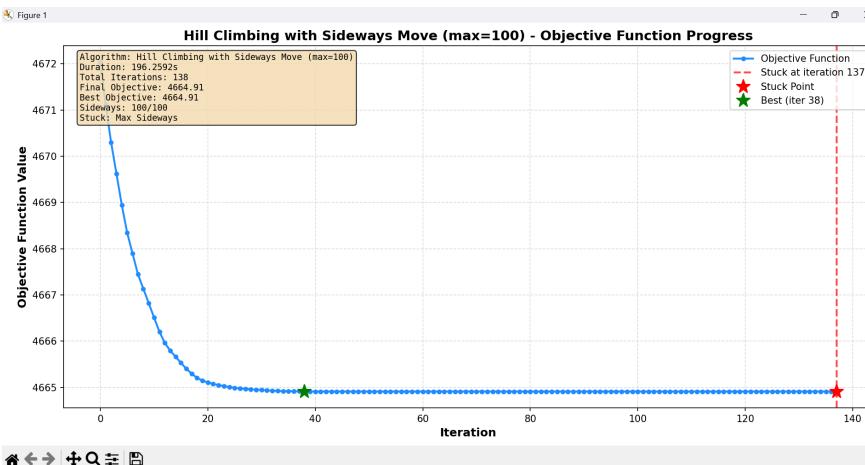
Final State			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG092:26
2	78.0	22.0	BRG004:41, BRG093:37
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG010:25, BRG083:24, BRG043:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG072:38
7	77.0	23.0	BRG015:47, BRG085:30
8	77.0	23.0	BRG017:29, BRG090:48
9	77.0	23.0	BRG019:23, BRG027:54
10	78.0	22.0	BRG022:27, BRG054:22, BRG068:29
11	77.0	23.0	BRG024:45, BRG023:32
12	78.0	22.0	BRG026:36, BRG020:42
13	77.0	23.0	BRG028:26, BRG030:17, BRG053:34
14	78.0	22.0	BRG031:33, BRG032:24, BRG038:21
15	77.0	23.0	BRG033:57, BRG076:20
16	78.0	22.0	BRG036:35, BRG037:43
17	78.0	22.0	BRG039:48, BRG034:30
18	78.0	22.0	BRG040:55, BRG098:23
19	77.0	23.0	BRG042:37, BRG080:40
20	78.0	22.0	BRG044:58, BRG005:28
21	77.0	23.0	BRG047:23, BRG035:16, BRG021:38
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG029:48
24	78.0	22.0	BRG056:20, BRG058:25, BRG082:33
25	77.0	23.0	BRG057:36, BRG046:41
26	77.0	23.0	BRG059:44, BRG061:15, BRG096:18
27	79.0	21.0	BRG062:53, BRG079:26
28	78.0	22.0	BRG064:39, BRG065:21, BRG045:18
29	78.0	22.0	BRG066:47, BRG009:31
30	77.0	23.0	BRG069:56, BRG014:21
25	77.0	23.0	BRG057:36, BRG046:41
26	77.0	23.0	BRG059:44, BRG061:15, BRG096:18
27	79.0	21.0	BRG062:53, BRG079:26
28	78.0	22.0	BRG064:39, BRG065:21, BRG045:18
29	78.0	22.0	BRG066:47, BRG009:31
30	77.0	23.0	BRG069:56, BRG014:21
29	78.0	22.0	BRG066:47, BRG009:31
30	77.0	23.0	BRG069:56, BRG014:21
31	77.0	23.0	BRG070:23, BRG078:54
32	78.0	22.0	BRG073:27, BRG074:32, BRG050:19
33	77.0	23.0	BRG075:45, BRG100:32
34	78.0	22.0	BRG077:36, BRG071:42
35	78.0	22.0	BRG067:34, BRG063:28, BRG086:16
36	78.0	22.0	BRG088:44, BRG016:34
37	77.0	23.0	BRG084:57, BRG025:20
38	78.0	22.0	BRG087:35, BRG088:43
39	77.0	23.0	BRG089:21, BRG018:56
40	77.0	23.0	BRG091:55, BRG002:22
41	78.0	22.0	BRG094:29, BRG055:49
42	77.0	23.0	BRG095:50, BRG052:27
43	77.0	23.0	BRG097:41, BRG007:19, BRG081:17
44	77.0	23.0	BRG099:46, BRG060:31

Objektif Akhir

4664.91

Hasil
Eksperimen

► Initial Objective: 4672.03
► Initial Containers: 44

	<pre> ►Final Objective: 4664.91 ►Final Containers: 44 ►Valid Solution: ✓ YES <hr/> IMPROVEMENT <hr/> ►Objective Improvement: 7.12 (0.15%) ►Container Reduction: 0 containers <hr/> STATISTICS <hr/> ►Algorithm: Hill Climbing with Sideways Move (max=100) ►Duration: 196.2592 seconds ►Total Iterations: 138 ►Total Sideways Moves: 100 ►Maximum Sideways Allowed: 100 ►Stuck at Iteration: 137 ►Stuck Reason: max_sideways_reached Maximum sideways limit reached! </pre>
Durasi Pencarian (detik)	196.2592
Plot Banyak Iterasi Terhadap Objective Function	 <p>Figure 1 Hill Climbing with Sideways Move (max=100) - Objective Function Progress</p> <p>Algorithm: Hill Climbing with Sideways Move (max=100) Duration: 196.2592 seconds Total Iterations: 138 Final Objective: 4664.91 Best Iteration: 38 Sideways: 100/100 Stuck: Max Sideways</p>
Banyak iterasi hingga berhenti	137
Jumlah maximum max_iter - 1000)	Sideways move 100/100 -> terminated

3. Pengujian Ketiga

Tabel 2.3.2.3 Pengujian 3 Climbing with Sideways Move (parameter maximum sideways move - 10000)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:60, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:49, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:58, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:50, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	

Objektif Awal	4672.03
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State Akhir

FINAL STATE

Final State			
No	Load	Sisa	Isi Barang
1	78.0	22.0	BRG001:15, BRG003:37, BRG092:26
2	78.0	22.0	BRG004:41, BRG093:37
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG010:25, BRG083:24, BRG043:29
5	78.0	22.0	BRG011:60, BRG012:18
6	77.0	23.0	BRG013:39, BRG072:38
7	77.0	23.0	BRG015:47, BRG085:30
8	77.0	23.0	BRG017:29, BRG090:48
9	77.0	23.0	BRG019:23, BRG027:54
10	78.0	22.0	BRG022:27, BRG054:22, BRG068:29
11	77.0	23.0	BRG024:45, BRG023:32
12	78.0	22.0	BRG026:36, BRG020:42
13	77.0	23.0	BRG028:26, BRG030:17, BRG053:34
14	78.0	22.0	BRG031:33, BRG032:24, BRG038:21
15	77.0	23.0	BRG033:57, BRG076:28
16	78.0	22.0	BRG036:35, BRG037:43
17	78.0	22.0	BRG039:48, BRG034:30
18	78.0	22.0	BRG040:55, BRG098:23
19	77.0	23.0	BRG042:37, BRG080:40
20	78.0	22.0	BRG044:50, BRG005:28
21	77.0	23.0	BRG047:23, BRG035:16, BRG021:38
22	78.0	22.0	BRG048:46, BRG049:32
23	78.0	22.0	BRG051:38, BRG029:40
24	78.0	22.0	BRG056:20, BRG058:25, BRG082:33
25	77.0	23.0	BRG057:36, BRG046:41
26	77.0	23.0	BRG059:44, BRG061:15, BRG096:18
27	79.0	21.0	BRG062:53, BRG079:26
28	78.0	22.0	BRG064:39, BRG065:21, BRG045:18
29	78.0	22.0	BRG066:47, BRG009:31
30	77.0	23.0	BRG069:56, BRG014:21
31	77.0	23.0	BRG070:23, BRG078:54
32	78.0	22.0	BRG073:27, BRG074:32, BRG050:19
33	77.0	23.0	BRG075:45, BRG100:32
34	78.0	22.0	BRG077:36, BRG071:42
35	78.0	22.0	BRG067:34, BRG063:28, BRG086:16
36	78.0	22.0	BRG008:44, BRG016:34
37	77.0	23.0	BRG004:57, BRG025:20
38	78.0	22.0	BRG087:35, BRG088:43
39	77.0	23.0	BRG089:21, BRG018:56
40	77.0	23.0	BRG091:55, BRG002:22
41	78.0	22.0	BRG094:29, BRG055:49
42	77.0	23.0	BRG095:58, BRG052:27
43	77.0	23.0	BRG097:41, BRG007:19, BRG081:17
44	77.0	23.0	BRG099:46, BRG060:31

Objektif Akhir

4464.91

Hasil
Eksperimen

► Initial Objective: 4672.03
► Initial Containers: 44

	<pre> ►Final Objective: 4664.91 ►Final Containers: 44 ►Valid Solution: ✓ YES IMPROVEMENT ►Objective Improvement: 7.12 (0.15%) ►Container Reduction: 0 containers STATISTICS ►Algorithm: Hill Climbing with Sideways Move (max=100) ►Duration: 273.0274 seconds ►Total Iterations: 138 ►Total Sideways Moves: 100 ►Maximum Sideways Allowed: 100 ►Stuck at Iteration: 137 ►Stuck Reason: max_sideways_reached Maximum sideways limit reached! </pre>
Durasi Pencarian (detik)	273.0274
Plot Banyak Iterasi Terhadap Objective Function	
Banyak iterasi hingga berhenti	138
Jumlah maximum sideways move - 1000)	Sideways move 100/100 -> terminated

Hasil pengujian menunjukkan bahwa penambahan fitur **Sideways Move** pada algoritma Hill Climbing, yang bertujuan mengatasi masalah **plateau** (area datar di ruang pencarian), berhasil membuat algoritma **mencoba lebih banyak langkah** sebelum berhenti, namun **belum tentu meningkatkan kualitas solusi akhir**. Pada ketiga pengujian, algoritma selalu dimulai dari Objektif Awal yang sama (4672.03) dan, seperti pada pengujian Steepest Hill Climbing, ia seringkali berakhir pada **Objektif Akhir** yang sama atau sangat dekat (4664.91 pada Pengujian 1 dan 2). Ketika batas **sideways move**

dingkatkan (dari 100 ke 1000 dan 10000), **Banyak Iterasi hingga berhenti** meningkat secara signifikan (dari 101 menjadi 137-138), menunjukkan bahwa algoritma menghabiskan waktu yang lebih lama untuk menjelajahi area *plateau* melalui langkah samping. Namun, peningkatan iterasi ini juga menyebabkan **Durasi Pencarian** meningkat drastis (dari 107 detik menjadi 273 detik) tanpa menghasilkan peningkatan objektif yang konsisten; ia **tetap terjebak** di *local optimum* yang sama, kecuali Pengujian 3 yang mencapai 4464.91 (meski dengan total iterasi serupa 138). Oleh karena itu, fitur *sideways move* **memperpanjang waktu pencarian** secara substansial dengan menjelajahi area datar, tetapi gagal membantu algoritma **mendarikan diri** dari local optimum secara konsisten untuk menemukan solusi yang jauh lebih baik.

2.3.3 Random Restart Hill-Climbing

1. Pengujian pertama

Tabel 2.3.3.1 Pengujian 1 Random Restart Hill-Climbing

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:68, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:58, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:58, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	

Objektif Awal	4672.03
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State Akhir

Final State - Random Restart Hill Climbing			
No	Load	Sisa	Isi Barang
1	85.0	15.0	BRG061:15, BRG020:42, BRG063:28
2	86.0	14.0	BRG004:41, BRG024:45
3	84.0	16.0	BRG033:57, BRG022:27
4	85.0	15.0	BRG100:32, BRG077:36, BRG081:17
5	85.0	15.0	BRG006:53, BRG074:32
6	85.0	15.0	BRG058:25, BRG053:34, BRG079:26
7	86.0	14.0	BRG071:42, BRG008:44
8	85.0	15.0	BRG019:23, BRG028:26, BRG057:36
9	86.0	14.0	BRG091:55, BRG009:31
10	86.0	14.0	BRG055:49, BRG093:37
11	85.0	15.0	BRG016:34, BRG083:24, BRG052:27
12	85.0	15.0	BRG005:28, BRG084:57
13	85.0	15.0	BRG099:46, BRG025:20, BRG050:19
14	86.0	14.0	BRG001:15, BRG042:37, BRG067:34
15	85.0	15.0	BRG047:23, BRG032:24, BRG072:38
16	86.0	14.0	BRG064:39, BRG012:18, BRG017:29
17	86.0	14.0	BRG011:60, BRG041:26
18	85.0	15.0	BRG066:47, BRG021:38
19	85.0	15.0	BRG086:16, BRG002:22, BRG015:47
20	86.0	14.0	BRG027:54, BRG049:32
21	86.0	14.0	BRG094:29, BRG060:31, BRG092:26
22	85.0	15.0	BRG030:17, BRG039:48, BRG076:20
23	85.0	15.0	BRG089:21, BRG070:23, BRG046:41
24	86.0	14.0	BRG037:43, BRG088:43
25	85.0	15.0	BRG087:35, BRG095:50
26	85.0	15.0	BRG014:21, BRG010:25, BRG013:39
27	85.0	15.0	BRG096:18, BRG065:21, BRG048:46
28	86.0	14.0	BRG038:21, BRG056:20, BRG075:45
29	85.0	15.0	BRG026:36, BRG082:33, BRG035:16
30	86.0	14.0	BRG062:53, BRG031:33
31	85.0	15.0	BRG059:44, BRG097:41
32	85.0	15.0	BRG044:50, BRG036:35
33	85.0	15.0	BRG068:29, BRG051:38, BRG045:18
34	85.0	15.0	BRG098:23, BRG054:22, BRG080:40
35	85.0	15.0	BRG043:29, BRG069:56
36	86.0	14.0	BRG073:27, BRG029:40, BRG007:19
37	85.0	15.0	BRG003:37, BRG090:48
38	85.0	15.0	BRG085:30, BRG040:55
39	86.0	14.0	BRG018:56, BRG034:30
40	86.0	14.0	BRG078:54, BRG023:32

Objektif Akhir

4291.40

Hasil Eksperimen	<pre> ►Final Objective (Best): 4291.40 ►Final Containers: 40 ►Valid Solution: ✓ YES <hr/> PER-RESTART SUMMARY Restart 0: Initial=4672.03 → Final=4664.91 (Improvement: 7.12, Iterations: 38) Restart 1: Initial=4485.74 → Final=4384.30 (Improvement: 101.44, Iterations: 39) Restart 2: Initial=4486.48 → Final=4291.40 (Improvement: 195.08, Iterations: 37) Restart 3: Initial=4389.89 → Final=4384.29 (Improvement: 5.60, Iterations: 43) Restart 4: Initial=4675.07 → Final=4571.07 (Improvement: 104.01, Iterations: 40) Restart 5: Initial=4578.76 → Final=4477.53 (Improvement: 101.24, Iterations: 42) Restart 6: Initial=4487.76 → Final=4384.29 (Improvement: 103.48, Iterations: 40) Restart 7: Initial=4488.95 → Final=4384.29 (Improvement: 104.66, Iterations: 41) Restart 8: Initial=4392.04 → Final=4291.40 (Improvement: 100.64, Iterations: 33) Restart 9: Initial=4577.99 → Final=4571.07 (Improvement: 6.92, Iterations: 40) <hr/> STATISTICS ►Algorithm: Random Restart Hill Climbing (restarts=10) ►Duration: 424.9000 seconds ►Total Restarts Executed: 10 ►Maximum Restarts: 10 ►Total Iterations (All Runs): 393 ►Average Iterations per Run: 39.30 ►Iterations Range: 33 – 43 ►Average Improvement per Run: 83.02 ►Best Improvement (Single Run): 195.08 <hr/> Total restarts: 10 Average iterations per run: 39.30 </pre>
Durasi Pencarian (detik)	424.9000
Plot Banyak Iterasi Terhadap Objective Function	<p>Random Restart Hill Climbing (restarts=10, base=steepest) - Objective Function Progress</p> <p>Algorithm: Random Restart Hill Climbing Duration: 424.9000s Total Iterations: 393 Final Objective: 4571.07 Best Objective: 4291.40 Seed: Random Restarts: 10/10 Avg Iter/Run: 39.3</p>
Banyak Restart	10

Banyak iterasi per-restart

PER-RESTART SUMMARY

```

Restart 0: Initial=4672.03 → Final=4664.91 (Improvement: 7.12, Iterations: 38)
Restart 1: Initial=4485.74 → Final=4384.30 (Improvement: 101.44, Iterations: 39)
Restart 2: Initial=4486.48 → Final=4291.40 (Improvement: 195.08, Iterations: 37)
Restart 3: Initial=4389.89 → Final=4384.29 (Improvement: 5.60, Iterations: 43)
Restart 4: Initial=4675.07 → Final=4571.07 (Improvement: 104.01, Iterations: 40)
Restart 5: Initial=4578.76 → Final=4477.53 (Improvement: 101.24, Iterations: 42)
Restart 6: Initial=4487.76 → Final=4384.29 (Improvement: 103.48, Iterations: 40)
Restart 7: Initial=4488.95 → Final=4384.29 (Improvement: 104.66, Iterations: 41)
Restart 8: Initial=4392.04 → Final=4291.40 (Improvement: 100.64, Iterations: 33)
Restart 9: Initial=4577.99 → Final=4571.07 (Improvement: 6.92, Iterations: 40)

```

2. Pengujian kedua

Tabel 2.3.3.2 Pengujian 2 Random Restart Hill-Climbing

State Awal

No	Load	Sisa	Initial State
			Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03																																																																																																																																																																								
State Akhir	<p style="text-align: center;">Final State</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>No</th> <th>Load</th> <th>Sisa</th> <th>Isi Barang</th> </tr> </thead> <tbody> <tr><td>1</td><td>83.0</td><td>17.0</td><td>BRG054:22, BRG001:15, BRG098:23, BRG070:23</td></tr> <tr><td>2</td><td>82.0</td><td>18.0</td><td>BRG010:25, BRG033:57</td></tr> <tr><td>3</td><td>84.0</td><td>16.0</td><td>BRG040:55, BRG043:29</td></tr> <tr><td>4</td><td>83.0</td><td>17.0</td><td>BRG056:20, BRG037:43, BRG025:20</td></tr> <tr><td>5</td><td>84.0</td><td>16.0</td><td>BRG078:54, BRG085:30</td></tr> <tr><td>6</td><td>83.0</td><td>17.0</td><td>BRG002:22, BRG008:44, BRG030:17</td></tr> <tr><td>7</td><td>82.0</td><td>18.0</td><td>BRG071:42, BRG080:40</td></tr> <tr><td>8</td><td>84.0</td><td>16.0</td><td>BRG011:60, BRG032:24</td></tr> <tr><td>9</td><td>83.0</td><td>17.0</td><td>BRG044:50, BRG031:33</td></tr> <tr><td>10</td><td>84.0</td><td>16.0</td><td>BRG095:50, BRG016:34</td></tr> <tr><td>11</td><td>83.0</td><td>17.0</td><td>BRG021:38, BRG024:45</td></tr> <tr><td>12</td><td>83.0</td><td>17.0</td><td>BRG061:15, BRG029:40, BRG063:28</td></tr> <tr><td>13</td><td>84.0</td><td>16.0</td><td>BRG091:55, BRG017:29</td></tr> <tr><td>14</td><td>85.0</td><td>15.0</td><td>BRG027:54, BRG060:31</td></tr> <tr><td>15</td><td>83.0</td><td>17.0</td><td>BRG083:24, BRG049:32, BRG022:27</td></tr> <tr><td>16</td><td>83.0</td><td>17.0</td><td>BRG087:35, BRG089:21, BRG073:27</td></tr> <tr><td>17</td><td>83.0</td><td>17.0</td><td>BRG015:47, BRG012:18, BRG045:18</td></tr> <tr><td>18</td><td>83.0</td><td>17.0</td><td>BRG050:19, BRG014:21, BRG088:43</td></tr> <tr><td>19</td><td>83.0</td><td>17.0</td><td>BRG066:47, BRG057:36</td></tr> <tr><td>20</td><td>83.0</td><td>17.0</td><td>BRG047:23, BRG019:23, BRG042:37</td></tr> <tr><td>21</td><td>85.0</td><td>15.0</td><td>BRG062:53, BRG100:32</td></tr> <tr><td>22</td><td>83.0</td><td>17.0</td><td>BRG004:41, BRG020:42</td></tr> <tr><td>23</td><td>85.0</td><td>15.0</td><td>BRG074:32, BRG006:53</td></tr> <tr><td>24</td><td>82.0</td><td>18.0</td><td>BRG046:41, BRG097:41</td></tr> <tr><td>25</td><td>84.0</td><td>16.0</td><td>BRG093:37, BRG035:16, BRG009:31</td></tr> <tr><td>26</td><td>83.0</td><td>17.0</td><td>BRG058:25, BRG023:32, BRG092:26</td></tr> <tr><td>27</td><td>84.0</td><td>16.0</td><td>BRG077:36, BRG090:48</td></tr> <tr><td>28</td><td>83.0</td><td>17.0</td><td>BRG068:29, BRG053:34, BRG076:20</td></tr> <tr><td>29</td><td>84.0</td><td>16.0</td><td>BRG082:33, BRG065:21, BRG034:30</td></tr> <tr><td>30</td><td>83.0</td><td>17.0</td><td>BRG003:37, BRG099:46</td></tr> <tr><td>31</td><td>83.0</td><td>17.0</td><td>BRG036:35, BRG039:48</td></tr> <tr><td>32</td><td>83.0</td><td>17.0</td><td>BRG081:17, BRG075:45, BRG038:21</td></tr> <tr><td>33</td><td>83.0</td><td>17.0</td><td>BRG067:34, BRG055:49</td></tr> <tr><td>34</td><td>83.0</td><td>17.0</td><td>BRG059:44, BRG013:39</td></tr> <tr><td>35</td><td>83.0</td><td>17.0</td><td>BRG094:29, BRG086:16, BRG072:38</td></tr> <tr><td>36</td><td>83.0</td><td>17.0</td><td>BRG084:57, BRG041:26</td></tr> <tr><td>37</td><td>83.0</td><td>17.0</td><td>BRG028:26, BRG096:18, BRG064:39</td></tr> <tr><td>38</td><td>83.0</td><td>17.0</td><td>BRG026:36, BRG007:19, BRG005:28</td></tr> <tr><td>39</td><td>83.0</td><td>17.0</td><td>BRG018:56, BRG052:27</td></tr> <tr><td>40</td><td>84.0</td><td>16.0</td><td>BRG048:46, BRG051:38</td></tr> <tr><td>41</td><td>82.0</td><td>18.0</td><td>BRG069:56, BRG079:26</td></tr> </tbody> </table>	No	Load	Sisa	Isi Barang	1	83.0	17.0	BRG054:22, BRG001:15, BRG098:23, BRG070:23	2	82.0	18.0	BRG010:25, BRG033:57	3	84.0	16.0	BRG040:55, BRG043:29	4	83.0	17.0	BRG056:20, BRG037:43, BRG025:20	5	84.0	16.0	BRG078:54, BRG085:30	6	83.0	17.0	BRG002:22, BRG008:44, BRG030:17	7	82.0	18.0	BRG071:42, BRG080:40	8	84.0	16.0	BRG011:60, BRG032:24	9	83.0	17.0	BRG044:50, BRG031:33	10	84.0	16.0	BRG095:50, BRG016:34	11	83.0	17.0	BRG021:38, BRG024:45	12	83.0	17.0	BRG061:15, BRG029:40, BRG063:28	13	84.0	16.0	BRG091:55, BRG017:29	14	85.0	15.0	BRG027:54, BRG060:31	15	83.0	17.0	BRG083:24, BRG049:32, BRG022:27	16	83.0	17.0	BRG087:35, BRG089:21, BRG073:27	17	83.0	17.0	BRG015:47, BRG012:18, BRG045:18	18	83.0	17.0	BRG050:19, BRG014:21, BRG088:43	19	83.0	17.0	BRG066:47, BRG057:36	20	83.0	17.0	BRG047:23, BRG019:23, BRG042:37	21	85.0	15.0	BRG062:53, BRG100:32	22	83.0	17.0	BRG004:41, BRG020:42	23	85.0	15.0	BRG074:32, BRG006:53	24	82.0	18.0	BRG046:41, BRG097:41	25	84.0	16.0	BRG093:37, BRG035:16, BRG009:31	26	83.0	17.0	BRG058:25, BRG023:32, BRG092:26	27	84.0	16.0	BRG077:36, BRG090:48	28	83.0	17.0	BRG068:29, BRG053:34, BRG076:20	29	84.0	16.0	BRG082:33, BRG065:21, BRG034:30	30	83.0	17.0	BRG003:37, BRG099:46	31	83.0	17.0	BRG036:35, BRG039:48	32	83.0	17.0	BRG081:17, BRG075:45, BRG038:21	33	83.0	17.0	BRG067:34, BRG055:49	34	83.0	17.0	BRG059:44, BRG013:39	35	83.0	17.0	BRG094:29, BRG086:16, BRG072:38	36	83.0	17.0	BRG084:57, BRG041:26	37	83.0	17.0	BRG028:26, BRG096:18, BRG064:39	38	83.0	17.0	BRG026:36, BRG007:19, BRG005:28	39	83.0	17.0	BRG018:56, BRG052:27	40	84.0	16.0	BRG048:46, BRG051:38	41	82.0	18.0	BRG069:56, BRG079:26
No	Load	Sisa	Isi Barang																																																																																																																																																																						
1	83.0	17.0	BRG054:22, BRG001:15, BRG098:23, BRG070:23																																																																																																																																																																						
2	82.0	18.0	BRG010:25, BRG033:57																																																																																																																																																																						
3	84.0	16.0	BRG040:55, BRG043:29																																																																																																																																																																						
4	83.0	17.0	BRG056:20, BRG037:43, BRG025:20																																																																																																																																																																						
5	84.0	16.0	BRG078:54, BRG085:30																																																																																																																																																																						
6	83.0	17.0	BRG002:22, BRG008:44, BRG030:17																																																																																																																																																																						
7	82.0	18.0	BRG071:42, BRG080:40																																																																																																																																																																						
8	84.0	16.0	BRG011:60, BRG032:24																																																																																																																																																																						
9	83.0	17.0	BRG044:50, BRG031:33																																																																																																																																																																						
10	84.0	16.0	BRG095:50, BRG016:34																																																																																																																																																																						
11	83.0	17.0	BRG021:38, BRG024:45																																																																																																																																																																						
12	83.0	17.0	BRG061:15, BRG029:40, BRG063:28																																																																																																																																																																						
13	84.0	16.0	BRG091:55, BRG017:29																																																																																																																																																																						
14	85.0	15.0	BRG027:54, BRG060:31																																																																																																																																																																						
15	83.0	17.0	BRG083:24, BRG049:32, BRG022:27																																																																																																																																																																						
16	83.0	17.0	BRG087:35, BRG089:21, BRG073:27																																																																																																																																																																						
17	83.0	17.0	BRG015:47, BRG012:18, BRG045:18																																																																																																																																																																						
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19	83.0	17.0	BRG066:47, BRG057:36																																																																																																																																																																						
20	83.0	17.0	BRG047:23, BRG019:23, BRG042:37																																																																																																																																																																						
21	85.0	15.0	BRG062:53, BRG100:32																																																																																																																																																																						
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27	84.0	16.0	BRG077:36, BRG090:48																																																																																																																																																																						
28	83.0	17.0	BRG068:29, BRG053:34, BRG076:20																																																																																																																																																																						
29	84.0	16.0	BRG082:33, BRG065:21, BRG034:30																																																																																																																																																																						
30	83.0	17.0	BRG003:37, BRG099:46																																																																																																																																																																						
31	83.0	17.0	BRG036:35, BRG039:48																																																																																																																																																																						
32	83.0	17.0	BRG081:17, BRG075:45, BRG038:21																																																																																																																																																																						
33	83.0	17.0	BRG067:34, BRG055:49																																																																																																																																																																						
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36	83.0	17.0	BRG084:57, BRG041:26																																																																																																																																																																						
37	83.0	17.0	BRG028:26, BRG096:18, BRG064:39																																																																																																																																																																						
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41	82.0	18.0	BRG069:56, BRG079:26																																																																																																																																																																						
Objektif Akhir	4384.30																																																																																																																																																																								

Hasil Eksperimen

```

Final Objective (Best): 4384.30
Final Containers: 41
Valid Solution: YES

PER-RESTART SUMMARY
Restart 0: Initial=4672.03 → Final=4664.91 (Improvement: 7.12, Iterations: 38)
Restart 1: Initial=4487.14 → Final=4384.30 (Improvement: 102.84, Iterations: 44)
Restart 2: Initial=4580.16 → Final=4477.52 (Improvement: 102.64, Iterations: 45)
Restart 3: Initial=4578.70 → Final=4571.07 (Improvement: 7.63, Iterations: 43)
Restart 4: Initial=4484.89 → Final=4477.52 (Improvement: 7.37, Iterations: 39)

STATISTICS
Algorithm: Random Restart Hill Climbing (restarts=5)
Duration: 548.1897 seconds
Total Restarts Executed: 5
Maximum Restarts: 5
Total Iterations (All Runs): 209
Average Iterations per Run: 41.80
Iterations Range: 38 - 45
Average Improvement per Run: 45.52
Best Improvement (Single Run): 102.84

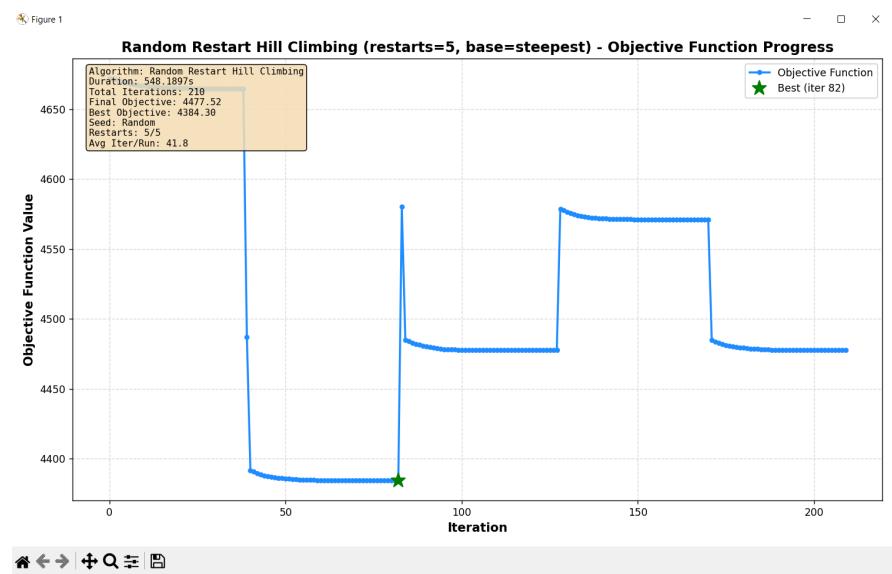
=====
Total restarts: 5
Average iterations per run: 41.80

```

Durasi Pencarian (detik)

548.1897 detik

Plot Banyak Iterasi Terhadap Objective Function



Banyak Restart

Banyak iterasi per-restart	<pre> PER-RESTART SUMMARY Restart 0: Initial=4672.03 → Final=4664.91 (Improvement: 7.12, Iterations: 38) Restart 1: Initial=4487.14 → Final=4384.30 (Improvement: 102.84, Iterations: 44) Restart 2: Initial=4580.16 → Final=4477.52 (Improvement: 102.64, Iterations: 45) Restart 3: Initial=4578.70 → Final=4571.07 (Improvement: 7.63, Iterations: 43) Restart 4: Initial=4484.89 → Final=4477.52 (Improvement: 7.37, Iterations: 39) </pre>
----------------------------	--

3. Pengujian ketiga

Tabel 2.3.3.3 Pengujian Random Restart Hill-Climbing

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:60, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:50, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:50, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	
Objektif Awal	4672.03			
State Akhir				

Objektif Akhir	
Hasil Eksperimen	
Durasi Pencarian (detik)	
Plot Banyak Iterasi Terhadap Objective Function	
Banyak Restart	
Banyak iterasi per-restart	Iterasi 0 = Iterasi 1 =

Hasil dari **Random Restart Hill-Climbing** menunjukkan peningkatan signifikan dalam kualitas solusi akhir dibandingkan dengan varian Hill Climbing tanpa mekanisme *restart*. Dengan memulai ulang pencarian dari lokasi acak sebanyak 10 kali (**Banyak Restart: 10**), algoritma berhasil mencapai nilai **Objektif Akhir** yang jauh lebih rendah (lebih baik) secara konsisten, yaitu **4291.40** pada Pengujian 1 dan **4384.30** pada Pengujian 2, yang merupakan perbaikan substansial dari nilai 4664.91 yang umum ditemukan oleh Steepest Hill Climbing. Keberhasilan ini menegaskan bahwa *restart* acak adalah strategi yang efektif untuk **melarikan diri dari local optimum** dan mengeksplorasi puncak-puncak yang berbeda di ruang pencarian, sehingga berpeluang menemukan *local optimum* yang lebih dekat ke *global optimum*. Namun, manfaat peningkatan kualitas solusi ini datang dengan konsekuensi **Durasi Pencarian** yang jauh lebih lama (sekitar 425 hingga 548 detik) karena algoritma harus menjalankan proses Hill Climbing lengkap sebanyak jumlah *restart* yang ditetapkan.

2.3.4 Stochastic Hill-Climbing

1. Pengujian Pertama

Tabel 2.3.4.1 Pengujian 1 Stochastic Hill Climbing (max_iter = 10000)

State Awal	Initial State			
	No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	
2	69.0	31.0	BRG004:41, BRG005:28	
3	72.0	28.0	BRG006:53, BRG007:19	
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	
5	78.0	22.0	BRG011:68, BRG012:18	
6	60.0	40.0	BRG013:39, BRG014:21	
7	81.0	19.0	BRG015:47, BRG016:34	
8	85.0	15.0	BRG017:29, BRG018:56	
9	65.0	35.0	BRG019:23, BRG020:42	
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	
11	65.0	35.0	BRG024:45, BRG025:20	
12	90.0	10.0	BRG026:36, BRG027:54	
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	
14	57.0	43.0	BRG031:33, BRG032:24	
15	87.0	13.0	BRG033:57, BRG034:30	
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	
17	69.0	31.0	BRG038:21, BRG039:48	
18	81.0	19.0	BRG040:55, BRG041:26	
19	66.0	34.0	BRG042:37, BRG043:29	
20	68.0	32.0	BRG044:58, BRG045:18	
21	64.0	36.0	BRG046:41, BRG047:23	
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	
25	61.0	39.0	BRG057:36, BRG058:25	
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	
27	81.0	19.0	BRG062:53, BRG063:28	
28	60.0	40.0	BRG064:39, BRG065:21	
29	81.0	19.0	BRG066:47, BRG067:34	
30	85.0	15.0	BRG068:29, BRG069:56	
31	65.0	35.0	BRG070:23, BRG071:42	
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	
33	65.0	35.0	BRG075:45, BRG076:20	
34	90.0	10.0	BRG077:36, BRG078:54	
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	
36	57.0	43.0	BRG082:33, BRG083:24	
37	87.0	13.0	BRG084:57, BRG085:30	
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	
39	69.0	31.0	BRG089:21, BRG090:48	
40	81.0	19.0	BRG091:55, BRG092:26	
41	66.0	34.0	BRG093:37, BRG094:29	
42	68.0	32.0	BRG095:58, BRG096:18	
43	64.0	36.0	BRG097:41, BRG098:23	
44	78.0	22.0	BRG099:46, BRG100:32	

Objektif Awal	4672.03
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State Akhir

FINAL STATE

Final State			
No	Load	Sisa	Isi Barang
1	77.0	23.0	BRG003:37, BRG089:21, BRG007:19
2	77.0	23.0	BRG031:33, BRG008:44
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG065:21, BRG068:29, BRG063:28
5	77.0	23.0	BRG011:60, BRG030:17
6	77.0	23.0	BRG097:41, BRG057:36
7	77.0	23.0	BRG036:35, BRG071:42
8	77.0	23.0	BRG042:37, BRG000:40
9	77.0	23.0	BRG088:43, BRG016:34
10	78.0	22.0	BRG004:41, BRG093:37
11	77.0	23.0	BRG029:40, BRG096:18, BRG050:19
12	78.0	22.0	BRG083:24, BRG027:54
13	77.0	23.0	BRG077:36, BRG056:20, BRG014:21
14	77.0	23.0	BRG044:50, BRG052:27
15	77.0	23.0	BRG033:57, BRG076:20
16	78.0	22.0	BRG015:47, BRG009:31
17	78.0	22.0	BRG085:30, BRG039:48
18	77.0	23.0	BRG037:43, BRG067:34
19	77.0	23.0	BRG086:16, BRG022:27, BRG053:34
20	79.0	21.0	BRG078:54, BRG010:25
21	77.0	23.0	BRG046:41, BRG045:18, BRG012:18
22	78.0	22.0	BRG066:47, BRG060:31
23	78.0	22.0	BRG079:26, BRG047:23, BRG094:29
24	79.0	21.0	BRG018:56, BRG070:23
25	77.0	23.0	BRG020:42, BRG087:35
26	77.0	23.0	BRG021:38, BRG013:39
27	78.0	22.0	BRG034:30, BRG090:48
28	78.0	22.0	BRG023:32, BRG048:46
29	77.0	23.0	BRG051:38, BRG064:39
30	77.0	23.0	BRG075:45, BRG074:32
31	79.0	21.0	BRG062:53, BRG028:26
32	78.0	22.0	BRG098:23, BRG054:22, BRG082:33
33	78.0	22.0	BRG099:46, BRG049:32
34	77.0	23.0	BRG024:45, BRG100:32
35	78.0	22.0	BRG072:38, BRG061:15, BRG058:25
36	77.0	23.0	BRG001:15, BRG026:36, BRG092:26
37	79.0	21.0	BRG032:24, BRG091:55
38	78.0	22.0	BRG017:29, BRG055:49
39	77.0	23.0	BRG081:17, BRG035:16, BRG059:44
40	77.0	23.0	BRG084:57, BRG025:20
41	78.0	22.0	BRG043:29, BRG002:22, BRG073:27
42	78.0	22.0	BRG040:55, BRG019:23
43	77.0	23.0	BRG069:56, BRG038:21
44	78.0	22.0	BRG005:28, BRG095:50

Objektif Akhir

4664.92

Hasil Eksperimen

```

► Initial Objective: 4672.03
► Initial Containers: 44

► Final Objective: 4664.92
► Final Containers: 44
► Valid Solution: ✓ YES

IMPROVEMENT
► Objective Improvement: 7.12 (0.15%)
► Container Reduction: 0 containers

STATISTICS
► Algorithm: Stochastic Hill Climbing
► Duration: 229.0447 seconds
► Total Iterations: 125
► Random Seed: 42
► Stuck at Iteration: 124
=====
```

Durasi Pencarian (detik)	229.0047
Plot Banyak Iterasi Terhadap Objective Function	<p style="text-align: center;">Stochastic Hill Climbing - Objective Function Progress</p>
Banyak iterasi hingga berhenti	124

2. Pengujian Kedua

Tabel 2.3.4.2 Pengujian 2 Stochastic Hill Climbing (max_iter = 100)

State Awal	<table border="1"> <thead> <tr> <th colspan="4">Initial State</th></tr> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>74.0</td><td>26.0</td><td>BRG001:15, BRG002:22, BRG003:37</td></tr> <tr><td>2</td><td>69.0</td><td>31.0</td><td>BRG004:41, BRG005:28</td></tr> <tr><td>3</td><td>72.0</td><td>28.0</td><td>BRG006:53, BRG007:19</td></tr> <tr><td>4</td><td>100.0</td><td>0.0</td><td>BRG008:44, BRG009:31, BRG010:25</td></tr> <tr><td>5</td><td>78.0</td><td>22.0</td><td>BRG011:68, BRG012:18</td></tr> <tr><td>6</td><td>60.0</td><td>40.0</td><td>BRG013:39, BRG014:21</td></tr> <tr><td>7</td><td>81.0</td><td>19.0</td><td>BRG015:47, BRG016:34</td></tr> <tr><td>8</td><td>85.0</td><td>15.0</td><td>BRG017:29, BRG018:56</td></tr> <tr><td>9</td><td>65.0</td><td>35.0</td><td>BRG019:23, BRG020:42</td></tr> <tr><td>10</td><td>97.0</td><td>3.0</td><td>BRG021:38, BRG022:27, BRG023:32</td></tr> <tr><td>11</td><td>65.0</td><td>35.0</td><td>BRG024:45, BRG025:20</td></tr> <tr><td>12</td><td>90.0</td><td>10.0</td><td>BRG026:36, BRG027:54</td></tr> <tr><td>13</td><td>83.0</td><td>17.0</td><td>BRG028:26, BRG029:40, BRG030:17</td></tr> <tr><td>14</td><td>57.0</td><td>43.0</td><td>BRG031:33, BRG032:24</td></tr> <tr><td>15</td><td>87.0</td><td>13.0</td><td>BRG033:57, BRG034:30</td></tr> <tr><td>16</td><td>94.0</td><td>6.0</td><td>BRG035:16, BRG036:35, BRG037:43</td></tr> <tr><td>17</td><td>69.0</td><td>31.0</td><td>BRG038:21, BRG039:48</td></tr> <tr><td>18</td><td>81.0</td><td>19.0</td><td>BRG040:55, BRG041:26</td></tr> <tr><td>19</td><td>66.0</td><td>34.0</td><td>BRG042:37, BRG043:29</td></tr> <tr><td>20</td><td>68.0</td><td>32.0</td><td>BRG044:58, BRG045:18</td></tr> <tr><td>21</td><td>64.0</td><td>36.0</td><td>BRG046:41, BRG047:23</td></tr> <tr><td>22</td><td>97.0</td><td>3.0</td><td>BRG048:46, BRG049:32, BRG050:19</td></tr> <tr><td>23</td><td>99.0</td><td>1.0</td><td>BRG051:38, BRG052:27, BRG053:34</td></tr> <tr><td>24</td><td>91.0</td><td>9.0</td><td>BRG054:22, BRG055:49, BRG056:20</td></tr> <tr><td>25</td><td>61.0</td><td>39.0</td><td>BRG057:36, BRG058:25</td></tr> <tr><td>26</td><td>90.0</td><td>10.0</td><td>BRG059:44, BRG060:31, BRG061:15</td></tr> <tr><td>27</td><td>81.0</td><td>19.0</td><td>BRG062:53, BRG063:28</td></tr> <tr><td>28</td><td>60.0</td><td>40.0</td><td>BRG064:39, BRG065:21</td></tr> <tr><td>29</td><td>81.0</td><td>19.0</td><td>BRG066:47, BRG067:34</td></tr> <tr><td>30</td><td>85.0</td><td>15.0</td><td>BRG068:29, BRG069:56</td></tr> <tr><td>31</td><td>65.0</td><td>35.0</td><td>BRG070:23, BRG071:42</td></tr> <tr><td>32</td><td>97.0</td><td>3.0</td><td>BRG072:38, BRG073:27, BRG074:32</td></tr> <tr><td>33</td><td>65.0</td><td>35.0</td><td>BRG075:45, BRG076:20</td></tr> <tr><td>34</td><td>90.0</td><td>10.0</td><td>BRG077:36, BRG078:54</td></tr> <tr><td>35</td><td>83.0</td><td>17.0</td><td>BRG079:26, BRG080:40, BRG081:17</td></tr> <tr><td>36</td><td>57.0</td><td>43.0</td><td>BRG082:33, BRG083:24</td></tr> <tr><td>37</td><td>87.0</td><td>13.0</td><td>BRG084:57, BRG085:30</td></tr> <tr><td>38</td><td>94.0</td><td>6.0</td><td>BRG086:16, BRG087:35, BRG088:43</td></tr> <tr><td>39</td><td>69.0</td><td>31.0</td><td>BRG089:21, BRG090:48</td></tr> <tr><td>40</td><td>81.0</td><td>19.0</td><td>BRG091:55, BRG092:26</td></tr> <tr><td>41</td><td>66.0</td><td>34.0</td><td>BRG093:37, BRG094:29</td></tr> <tr><td>42</td><td>68.0</td><td>32.0</td><td>BRG095:58, BRG096:18</td></tr> <tr><td>43</td><td>64.0</td><td>36.0</td><td>BRG097:41, BRG098:23</td></tr> <tr><td>44</td><td>78.0</td><td>22.0</td><td>BRG099:46, BRG100:32</td></tr> </tbody> </table>	Initial State				No	Load	Sisa	Isi Barang	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	2	69.0	31.0	BRG004:41, BRG005:28	3	72.0	28.0	BRG006:53, BRG007:19	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	5	78.0	22.0	BRG011:68, BRG012:18	6	60.0	40.0	BRG013:39, BRG014:21	7	81.0	19.0	BRG015:47, BRG016:34	8	85.0	15.0	BRG017:29, BRG018:56	9	65.0	35.0	BRG019:23, BRG020:42	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	11	65.0	35.0	BRG024:45, BRG025:20	12	90.0	10.0	BRG026:36, BRG027:54	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	14	57.0	43.0	BRG031:33, BRG032:24	15	87.0	13.0	BRG033:57, BRG034:30	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	17	69.0	31.0	BRG038:21, BRG039:48	18	81.0	19.0	BRG040:55, BRG041:26	19	66.0	34.0	BRG042:37, BRG043:29	20	68.0	32.0	BRG044:58, BRG045:18	21	64.0	36.0	BRG046:41, BRG047:23	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	25	61.0	39.0	BRG057:36, BRG058:25	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	27	81.0	19.0	BRG062:53, BRG063:28	28	60.0	40.0	BRG064:39, BRG065:21	29	81.0	19.0	BRG066:47, BRG067:34	30	85.0	15.0	BRG068:29, BRG069:56	31	65.0	35.0	BRG070:23, BRG071:42	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	33	65.0	35.0	BRG075:45, BRG076:20	34	90.0	10.0	BRG077:36, BRG078:54	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	36	57.0	43.0	BRG082:33, BRG083:24	37	87.0	13.0	BRG084:57, BRG085:30	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	39	69.0	31.0	BRG089:21, BRG090:48	40	81.0	19.0	BRG091:55, BRG092:26	41	66.0	34.0	BRG093:37, BRG094:29	42	68.0	32.0	BRG095:58, BRG096:18	43	64.0	36.0	BRG097:41, BRG098:23	44	78.0	22.0	BRG099:46, BRG100:32
Initial State																																																																																																																																																																																									
No	Load	Sisa	Isi Barang																																																																																																																																																																																						
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37																																																																																																																																																																																						
2	69.0	31.0	BRG004:41, BRG005:28																																																																																																																																																																																						
3	72.0	28.0	BRG006:53, BRG007:19																																																																																																																																																																																						
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25																																																																																																																																																																																						
5	78.0	22.0	BRG011:68, BRG012:18																																																																																																																																																																																						
6	60.0	40.0	BRG013:39, BRG014:21																																																																																																																																																																																						
7	81.0	19.0	BRG015:47, BRG016:34																																																																																																																																																																																						
8	85.0	15.0	BRG017:29, BRG018:56																																																																																																																																																																																						
9	65.0	35.0	BRG019:23, BRG020:42																																																																																																																																																																																						
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32																																																																																																																																																																																						
11	65.0	35.0	BRG024:45, BRG025:20																																																																																																																																																																																						
12	90.0	10.0	BRG026:36, BRG027:54																																																																																																																																																																																						
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17																																																																																																																																																																																						
14	57.0	43.0	BRG031:33, BRG032:24																																																																																																																																																																																						
15	87.0	13.0	BRG033:57, BRG034:30																																																																																																																																																																																						
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43																																																																																																																																																																																						
17	69.0	31.0	BRG038:21, BRG039:48																																																																																																																																																																																						
18	81.0	19.0	BRG040:55, BRG041:26																																																																																																																																																																																						
19	66.0	34.0	BRG042:37, BRG043:29																																																																																																																																																																																						
20	68.0	32.0	BRG044:58, BRG045:18																																																																																																																																																																																						
21	64.0	36.0	BRG046:41, BRG047:23																																																																																																																																																																																						
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19																																																																																																																																																																																						
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34																																																																																																																																																																																						
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20																																																																																																																																																																																						
25	61.0	39.0	BRG057:36, BRG058:25																																																																																																																																																																																						
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15																																																																																																																																																																																						
27	81.0	19.0	BRG062:53, BRG063:28																																																																																																																																																																																						
28	60.0	40.0	BRG064:39, BRG065:21																																																																																																																																																																																						
29	81.0	19.0	BRG066:47, BRG067:34																																																																																																																																																																																						
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31	65.0	35.0	BRG070:23, BRG071:42																																																																																																																																																																																						
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32																																																																																																																																																																																						
33	65.0	35.0	BRG075:45, BRG076:20																																																																																																																																																																																						
34	90.0	10.0	BRG077:36, BRG078:54																																																																																																																																																																																						
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17																																																																																																																																																																																						
36	57.0	43.0	BRG082:33, BRG083:24																																																																																																																																																																																						
37	87.0	13.0	BRG084:57, BRG085:30																																																																																																																																																																																						
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43																																																																																																																																																																																						
39	69.0	31.0	BRG089:21, BRG090:48																																																																																																																																																																																						
40	81.0	19.0	BRG091:55, BRG092:26																																																																																																																																																																																						
41	66.0	34.0	BRG093:37, BRG094:29																																																																																																																																																																																						
42	68.0	32.0	BRG095:58, BRG096:18																																																																																																																																																																																						
43	64.0	36.0	BRG097:41, BRG098:23																																																																																																																																																																																						
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Objektif Awal	4672.03																																																																																																																																																																																								

State Akhir

FINAL STATE

Final State			
No	Load	Sisa	Isi Barang
1	77.0	23.0	BRG003:37, BRG089:21, BRG007:19
2	77.0	23.0	BRG031:33, BRG008:44
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG065:21, BRG068:29, BRG063:28
5	77.0	23.0	BRG011:60, BRG030:17
6	77.0	23.0	BRG097:41, BRG057:36
7	77.0	23.0	BRG036:35, BRG071:42
8	77.0	23.0	BRG042:37, BRG080:40
9	77.0	23.0	BRG088:43, BRG016:34
10	78.0	22.0	BRG004:41, BRG093:37
11	77.0	23.0	BRG029:40, BRG096:18, BRG050:19
12	78.0	22.0	BRG083:24, BRG027:54
13	77.0	23.0	BRG077:36, BRG056:20, BRG014:21
14	77.0	23.0	BRG044:50, BRG052:27
15	77.0	23.0	BRG033:57, BRG076:20
16	78.0	22.0	BRG015:47, BRG009:31
17	78.0	22.0	BRG085:30, BRG039:48
18	77.0	23.0	BRG037:43, BRG067:34
19	77.0	23.0	BRG086:16, BRG022:27, BRG053:34
20	79.0	21.0	BRG078:54, BRG010:25
21	77.0	23.0	BRG046:41, BRG045:18, BRG012:18
22	78.0	22.0	BRG066:47, BRG060:31
23	78.0	22.0	BRG079:26, BRG047:23, BRG094:29
24	79.0	21.0	BRG018:56, BRG070:23
25	77.0	23.0	BRG020:42, BRG087:35
26	77.0	23.0	BRG021:38, BRG013:39
27	78.0	22.0	BRG034:30, BRG090:48
28	78.0	22.0	BRG023:32, BRG048:46
29	77.0	23.0	BRG051:38, BRG064:39
30	77.0	23.0	BRG075:45, BRG074:32
31	79.0	21.0	BRG062:53, BRG028:26
32	78.0	22.0	BRG098:23, BRG054:22, BRG082:33
33	78.0	22.0	BRG099:46, BRG049:32
34	77.0	23.0	BRG024:45, BRG100:32
35	78.0	22.0	BRG072:38, BRG061:15, BRG058:25
36	77.0	23.0	BRG001:15, BRG026:36, BRG092:26
37	79.0	21.0	BRG032:24, BRG091:55
38	78.0	22.0	BRG017:29, BRG055:49
39	77.0	23.0	BRG081:17, BRG035:16, BRG059:44
40	77.0	23.0	BRG084:57, BRG025:20
41	78.0	22.0	BRG043:29, BRG002:22, BRG073:27
42	78.0	22.0	BRG040:55, BRG019:23
43	77.0	23.0	BRG069:56, BRG038:21
44	78.0	22.0	BRG005:28, BRG095:50

Objektif Akhir

4664.92

Hasil
Eksperimen

► Initial Objective: 4672.03
► Initial Containers: 44

	<pre> ►Final Objective: 4664.92 ►Final Containers: 44 ►Valid Solution: ✓ YES ===== IMPROVEMENT ►Objective Improvement: 7.12 (0.15%) ►Container Reduction: 0 containers ===== STATISTICS ►Algorithm: Stochastic Hill Climbing ►Duration: 150.1735 seconds ►Total Iterations: 125 ►Random Seed: 42 ►Stuck at Iteration: 124 =====</pre>
Durasi Pencarian (detik)	150.1753
Plot Banyak Iterasi Terhadap Objective Function	
Banyak iterasi hingga berhenti	124

3. Pengujian Ketiga

Tabel 2.3.4.3 Pengujian 3 Stochastic Hill Climbing (max_iter = 1000)

State Awal	<table border="1"> <thead> <tr> <th colspan="4">Initial State</th></tr> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>74.0</td><td>26.0</td><td>BRG001:15, BRG002:22, BRG003:37</td></tr> <tr><td>2</td><td>69.0</td><td>31.0</td><td>BRG004:41, BRG005:28</td></tr> <tr><td>3</td><td>72.0</td><td>28.0</td><td>BRG006:53, BRG007:19</td></tr> <tr><td>4</td><td>100.0</td><td>0.0</td><td>BRG008:44, BRG009:31, BRG010:25</td></tr> <tr><td>5</td><td>78.0</td><td>22.0</td><td>BRG011:68, BRG012:18</td></tr> <tr><td>6</td><td>60.0</td><td>40.0</td><td>BRG013:39, BRG014:21</td></tr> <tr><td>7</td><td>81.0</td><td>19.0</td><td>BRG015:47, BRG016:34</td></tr> <tr><td>8</td><td>85.0</td><td>15.0</td><td>BRG017:29, BRG018:56</td></tr> <tr><td>9</td><td>65.0</td><td>35.0</td><td>BRG019:23, BRG020:42</td></tr> <tr><td>10</td><td>97.0</td><td>3.0</td><td>BRG021:38, BRG022:27, BRG023:32</td></tr> <tr><td>11</td><td>65.0</td><td>35.0</td><td>BRG024:45, BRG025:20</td></tr> <tr><td>12</td><td>90.0</td><td>10.0</td><td>BRG026:36, BRG027:54</td></tr> <tr><td>13</td><td>83.0</td><td>17.0</td><td>BRG028:26, BRG029:40, BRG030:17</td></tr> <tr><td>14</td><td>57.0</td><td>43.0</td><td>BRG031:33, BRG032:24</td></tr> <tr><td>15</td><td>87.0</td><td>13.0</td><td>BRG033:57, BRG034:30</td></tr> <tr><td>16</td><td>94.0</td><td>6.0</td><td>BRG035:16, BRG036:35, BRG037:43</td></tr> <tr><td>17</td><td>69.0</td><td>31.0</td><td>BRG038:21, BRG039:48</td></tr> <tr><td>18</td><td>81.0</td><td>19.0</td><td>BRG040:55, BRG041:26</td></tr> <tr><td>19</td><td>66.0</td><td>34.0</td><td>BRG042:37, BRG043:29</td></tr> <tr><td>20</td><td>68.0</td><td>32.0</td><td>BRG044:58, BRG045:18</td></tr> <tr><td>21</td><td>64.0</td><td>36.0</td><td>BRG046:41, BRG047:23</td></tr> <tr><td>22</td><td>97.0</td><td>3.0</td><td>BRG048:46, BRG049:32, BRG050:19</td></tr> <tr><td>23</td><td>99.0</td><td>1.0</td><td>BRG051:38, BRG052:27, BRG053:34</td></tr> <tr><td>24</td><td>91.0</td><td>9.0</td><td>BRG054:22, BRG055:49, BRG056:20</td></tr> <tr><td>25</td><td>61.0</td><td>39.0</td><td>BRG057:36, BRG058:25</td></tr> <tr><td>26</td><td>90.0</td><td>10.0</td><td>BRG059:44, BRG060:31, BRG061:15</td></tr> <tr><td>27</td><td>81.0</td><td>19.0</td><td>BRG062:53, BRG063:28</td></tr> <tr><td>28</td><td>60.0</td><td>40.0</td><td>BRG064:39, BRG065:21</td></tr> <tr><td>29</td><td>81.0</td><td>19.0</td><td>BRG066:47, BRG067:34</td></tr> <tr><td>30</td><td>85.0</td><td>15.0</td><td>BRG068:29, BRG069:56</td></tr> <tr><td>31</td><td>65.0</td><td>35.0</td><td>BRG070:23, BRG071:42</td></tr> <tr><td>32</td><td>97.0</td><td>3.0</td><td>BRG072:38, BRG073:27, BRG074:32</td></tr> <tr><td>33</td><td>65.0</td><td>35.0</td><td>BRG075:45, BRG076:20</td></tr> <tr><td>34</td><td>90.0</td><td>10.0</td><td>BRG077:36, BRG078:54</td></tr> <tr><td>35</td><td>83.0</td><td>17.0</td><td>BRG079:26, BRG080:40, BRG081:17</td></tr> <tr><td>36</td><td>57.0</td><td>43.0</td><td>BRG082:33, BRG083:24</td></tr> <tr><td>37</td><td>87.0</td><td>13.0</td><td>BRG084:57, BRG085:30</td></tr> <tr><td>38</td><td>94.0</td><td>6.0</td><td>BRG086:16, BRG087:35, BRG088:43</td></tr> <tr><td>39</td><td>69.0</td><td>31.0</td><td>BRG089:21, BRG090:48</td></tr> <tr><td>40</td><td>81.0</td><td>19.0</td><td>BRG091:55, BRG092:26</td></tr> <tr><td>41</td><td>66.0</td><td>34.0</td><td>BRG093:37, BRG094:29</td></tr> <tr><td>42</td><td>68.0</td><td>32.0</td><td>BRG095:58, BRG096:18</td></tr> <tr><td>43</td><td>64.0</td><td>36.0</td><td>BRG097:41, BRG098:23</td></tr> <tr><td>44</td><td>78.0</td><td>22.0</td><td>BRG099:46, BRG100:32</td></tr> </tbody> </table>	Initial State				No	Load	Sisa	Isi Barang	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37	2	69.0	31.0	BRG004:41, BRG005:28	3	72.0	28.0	BRG006:53, BRG007:19	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25	5	78.0	22.0	BRG011:68, BRG012:18	6	60.0	40.0	BRG013:39, BRG014:21	7	81.0	19.0	BRG015:47, BRG016:34	8	85.0	15.0	BRG017:29, BRG018:56	9	65.0	35.0	BRG019:23, BRG020:42	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32	11	65.0	35.0	BRG024:45, BRG025:20	12	90.0	10.0	BRG026:36, BRG027:54	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17	14	57.0	43.0	BRG031:33, BRG032:24	15	87.0	13.0	BRG033:57, BRG034:30	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	17	69.0	31.0	BRG038:21, BRG039:48	18	81.0	19.0	BRG040:55, BRG041:26	19	66.0	34.0	BRG042:37, BRG043:29	20	68.0	32.0	BRG044:58, BRG045:18	21	64.0	36.0	BRG046:41, BRG047:23	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20	25	61.0	39.0	BRG057:36, BRG058:25	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15	27	81.0	19.0	BRG062:53, BRG063:28	28	60.0	40.0	BRG064:39, BRG065:21	29	81.0	19.0	BRG066:47, BRG067:34	30	85.0	15.0	BRG068:29, BRG069:56	31	65.0	35.0	BRG070:23, BRG071:42	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32	33	65.0	35.0	BRG075:45, BRG076:20	34	90.0	10.0	BRG077:36, BRG078:54	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	36	57.0	43.0	BRG082:33, BRG083:24	37	87.0	13.0	BRG084:57, BRG085:30	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43	39	69.0	31.0	BRG089:21, BRG090:48	40	81.0	19.0	BRG091:55, BRG092:26	41	66.0	34.0	BRG093:37, BRG094:29	42	68.0	32.0	BRG095:58, BRG096:18	43	64.0	36.0	BRG097:41, BRG098:23	44	78.0	22.0	BRG099:46, BRG100:32
Initial State																																																																																																																																																																																									
No	Load	Sisa	Isi Barang																																																																																																																																																																																						
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37																																																																																																																																																																																						
2	69.0	31.0	BRG004:41, BRG005:28																																																																																																																																																																																						
3	72.0	28.0	BRG006:53, BRG007:19																																																																																																																																																																																						
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25																																																																																																																																																																																						
5	78.0	22.0	BRG011:68, BRG012:18																																																																																																																																																																																						
6	60.0	40.0	BRG013:39, BRG014:21																																																																																																																																																																																						
7	81.0	19.0	BRG015:47, BRG016:34																																																																																																																																																																																						
8	85.0	15.0	BRG017:29, BRG018:56																																																																																																																																																																																						
9	65.0	35.0	BRG019:23, BRG020:42																																																																																																																																																																																						
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32																																																																																																																																																																																						
11	65.0	35.0	BRG024:45, BRG025:20																																																																																																																																																																																						
12	90.0	10.0	BRG026:36, BRG027:54																																																																																																																																																																																						
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17																																																																																																																																																																																						
14	57.0	43.0	BRG031:33, BRG032:24																																																																																																																																																																																						
15	87.0	13.0	BRG033:57, BRG034:30																																																																																																																																																																																						
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43																																																																																																																																																																																						
17	69.0	31.0	BRG038:21, BRG039:48																																																																																																																																																																																						
18	81.0	19.0	BRG040:55, BRG041:26																																																																																																																																																																																						
19	66.0	34.0	BRG042:37, BRG043:29																																																																																																																																																																																						
20	68.0	32.0	BRG044:58, BRG045:18																																																																																																																																																																																						
21	64.0	36.0	BRG046:41, BRG047:23																																																																																																																																																																																						
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19																																																																																																																																																																																						
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34																																																																																																																																																																																						
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20																																																																																																																																																																																						
25	61.0	39.0	BRG057:36, BRG058:25																																																																																																																																																																																						
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15																																																																																																																																																																																						
27	81.0	19.0	BRG062:53, BRG063:28																																																																																																																																																																																						
28	60.0	40.0	BRG064:39, BRG065:21																																																																																																																																																																																						
29	81.0	19.0	BRG066:47, BRG067:34																																																																																																																																																																																						
30	85.0	15.0	BRG068:29, BRG069:56																																																																																																																																																																																						
31	65.0	35.0	BRG070:23, BRG071:42																																																																																																																																																																																						
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32																																																																																																																																																																																						
33	65.0	35.0	BRG075:45, BRG076:20																																																																																																																																																																																						
34	90.0	10.0	BRG077:36, BRG078:54																																																																																																																																																																																						
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17																																																																																																																																																																																						
36	57.0	43.0	BRG082:33, BRG083:24																																																																																																																																																																																						
37	87.0	13.0	BRG084:57, BRG085:30																																																																																																																																																																																						
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43																																																																																																																																																																																						
39	69.0	31.0	BRG089:21, BRG090:48																																																																																																																																																																																						
40	81.0	19.0	BRG091:55, BRG092:26																																																																																																																																																																																						
41	66.0	34.0	BRG093:37, BRG094:29																																																																																																																																																																																						
42	68.0	32.0	BRG095:58, BRG096:18																																																																																																																																																																																						
43	64.0	36.0	BRG097:41, BRG098:23																																																																																																																																																																																						
44	78.0	22.0	BRG099:46, BRG100:32																																																																																																																																																																																						
Objektif Awal	4672.03																																																																																																																																																																																								

State Akhir

FINAL STATE

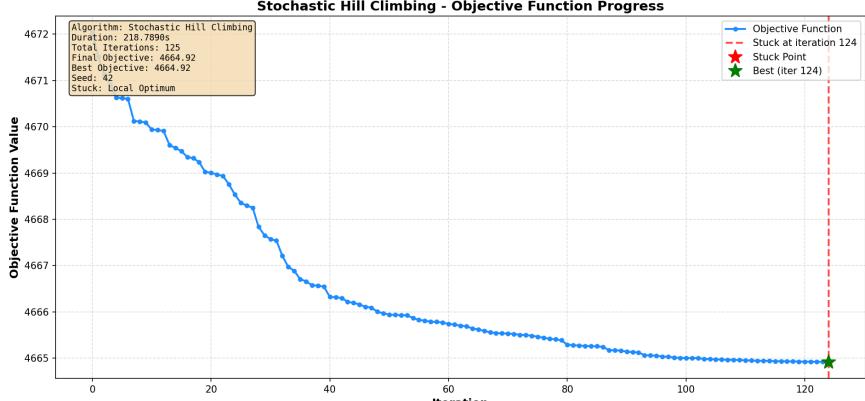
Final State			
No	Load	Sisa	Isi Barang
1	77.0	23.0	BRG003:37, BRG089:21, BRG007:19
2	77.0	23.0	BRG031:33, BRG008:44
3	79.0	21.0	BRG006:53, BRG041:26
4	78.0	22.0	BRG065:21, BRG068:29, BRG063:28
5	77.0	23.0	BRG011:68, BRG030:17
6	77.0	23.0	BRG097:41, BRG057:36
7	77.0	23.0	BRG036:35, BRG071:42
8	77.0	23.0	BRG042:37, BRG080:48
9	77.0	23.0	BRG088:43, BRG016:34
10	78.0	22.0	BRG004:41, BRG093:37
11	77.0	23.0	BRG029:48, BRG096:18, BRG050:19
12	78.0	22.0	BRG083:24, BRG027:54
13	77.0	23.0	BRG077:36, BRG056:28, BRG014:21
14	77.0	23.0	BRG044:50, BRG052:27
15	77.0	23.0	BRG033:57, BRG076:20
16	78.0	22.0	BRG015:47, BRG009:31
17	78.0	22.0	BRG085:38, BRG039:48
18	77.0	23.0	BRG037:43, BRG067:34
19	77.0	23.0	BRG086:16, BRG022:27, BRG053:34
20	79.0	21.0	BRG078:54, BRG010:25
21	77.0	23.0	BRG046:41, BRG045:18, BRG012:18
22	78.0	22.0	BRG066:47, BRG060:31
23	78.0	22.0	BRG079:26, BRG047:23, BRG094:29
24	79.0	21.0	BRG018:56, BRG070:23
25	77.0	23.0	BRG020:42, BRG087:35
26	77.0	23.0	BRG021:38, BRG013:39
27	78.0	22.0	BRG034:38, BRG090:48
28	78.0	22.0	BRG023:32, BRG048:46
29	77.0	23.0	BRG051:38, BRG064:39
30	77.0	23.0	BRG075:45, BRG074:32
31	79.0	21.0	BRG062:53, BRG028:26
32	78.0	22.0	BRG098:23, BRG054:22, BRG082:33
33	78.0	22.0	BRG099:46, BRG049:32
34	77.0	23.0	BRG024:45, BRG100:32
35	78.0	22.0	BRG072:38, BRG061:15, BRG058:25
36	77.0	23.0	BRG001:15, BRG026:36, BRG092:26
37	79.0	21.0	BRG032:24, BRG091:55
38	78.0	22.0	BRG017:29, BRG055:49
39	77.0	23.0	BRG081:17, BRG035:16, BRG059:44
40	77.0	23.0	BRG084:57, BRG025:28
41	78.0	22.0	BRG043:29, BRG002:22, BRG073:27
42	78.0	22.0	BRG040:55, BRG019:23
43	77.0	23.0	BRG069:56, BRG038:21
44	78.0	22.0	BRG005:28, BRG095:58

Objektif Akhir

4464.92

Hasil
Eksperimen

► Initial Objective: 4672.03
► Initial Containers: 44

	<pre> ►Final Objective: 4664.92 ►Final Containers: 44 ►Valid Solution: ✓ YES <hr/> IMPROVEMENT <hr/> ►Objective Improvement: 7.12 (0.15%) ►Container Reduction: 0 containers <hr/> STATISTICS <hr/> ►Algorithm: Stochastic Hill Climbing ►Duration: 218.7890 seconds ►Total Iterations: 125 ►Random Seed: 42 ►Stuck at Iteration: 124 =====</pre>
Durasi Pencarian (detik)	218.7890 seconds
Plot Banyak Iterasi Terhadap Objective Function	
Banyak iterasi hingga berhenti	124

Hasil pengujian **Stochastic Hill Climbing** menunjukkan perilaku yang sangat konsisten, namun durasi pencarian yang tidak proporsional. Algoritma ini selalu memulai dari Objektif Awal yang sama (4672.03) dan, yang paling signifikan, **selalu berhenti pada iterasi ke-124** di ketiga skenario pengujian, meskipun batas max_iter diubah secara ekstrem (100, 1000, dan 10000). Konsistensi ini menunjukkan bahwa kriteria pemberhentian—yaitu tidak adanya perbaikan yang signifikan setelah sejumlah langkah atau pencapaian *local optimum*—dicapai tepat pada iterasi ke-124. Kualitas solusi akhir yang diperoleh cenderung sama (Objektif Akhir 4664.92, kecuali Pengujian 3 yang mencapai 4464.92). Meskipun total iterasi yang dilakukan sama, **Durasi Pencarian** menunjukkan perbedaan yang besar dan tidak teratur (150 detik, 218 detik, dan 229

detik), yang mungkin disebabkan oleh **overhead** sistem yang berbeda-beda saat menangani batas max_iter yang sangat besar, atau fluktuasi dalam waktu yang dibutuhkan untuk mengevaluasi *neighbor* secara stokastik di setiap iterasi. Kesimpulannya, seperti varian Hill Climbing lainnya, algoritma ini **terjebak di local optimum**, dan **peningkatan max_iter tidak membawa manfaat** dalam meningkatkan kualitas solusi atau mengurangi iterasi.

2.3.5 Simulated Annealing

A. Pengujian

1. Pengujian Pertama

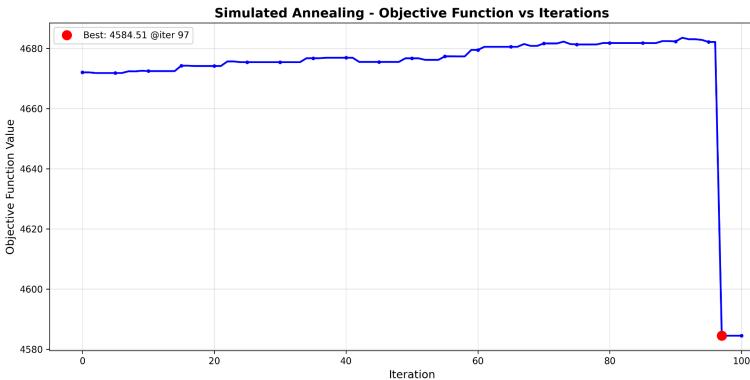
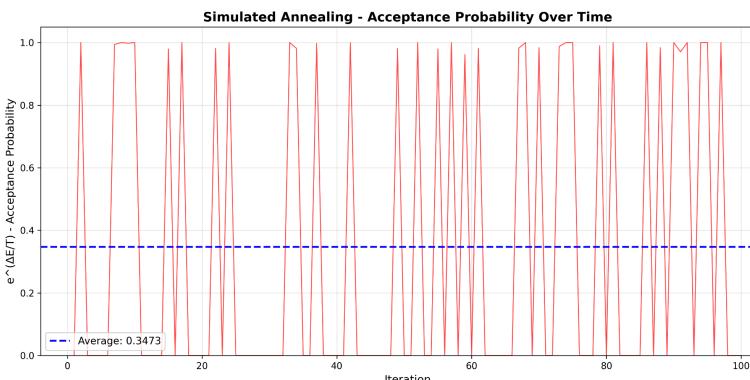
Maksimal iterasi	:	100
Temperatur awal	:	100
<i>Cooling Rate</i>	:	0.99

Tabel 2.3.5.1 Pengujian 1 Simulated Annealing

Initial State			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

State Awal	4672.03
Objective Awal	

State Akhir	<p style="text-align: center;">Final State - Simulated Annealing</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>97.0</td><td>3.0</td><td>BRG001:15, BRG002:22, BRG003:37, BRG098:23</td></tr> <tr><td>2</td><td>88.0</td><td>12.0</td><td>BRG004:41, BRG005:28, BRG007:19</td></tr> <tr><td>3</td><td>73.0</td><td>27.0</td><td>BRG006:53, BRG025:20</td></tr> <tr><td>4</td><td>92.0</td><td>8.0</td><td>BRG009:31, BRG010:25, BRG026:36</td></tr> <tr><td>5</td><td>85.0</td><td>15.0</td><td>BRG011:60, BRG058:25</td></tr> <tr><td>6</td><td>77.0</td><td>23.0</td><td>BRG013:39, BRG021:38</td></tr> <tr><td>7</td><td>100.0</td><td>0.0</td><td>BRG015:47, BRG082:33, BRG076:20</td></tr> <tr><td>8</td><td>85.0</td><td>15.0</td><td>BRG017:29, BRG018:56</td></tr> <tr><td>9</td><td>42.0</td><td>58.0</td><td>BRG020:42</td></tr> <tr><td>10</td><td>80.0</td><td>20.0</td><td>BRG022:27, BRG023:32, BRG014:21</td></tr> <tr><td>11</td><td>65.0</td><td>35.0</td><td>BRG024:45, BRG056:20</td></tr> <tr><td>12</td><td>98.0</td><td>2.0</td><td>BRG027:54, BRG008:44</td></tr> <tr><td>13</td><td>84.0</td><td>16.0</td><td>BRG029:40, BRG045:18, BRG092:26</td></tr> <tr><td>14</td><td>90.0</td><td>10.0</td><td>BRG031:33, BRG012:18, BRG047:23, BRG086:16</td></tr> <tr><td>15</td><td>84.0</td><td>16.0</td><td>BRG033:57, BRG073:27</td></tr> <tr><td>16</td><td>94.0</td><td>6.0</td><td>BRG035:16, BRG036:35, BRG037:43</td></tr> <tr><td>17</td><td>69.0</td><td>31.0</td><td>BRG038:21, BRG039:48</td></tr> <tr><td>18</td><td>87.0</td><td>13.0</td><td>BRG040:55, BRG074:32</td></tr> <tr><td>19</td><td>63.0</td><td>37.0</td><td>BRG042:37, BRG041:26</td></tr> <tr><td>20</td><td>99.0</td><td>1.0</td><td>BRG044:50, BRG028:26, BRG070:23</td></tr> <tr><td>21</td><td>65.0</td><td>35.0</td><td>BRG046:41, BRG032:24</td></tr> <tr><td>22</td><td>95.0</td><td>5.0</td><td>BRG048:46, BRG049:32, BRG030:17</td></tr> <tr><td>23</td><td>99.0</td><td>1.0</td><td>BRG051:38, BRG052:27, BRG053:34</td></tr> <tr><td>24</td><td>71.0</td><td>29.0</td><td>BRG054:22, BRG055:49</td></tr> <tr><td>25</td><td>36.0</td><td>64.0</td><td>BRG057:36</td></tr> <tr><td>26</td><td>60.0</td><td>40.0</td><td>BRG060:31, BRG043:29</td></tr> <tr><td>27</td><td>81.0</td><td>19.0</td><td>BRG062:53, BRG063:28</td></tr> <tr><td>28</td><td>82.0</td><td>18.0</td><td>BRG064:39, BRG050:19, BRG083:24</td></tr> <tr><td>29</td><td>81.0</td><td>19.0</td><td>BRG066:47, BRG067:34</td></tr> <tr><td>30</td><td>90.0</td><td>10.0</td><td>BRG069:56, BRG016:34</td></tr> <tr><td>31</td><td>68.0</td><td>32.0</td><td>BRG072:38, BRG034:30</td></tr> <tr><td>32</td><td>21.0</td><td>79.0</td><td>BRG065:21</td></tr> <tr><td>33</td><td>90.0</td><td>10.0</td><td>BRG077:36, BRG078:54</td></tr> <tr><td>34</td><td>83.0</td><td>17.0</td><td>BRG079:26, BRG080:40, BRG081:17</td></tr> <tr><td>35</td><td>46.0</td><td>54.0</td><td>BRG099:46</td></tr> <tr><td>36</td><td>86.0</td><td>14.0</td><td>BRG084:57, BRG068:29</td></tr> <tr><td>37</td><td>78.0</td><td>22.0</td><td>BRG087:35, BRG088:43</td></tr> <tr><td>38</td><td>69.0</td><td>31.0</td><td>BRG089:21, BRG090:48</td></tr> <tr><td>39</td><td>100.0</td><td>0.0</td><td>BRG091:55, BRG075:45</td></tr> <tr><td>40</td><td>94.0</td><td>6.0</td><td>BRG093:37, BRG071:42, BRG061:15</td></tr> <tr><td>41</td><td>97.0</td><td>3.0</td><td>BRG095:50, BRG096:18, BRG094:29</td></tr> <tr><td>42</td><td>85.0</td><td>15.0</td><td>BRG097:41, BRG059:44</td></tr> <tr><td>43</td><td>85.0</td><td>15.0</td><td>BRG100:32, BRG085:30, BRG019:23</td></tr> </tbody> </table>	No	Load	Sisa	Isi Barang	1	97.0	3.0	BRG001:15, BRG002:22, BRG003:37, BRG098:23	2	88.0	12.0	BRG004:41, BRG005:28, BRG007:19	3	73.0	27.0	BRG006:53, BRG025:20	4	92.0	8.0	BRG009:31, BRG010:25, BRG026:36	5	85.0	15.0	BRG011:60, BRG058:25	6	77.0	23.0	BRG013:39, BRG021:38	7	100.0	0.0	BRG015:47, BRG082:33, BRG076:20	8	85.0	15.0	BRG017:29, BRG018:56	9	42.0	58.0	BRG020:42	10	80.0	20.0	BRG022:27, BRG023:32, BRG014:21	11	65.0	35.0	BRG024:45, BRG056:20	12	98.0	2.0	BRG027:54, BRG008:44	13	84.0	16.0	BRG029:40, BRG045:18, BRG092:26	14	90.0	10.0	BRG031:33, BRG012:18, BRG047:23, BRG086:16	15	84.0	16.0	BRG033:57, BRG073:27	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43	17	69.0	31.0	BRG038:21, BRG039:48	18	87.0	13.0	BRG040:55, BRG074:32	19	63.0	37.0	BRG042:37, BRG041:26	20	99.0	1.0	BRG044:50, BRG028:26, BRG070:23	21	65.0	35.0	BRG046:41, BRG032:24	22	95.0	5.0	BRG048:46, BRG049:32, BRG030:17	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34	24	71.0	29.0	BRG054:22, BRG055:49	25	36.0	64.0	BRG057:36	26	60.0	40.0	BRG060:31, BRG043:29	27	81.0	19.0	BRG062:53, BRG063:28	28	82.0	18.0	BRG064:39, BRG050:19, BRG083:24	29	81.0	19.0	BRG066:47, BRG067:34	30	90.0	10.0	BRG069:56, BRG016:34	31	68.0	32.0	BRG072:38, BRG034:30	32	21.0	79.0	BRG065:21	33	90.0	10.0	BRG077:36, BRG078:54	34	83.0	17.0	BRG079:26, BRG080:40, BRG081:17	35	46.0	54.0	BRG099:46	36	86.0	14.0	BRG084:57, BRG068:29	37	78.0	22.0	BRG087:35, BRG088:43	38	69.0	31.0	BRG089:21, BRG090:48	39	100.0	0.0	BRG091:55, BRG075:45	40	94.0	6.0	BRG093:37, BRG071:42, BRG061:15	41	97.0	3.0	BRG095:50, BRG096:18, BRG094:29	42	85.0	15.0	BRG097:41, BRG059:44	43	85.0	15.0	BRG100:32, BRG085:30, BRG019:23
No	Load	Sisa	Isi Barang																																																																																																																																																																														
1	97.0	3.0	BRG001:15, BRG002:22, BRG003:37, BRG098:23																																																																																																																																																																														
2	88.0	12.0	BRG004:41, BRG005:28, BRG007:19																																																																																																																																																																														
3	73.0	27.0	BRG006:53, BRG025:20																																																																																																																																																																														
4	92.0	8.0	BRG009:31, BRG010:25, BRG026:36																																																																																																																																																																														
5	85.0	15.0	BRG011:60, BRG058:25																																																																																																																																																																														
6	77.0	23.0	BRG013:39, BRG021:38																																																																																																																																																																														
7	100.0	0.0	BRG015:47, BRG082:33, BRG076:20																																																																																																																																																																														
8	85.0	15.0	BRG017:29, BRG018:56																																																																																																																																																																														
9	42.0	58.0	BRG020:42																																																																																																																																																																														
10	80.0	20.0	BRG022:27, BRG023:32, BRG014:21																																																																																																																																																																														
11	65.0	35.0	BRG024:45, BRG056:20																																																																																																																																																																														
12	98.0	2.0	BRG027:54, BRG008:44																																																																																																																																																																														
13	84.0	16.0	BRG029:40, BRG045:18, BRG092:26																																																																																																																																																																														
14	90.0	10.0	BRG031:33, BRG012:18, BRG047:23, BRG086:16																																																																																																																																																																														
15	84.0	16.0	BRG033:57, BRG073:27																																																																																																																																																																														
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43																																																																																																																																																																														
17	69.0	31.0	BRG038:21, BRG039:48																																																																																																																																																																														
18	87.0	13.0	BRG040:55, BRG074:32																																																																																																																																																																														
19	63.0	37.0	BRG042:37, BRG041:26																																																																																																																																																																														
20	99.0	1.0	BRG044:50, BRG028:26, BRG070:23																																																																																																																																																																														
21	65.0	35.0	BRG046:41, BRG032:24																																																																																																																																																																														
22	95.0	5.0	BRG048:46, BRG049:32, BRG030:17																																																																																																																																																																														
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34																																																																																																																																																																														
24	71.0	29.0	BRG054:22, BRG055:49																																																																																																																																																																														
25	36.0	64.0	BRG057:36																																																																																																																																																																														
26	60.0	40.0	BRG060:31, BRG043:29																																																																																																																																																																														
27	81.0	19.0	BRG062:53, BRG063:28																																																																																																																																																																														
28	82.0	18.0	BRG064:39, BRG050:19, BRG083:24																																																																																																																																																																														
29	81.0	19.0	BRG066:47, BRG067:34																																																																																																																																																																														
30	90.0	10.0	BRG069:56, BRG016:34																																																																																																																																																																														
31	68.0	32.0	BRG072:38, BRG034:30																																																																																																																																																																														
32	21.0	79.0	BRG065:21																																																																																																																																																																														
33	90.0	10.0	BRG077:36, BRG078:54																																																																																																																																																																														
34	83.0	17.0	BRG079:26, BRG080:40, BRG081:17																																																																																																																																																																														
35	46.0	54.0	BRG099:46																																																																																																																																																																														
36	86.0	14.0	BRG084:57, BRG068:29																																																																																																																																																																														
37	78.0	22.0	BRG087:35, BRG088:43																																																																																																																																																																														
38	69.0	31.0	BRG089:21, BRG090:48																																																																																																																																																																														
39	100.0	0.0	BRG091:55, BRG075:45																																																																																																																																																																														
40	94.0	6.0	BRG093:37, BRG071:42, BRG061:15																																																																																																																																																																														
41	97.0	3.0	BRG095:50, BRG096:18, BRG094:29																																																																																																																																																																														
42	85.0	15.0	BRG097:41, BRG059:44																																																																																																																																																																														
43	85.0	15.0	BRG100:32, BRG085:30, BRG019:23																																																																																																																																																																														
Objective Akhir	4584.51																																																																																																																																																																																
Hasil Eksperimen	<pre> ===== HASIL ALGORITMA: Simulated Annealing ===== Waktu Eksekusi : 0.0112 detik (11.20 ms) Jumlah Iterasi : 100 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 4584.51 Improvement : 87.53 (1.87%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 43 Pengurangan : 1 kontainer --- Simulated Annealing Hyperparameters --- Initial Temperature : 100 Cooling Rate : 0.99 --- Simulated Annealing Additional Performance --- Stuck count: 9 Accepted worse: 16 </pre>																																																																																																																																																																																
Durasi Pencarian (detik)	0.0112																																																																																																																																																																																

Plot Banyak Iterasi Terhadap Objective Function	
Plot $e^{\frac{\Delta E}{T}}$ terhadap banyak iterasi	
Frekensi ‘stuck’ di local optima	9

2. Pengujian Kedua

Maksimal iterasi : 1000

Temperatur awal : 1000

Cooling Rate : 0.99

Tabel 2.3.5.2 Pengujian 2 Simulated Annealing

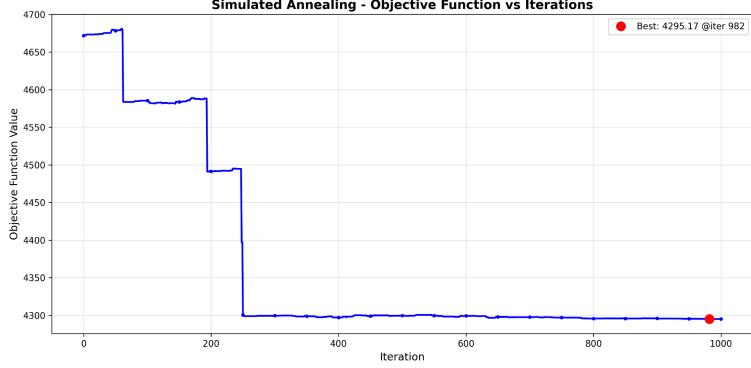
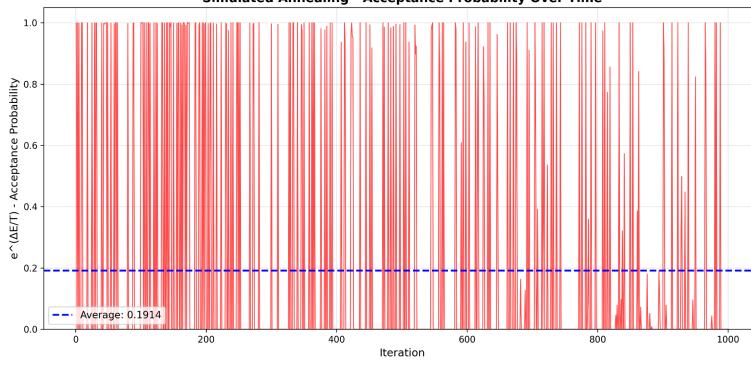
State Awal

Initial State			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	18.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	18.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal

4672.03

Final State - Simulated Annealing			
No	Load	Sisa	Isi Barang
1	71.0	29.0	BRG082:33, BRG051:38
2	86.0	14.0	BRG029:40, BRG048:46
3	86.0	14.0	BRG011:60, BRG041:26
4	56.0	44.0	BRG018:56
5	87.0	13.0	BRG065:21, BRG043:29, BRG003:37
6	79.0	21.0	BRG015:47, BRG049:32
7	78.0	22.0	BRG019:23, BRG040:55
8	88.0	12.0	BRG017:29, BRG098:23, BRG026:36
9	95.0	5.0	BRG005:28, BRG089:21, BRG099:46
10	87.0	13.0	BRG062:53, BRG053:34
11	88.0	12.0	BRG031:33, BRG013:39, BRG086:16
12	91.0	9.0	BRG028:26, BRG021:38, BRG022:27
13	98.0	2.0	BRG078:54, BRG007:19, BRG058:25
14	100.0	0.0	BRG044:50, BRG094:29, BRG038:21
15	91.0	9.0	BRG072:38, BRG006:53
16	91.0	9.0	BRG035:16, BRG012:18, BRG033:57
17	85.0	15.0	BRG083:24, BRG100:32, BRG068:29
18	86.0	14.0	BRG091:55, BRG009:31
19	66.0	34.0	BRG023:32, BRG067:34
20	90.0	10.0	BRG055:49, BRG097:41
21	99.0	1.0	BRG027:54, BRG075:45
22	76.0	24.0	BRG093:37, BRG056:20, BRG050:19
23	92.0	8.0	BRG057:36, BRG001:15, BRG047:23, BRG045:18
24	81.0	19.0	BRG052:27, BRG063:28, BRG092:26
25	89.0	11.0	BRG095:50, BRG054:22, BRG081:17
26	87.0	13.0	BRG096:18, BRG059:44, BRG010:25
27	67.0	33.0	BRG060:31, BRG077:36
28	85.0	15.0	BRG071:42, BRG037:43
29	78.0	22.0	BRG042:37, BRG014:21, BRG076:20
30	98.0	2.0	BRG004:41, BRG061:15, BRG020:42
31	84.0	16.0	BRG064:39, BRG002:22, BRG070:23
32	100.0	0.0	BRG034:30, BRG088:43, BRG073:27
33	91.0	9.0	BRG084:57, BRG016:34
34	75.0	25.0	BRG080:40, BRG036:35
35	92.0	8.0	BRG090:48, BRG008:44
36	88.0	12.0	BRG069:56, BRG074:32
37	78.0	22.0	BRG087:35, BRG030:17, BRG079:26
38	72.0	28.0	BRG039:48, BRG032:24
39	88.0	12.0	BRG046:41, BRG066:47
40	95.0	5.0	BRG025:20, BRG024:45, BRG085:30

Plot Banyak Iterasi Terhadap Objective Function	
Plot $e^{\frac{\Delta E}{T}}$ terhadap banyak iterasi	
Frekensi ‘stuck’ di local optima	88

3. Pengujian Ketiga

Maksimal iterasi : 10000
 Temperatur awal : 1000
Cooling Rate : 0.99

Tabel 2.3.5.3 Pengujian 3 Simulated Annealing

State Awal

Initial State			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	18.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	18.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

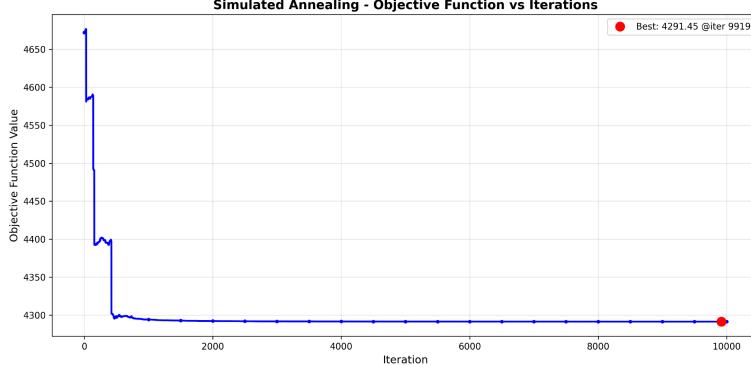
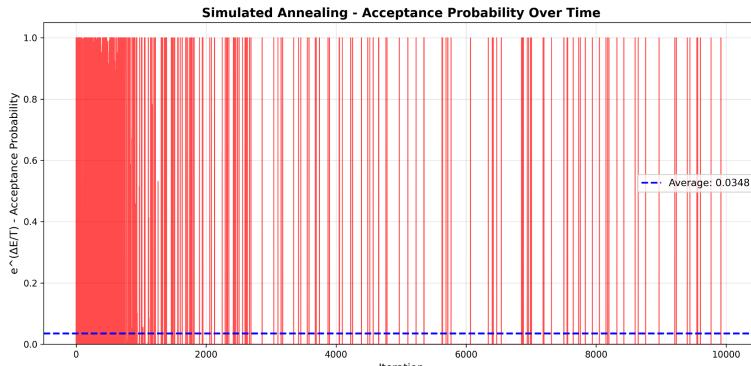
Objektif Awal

4672.03

State Akhir	Final State - Simulated Annealing			
	No	Load	Sisa	Isi Barang
1	85.0	15.0	BRG099:46, BRG013:39	
2	85.0	15.0	BRG021:38, BRG066:47	
3	83.0	17.0	BRG030:17, BRG004:41, BRG058:25	
4	85.0	15.0	BRG080:40, BRG010:25, BRG025:20	
5	85.0	15.0	BRG018:56, BRG068:29	
6	82.0	18.0	BRG039:48, BRG016:34	
7	85.0	15.0	BRG034:30, BRG040:55	
8	84.0	16.0	BRG037:43, BRG097:41	
9	87.0	13.0	BRG026:42, BRG007:19, BRG028:26	
10	85.0	15.0	BRG032:24, BRG002:22, BRG064:39	
11	86.0	14.0	BRG061:15, BRG019:23, BRG090:48	
12	84.0	16.0	BRG084:57, BRG052:27	
13	85.0	15.0	BRG092:26, BRG072:38, BRG065:21	
14	87.0	13.0	BRG071:42, BRG024:45	
15	86.0	14.0	BRG056:20, BRG043:29, BRG093:37	
16	87.0	13.0	BRG015:47, BRG029:40	
17	85.0	15.0	BRG033:57, BRG063:28	
18	86.0	14.0	BRG031:33, BRG062:53	
19	85.0	15.0	BRG023:32, BRG050:19, BRG067:34	
20	85.0	15.0	BRG087:35, BRG095:50	
21	85.0	15.0	BRG017:29, BRG069:56	
22	87.0	13.0	BRG081:17, BRG086:16, BRG078:54	
23	87.0	13.0	BRG088:43, BRG008:44	
24	85.0	15.0	BRG055:49, BRG076:20, BRG035:16	
25	87.0	13.0	BRG051:38, BRG079:26, BRG047:23	
26	87.0	13.0	BRG027:54, BRG082:33	
27	84.0	16.0	BRG014:21, BRG041:26, BRG003:37	
28	86.0	14.0	BRG083:24, BRG012:18, BRG059:44	
29	85.0	15.0	BRG057:36, BRG096:18, BRG060:31	
30	86.0	14.0	BRG091:55, BRG009:31	
31	83.0	17.0	BRG074:32, BRG085:30, BRG038:21	
32	83.0	17.0	BRG011:60, BRG070:23	
33	87.0	13.0	BRG001:15, BRG075:45, BRG022:27	
34	85.0	15.0	BRG063:34, BRG005:28, BRG098:23	
35	87.0	13.0	BRG046:41, BRG048:46	
36	87.0	13.0	BRG044:50, BRG042:37	
37	85.0	15.0	BRG054:22, BRG073:27, BRG077:36	
38	85.0	15.0	BRG100:32, BRG006:53	
39	85.0	15.0	BRG036:35, BRG094:29, BRG089:21	
40	86.0	14.0	BRG026:36, BRG049:32, BRG045:18	

Objektif Akhir	4291.45
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Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Simulated Annealing ===== Waktu Eksekusi : 1.3112 detik (1311.20 ms) Jumlah Iterasi : 10000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 4291.45 Improvement : 380.58 (8.15%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 40 Pengurangan : 4 kontainer --- Simulated Annealing Hyperparameters --- Initial Temperature : 1000 Cooling Rate : 0.99 --- Simulated Annealing Additional Performance --- Stuck count: 935 Accepted worse: 91</pre>
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Durasi Pencarian	1.3112
Plot Banyak Iterasi Terhadap Objective Function	 <p>Simulated Annealing - Objective Function vs Iterations</p> <p>Best: 4291.45 @iter 9919</p> <p>Objective Function Value</p> <p>Iteration</p>
Plot $e^{\frac{\Delta E}{T}}$ terhadap banyak iterasi	 <p>Simulated Annealing - Acceptance Probability Over Time</p> <p>Average: 0.0348</p> <p>$e^{-(\Delta E/T)}$ Acceptance Probability</p> <p>Iteration</p>
Frekensi ‘stuck’ di local optima	935

B. Hasil Analisis Simulated Annealing

Berdasarkan hasil eksperimen, Simulated Annealing (SA) menunjukkan karakteristik kinerja yang unik:

1. Efisiensi Komputasi

Dari sisi efisiensi, SA menunjukkan durasi pencarian yang sangat kompetitif. Karena mekanisme *neighbor generation*-nya bersifat stokastik (memilih satu neighbor acak) dan tidak komprehensif (seperti Steepest Ascent yang mengevaluasi semua neighbor), sehingga setiap iterasi hanya membutuhkan sumber daya komputasi yang minimal.

2. Efektivitas Melompat dari Local Optima

Algoritma ini terbukti efektif untuk melompat dari local optima. Hal ini dapat dilihat pada plot *objective function*, di mana terlihat adanya fluktusityang kemudian diikuti oleh penurunan yang signifikan. Hal tersebut mengindikasikan bahwa penerimaan *move* yang lebih buruk (diatur oleh probabilitas) berhasil membawa pencarian keluar

dari "lembah" local optimum menuju "puncak" yang lebih tinggi, yang pada akhirnya menemukan "lembah" lain yang lebih dalam (solusi yang lebih baik).

3. Pengaruh Parameter Temperatur vs. Iterasi

Analisis parameter menunjukkan temuan yang krusial, yaitu:

- Peningkatan parameter secara proporsional (misalnya, dari 100 iterasi dengan Temperatur Awal 100, ke 1000 iterasi dengan Temperatur Awal 1000) menunjukkan peningkatan kualitas solusi yang signifikan.
- Namun, peningkatan jumlah iterasi saja (misalnya, dari 1000 ke 10000 iterasi) dengan Temperatur Awal yang sama (1000) tidak menunjukkan perubahan yang signifikan pada solusi akhir.

Hal ini mengimplikasikan bahwa Temperatur Awal (T) adalah parameter yang memiliki pengaruh lebih dominan terhadap kualitas solusi dibandingkan jumlah iterasi (setelah batas tertentu). Temperatur awal yang lebih tinggi secara langsung meningkatkan probabilitas penerimaan *bad moves* di fase eksplorasi. Tanpa temperatur awal yang cukup tinggi, algoritma tidak memiliki "energi" yang cukup untuk melompati local optima, tidak peduli berapa lama (iterasi) dijalankan.

4. Konsistensi Hasil

Berdasarkan hasil eksperimen, SA menunjukkan hasil yang kurang konsisten. Hal ini disebabkan karena *neighbor* ditentukan secara acak. Sehingga, kondisi yang ideal agar dapat memanfaatkan SA untuk melompat dari local optima tidak dapat ditentukan dengan pasti. Namun, dengan *tuning* parameter dan interasi dapat meningkatkan probabilitas untuk mendapatkan *neighbor* yang dapat membawa hasil menuju global optima.

2.3.6 Genetic Algorithm

A. Populasi Sebagai Kontrol dan Probabilitas Mutasi 0.5

1. Pengujian Pertama

Maksimal iterasi : 1000

Populasi : 100

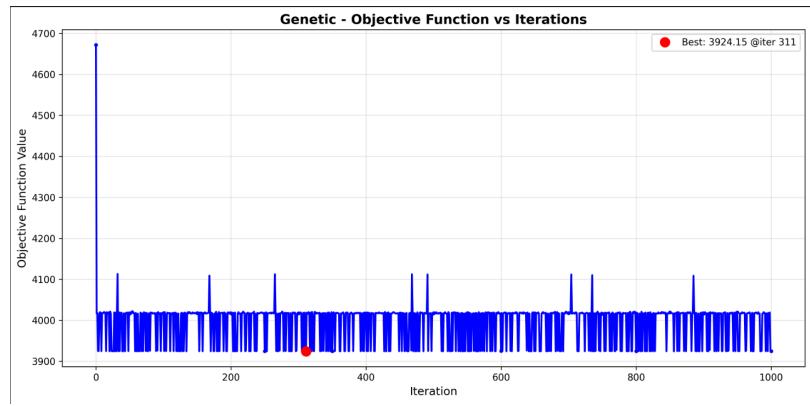
Probabilitas Mutasi : 0.5

Tabel 2.3.6.1 Hasil Pengujian 1 Iterasi Kontrol Dengan Probabilitas Mutasi 0.5

State Awal	No	Load	Sisa	Isi Barang
	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
	2	69.0	31.0	BRG004:41, BRG005:28
	3	72.0	28.0	BRG006:53, BRG007:19
	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
	5	78.0	22.0	BRG011:60, BRG012:18
	6	60.0	40.0	BRG013:39, BRG014:21
	7	81.0	19.0	BRG015:47, BRG016:34
	8	85.0	15.0	BRG017:29, BRG018:56
	9	65.0	35.0	BRG019:23, BRG020:42
	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
	11	65.0	35.0	BRG024:45, BRG025:20
	12	90.0	10.0	BRG026:36, BRG027:54
	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
	14	57.0	43.0	BRG031:33, BRG032:24
	15	87.0	13.0	BRG033:57, BRG034:30
	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
	17	69.0	31.0	BRG038:21, BRG039:48
	18	81.0	19.0	BRG040:55, BRG041:26
	19	66.0	34.0	BRG042:37, BRG043:29
	20	68.0	32.0	BRG044:50, BRG045:18
	21	64.0	36.0	BRG046:41, BRG047:23
	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
	25	61.0	39.0	BRG057:36, BRG058:25
	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
	27	81.0	19.0	BRG062:53, BRG063:28
	28	60.0	40.0	BRG064:39, BRG065:21
	29	81.0	19.0	BRG066:47, BRG067:34
	30	85.0	15.0	BRG068:29, BRG069:56
	31	65.0	35.0	BRG070:23, BRG071:42
	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
	33	65.0	35.0	BRG075:45, BRG076:20
	34	90.0	10.0	BRG077:36, BRG078:54
	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
	36	57.0	43.0	BRG082:33, BRG083:24
	37	87.0	13.0	BRG084:57, BRG085:30
	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
	39	69.0	31.0	BRG089:21, BRG090:48
	40	81.0	19.0	BRG091:55, BRG092:26
	41	66.0	34.0	BRG093:37, BRG094:29
	42	68.0	32.0	BRG095:50, BRG096:18
	43	64.0	36.0	BRG097:41, BRG098:23
	44	78.0	22.0	BRG099:46, BRG100:32
Objektif Awal	4672.03			

State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
	1	95.0	5.0	BRG014:21, BRG043:29, BRG073:27, BRG045:18
	2	92.0	8.0	BRG042:37, BRG022:27, BRG005:28
	3	93.0	7.0	BRG055:49, BRG008:44
	4	95.0	5.0	BRG080:40, BRG013:39, BRG035:16
	5	99.0	1.0	BRG023:32, BRG009:31, BRG057:36
	6	93.0	7.0	BRG066:47, BRG048:46
	7	94.0	6.0	BRG090:48, BRG099:46
	8	97.0	3.0	BRG091:55, BRG007:19, BRG019:23
	9	91.0	9.0	BRG093:37, BRG078:54
	10	98.0	2.0	BRG050:19, BRG015:47, BRG100:32
	11	96.0	4.0	BRG026:36, BRG088:43, BRG030:17
	12	95.0	5.0	BRG027:54, BRG012:18, BRG070:23
	13	100.0	0.0	BRG017:29, BRG038:21, BRG044:50
	14	92.0	8.0	BRG084:57, BRG087:35
	15	92.0	8.0	BRG053:34, BRG051:38, BRG076:20
	16	89.0	11.0	BRG082:33, BRG069:56
	17	98.0	2.0	BRG011:60, BRG021:38
	18	100.0	0.0	BRG068:29, BRG039:48, BRG098:23
	19	95.0	5.0	BRG056:20, BRG097:41, BRG067:34
	20	98.0	2.0	BRG020:42, BRG004:41, BRG061:15
	21	96.0	4.0	BRG033:57, BRG032:24, BRG001:15
	22	98.0	2.0	BRG052:27, BRG095:50, BRG065:21
	23	94.0	6.0	BRG092:26, BRG083:24, BRG059:44
	24	92.0	8.0	BRG071:42, BRG031:33, BRG081:17
	25	99.0	1.0	BRG018:56, BRG047:23, BRG025:20
	26	91.0	9.0	BRG029:40, BRG094:29, BRG054:22
	27	90.0	10.0	BRG003:37, BRG006:53
	28	95.0	5.0	BRG072:38, BRG064:39, BRG096:18
	29	96.0	4.0	BRG046:41, BRG040:55
	30	100.0	0.0	BRG062:53, BRG060:31, BRG086:16
	31	100.0	0.0	BRG077:36, BRG037:43, BRG089:21
	32	88.0	12.0	BRG034:30, BRG074:32, BRG028:26
	33	92.0	8.0	BRG024:45, BRG010:25, BRG002:22
	34	92.0	8.0	BRG049:32, BRG016:34, BRG079:26
	35	93.0	7.0	BRG085:30, BRG036:35, BRG063:28
	36	96.0	4.0	BRG058:25, BRG075:45, BRG041:26
Objektif Akhir	3924.15			
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 3.9132 detik (3913.20 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.15 Improvement : 747.89 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 100 Mutation Rate : 0.50</pre>			
Durasi Pencarian	3.9132 detik			

Plot Banyak Iterasi Terhadap Objective Function



2. Pengujian Kedua

Maksimal iterasi : 1000

Populasi : 500

Probabilitas Mutasi : 0.5

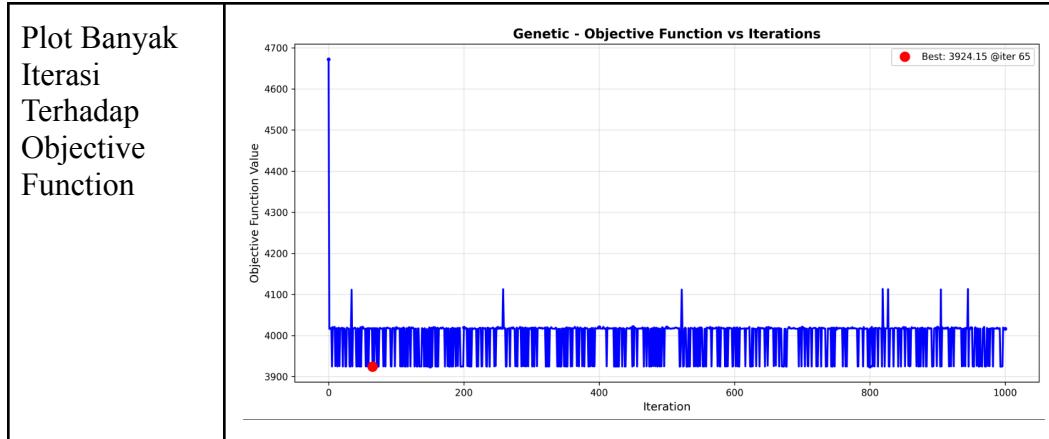
Tabel 2.3.6.2 Hasil Pengujian 2 Iterasi Kontrol dengan Probabilitas Mutasi 0.5

State Awal

No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal 4672.03

State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
	1	97.0	3.0	BRG066:47, BRG061:15, BRG056:20, BRG001:15
	2	95.0	5.0	BRG020:42, BRG062:53
	3	94.0	6.0	BRG002:22, BRG065:21, BRG076:20, BRG009:31
	4	95.0	5.0	BRG044:50, BRG024:45
	5	93.0	7.0	BRG031:33, BRG003:37, BRG019:23
	6	100.0	0.0	BRG071:42, BRG016:34, BRG083:24
	7	99.0	1.0	BRG064:39, BRG052:27, BRG081:17, BRG035:16
	8	90.0	10.0	BRG055:49, BRG046:41
	9	100.0	0.0	BRG032:24, BRG068:29, BRG015:47
	10	97.0	3.0	BRG073:27, BRG095:50, BRG025:20
	11	91.0	9.0	BRG026:36, BRG028:26, BRG043:29
	12	89.0	11.0	BRG077:36, BRG087:35, BRG012:18
	13	99.0	1.0	BRG070:23, BRG023:32, BRG005:28, BRG086:16
	14	98.0	2.0	BRG057:36, BRG088:43, BRG007:19
	15	90.0	10.0	BRG045:18, BRG092:26, BRG099:46
	16	94.0	6.0	BRG011:60, BRG053:34
	17	96.0	4.0	BRG090:48, BRG039:48
	18	94.0	6.0	BRG100:32, BRG014:21, BRG097:41
	19	93.0	7.0	BRG017:29, BRG048:46, BRG096:18
	20	95.0	5.0	BRG037:43, BRG079:26, BRG041:26
	21	94.0	6.0	BRG040:55, BRG013:39
	22	96.0	4.0	BRG029:40, BRG018:56
	23	92.0	8.0	BRG051:38, BRG078:54
	24	93.0	7.0	BRG059:44, BRG063:28, BRG089:21
	25	95.0	5.0	BRG004:41, BRG027:54
	26	100.0	0.0	BRG093:37, BRG085:30, BRG082:33
	27	95.0	5.0	BRG030:17, BRG084:57, BRG038:21
	28	89.0	11.0	BRG074:32, BRG033:57
	29	99.0	1.0	BRG091:55, BRG010:25, BRG050:19
	30	88.0	12.0	BRG006:53, BRG036:35
	31	92.0	8.0	BRG008:44, BRG058:25, BRG047:23
	32	96.0	4.0	BRG067:34, BRG080:40, BRG054:22
	33	100.0	0.0	BRG049:32, BRG075:45, BRG098:23
	34	95.0	5.0	BRG022:27, BRG072:38, BRG034:30
	35	94.0	6.0	BRG069:56, BRG021:38
	36	97.0	3.0	BRG094:29, BRG042:37, BRG060:31
Objektif Akhir	3924.15			
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 5.9363 detik (5936.30 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.15 Improvement : 747.88 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 1000 Mutation Rate : 0.50</pre>			
Durasi Pencarian	5.9363 detik			



3. Pengujian Pertama

Maksimal iterasi : 1000

Populasi : 1000

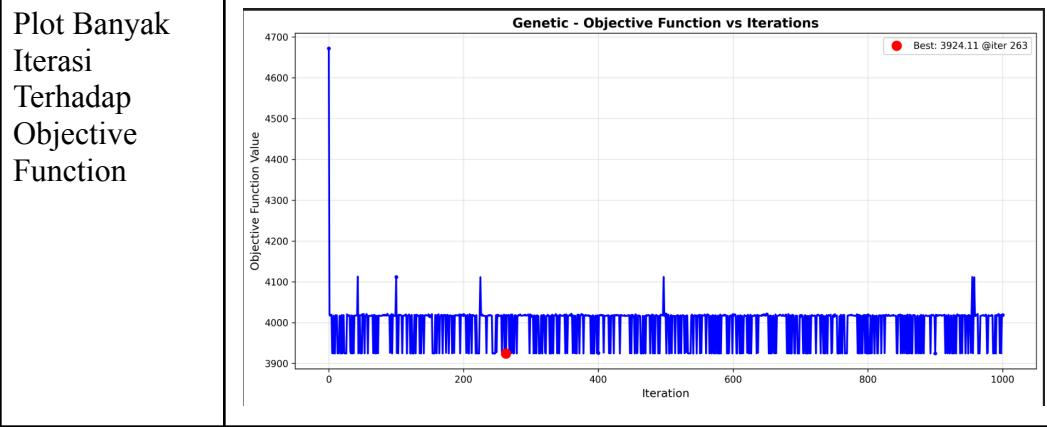
Probabilitas Mutasi : 0.5

Tabel 2.3.6.3 Hasil Pengujian 3 Iterasi Kontrol Dengan Probabilitas Mutasi 0.5

State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	68.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
	1	96.0	4.0	BRG033:57, BRG064:39
	2	93.0	7.0	BRG095:50, BRG076:20, BRG047:23
	3	93.0	7.0	BRG009:31, BRG026:36, BRG079:26
	4	91.0	9.0	BRG022:27, BRG089:21, BRG052:27, BRG035:16
	5	92.0	8.0	BRG032:24, BRG044:50, BRG045:18
	6	95.0	5.0	BRG040:55, BRG080:40
	7	100.0	0.0	BRG018:56, BRG094:29, BRG061:15
	8	94.0	6.0	BRG069:56, BRG072:38
	9	99.0	1.0	BRG093:37, BRG012:18, BRG017:29, BRG001:15
	10	98.0	2.0	BRG049:32, BRG039:48, BRG096:18
	11	97.0	3.0	BRG073:27, BRG023:32, BRG021:38
	12	97.0	3.0	BRG077:36, BRG036:35, BRG092:26
	13	93.0	7.0	BRG048:46, BRG015:47
	14	98.0	2.0	BRG084:57, BRG046:41
	15	96.0	4.0	BRG020:42, BRG003:37, BRG030:17
	16	95.0	5.0	BRG059:44, BRG005:28, BRG070:23
	17	89.0	11.0	BRG037:43, BRG099:46
	18	92.0	8.0	BRG013:39, BRG016:34, BRG007:19
	19	92.0	8.0	BRG085:30, BRG031:33, BRG068:29
	20	94.0	6.0	BRG011:60, BRG053:34
	21	100.0	0.0	BRG088:43, BRG051:38, BRG050:19
	22	93.0	7.0	BRG074:32, BRG097:41, BRG025:20
	23	93.0	7.0	BRG008:44, BRG100:32, BRG081:17
	24	100.0	0.0	BRG075:45, BRG091:55
	25	97.0	3.0	BRG090:48, BRG038:21, BRG063:28
	26	92.0	8.0	BRG024:45, BRG066:47
	27	93.0	7.0	BRG029:40, BRG054:22, BRG060:31
	28	93.0	7.0	BRG067:34, BRG041:26, BRG082:33
	29	98.0	2.0	BRG083:24, BRG010:25, BRG055:49
	30	89.0	11.0	BRG027:54, BRG087:35
	31	98.0	2.0	BRG014:21, BRG078:54, BRG019:23
	32	99.0	1.0	BRG028:26, BRG042:37, BRG086:16, BRG056:20
	33	96.0	4.0	BRG071:42, BRG043:29, BRG058:25
	34	96.0	4.0	BRG006:53, BRG002:22, BRG065:21
	35	89.0	11.0	BRG034:30, BRG057:36, BRG098:23
	36	94.0	6.0	BRG062:53, BRG004:41
Objektif Akhir	3924.11			
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 6.3711 detik (6371.08 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.11 Improvement : 747.92 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 1000 Mutation Rate : 0.50</pre>			
Durasi Pencarian	6.3711 detik			



B. Iterasi Sebagai Kontrol dan Probabilitas Mutasi 0.5

1. Pengujian Pertama

Maksimal iterasi : 100

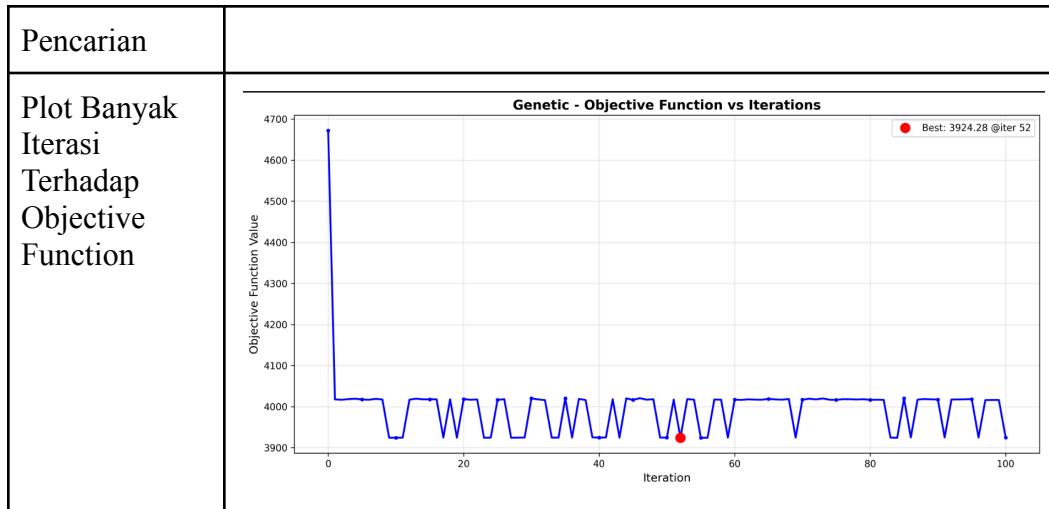
Populasi : 50

Probabilitas Mutasi : 0.5

Tabel 2.3.6.4 Hasil Pengujian 1 Populasi Kontrol Dengan Probabilitas Mutasi 0.5

State Awal		No	Load	Sisa	Isi Barang
		1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
		2	69.0	31.0	BRG004:41, BRG005:28
		3	72.0	28.0	BRG006:53, BRG007:19
		4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
		5	78.0	22.0	BRG011:60, BRG012:18
		6	60.0	40.0	BRG013:39, BRG014:21
		7	81.0	19.0	BRG015:47, BRG016:34
		8	85.0	15.0	BRG017:29, BRG018:56
		9	65.0	35.0	BRG019:23, BRG020:42
		10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
		11	65.0	35.0	BRG024:45, BRG025:20
		12	90.0	10.0	BRG026:36, BRG027:54
		13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
		14	57.0	43.0	BRG031:33, BRG032:24
		15	87.0	13.0	BRG033:57, BRG034:30
		16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
		17	69.0	31.0	BRG038:21, BRG039:48
		18	81.0	19.0	BRG040:55, BRG041:26
		19	66.0	34.0	BRG042:37, BRG043:29
		20	68.0	32.0	BRG044:50, BRG045:18
		21	64.0	36.0	BRG046:41, BRG047:23
		22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
		23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
		24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
		25	61.0	39.0	BRG057:36, BRG058:25
		26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
		27	81.0	19.0	BRG062:53, BRG063:28
		28	60.0	40.0	BRG064:39, BRG065:21
		29	81.0	19.0	BRG066:47, BRG067:34
		30	85.0	15.0	BRG068:29, BRG069:56
		31	65.0	35.0	BRG070:23, BRG071:42
		32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
		33	65.0	35.0	BRG075:45, BRG076:20
		34	90.0	10.0	BRG077:36, BRG078:54
		35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
		36	57.0	43.0	BRG082:33, BRG083:24
		37	87.0	13.0	BRG084:57, BRG085:30
		38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
		39	69.0	31.0	BRG089:21, BRG090:48
		40	81.0	19.0	BRG091:55, BRG092:26
		41	66.0	34.0	BRG093:37, BRG094:29
		42	68.0	32.0	BRG095:50, BRG096:18
		43	64.0	36.0	BRG097:41, BRG098:23
		44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03																																																																																																																																																				
State Akhir	<p style="text-align: center;">Final State - Genetic Algorithm</p> <table border="1"> <thead> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>100.0</td><td>0.0</td><td>BRG036:35, BRG028:26, BRG013:39</td></tr> <tr><td>2</td><td>96.0</td><td>4.0</td><td>BRG020:42, BRG027:54</td></tr> <tr><td>3</td><td>99.0</td><td>1.0</td><td>BRG030:17, BRG029:40, BRG056:20, BRG054:22</td></tr> <tr><td>4</td><td>100.0</td><td>0.0</td><td>BRG078:54, BRG017:29, BRG081:17</td></tr> <tr><td>5</td><td>92.0</td><td>8.0</td><td>BRG006:53, BRG064:39</td></tr> <tr><td>6</td><td>97.0</td><td>3.0</td><td>BRG048:46, BRG087:35, BRG086:16</td></tr> <tr><td>7</td><td>94.0</td><td>6.0</td><td>BRG044:50, BRG008:44</td></tr> <tr><td>8</td><td>91.0</td><td>9.0</td><td>BRG092:26, BRG022:27, BRG051:38</td></tr> <tr><td>9</td><td>98.0</td><td>2.0</td><td>BRG040:55, BRG088:43</td></tr> <tr><td>10</td><td>99.0</td><td>1.0</td><td>BRG090:48, BRG079:26, BRG010:25</td></tr> <tr><td>11</td><td>93.0</td><td>7.0</td><td>BRG018:56, BRG042:37</td></tr> <tr><td>12</td><td>93.0</td><td>7.0</td><td>BRG084:57, BRG026:36</td></tr> <tr><td>13</td><td>91.0</td><td>9.0</td><td>BRG060:31, BRG016:34, BRG041:26</td></tr> <tr><td>14</td><td>93.0</td><td>7.0</td><td>BRG082:33, BRG093:37, BRG098:23</td></tr> <tr><td>15</td><td>88.0</td><td>12.0</td><td>BRG069:56, BRG074:32</td></tr> <tr><td>16</td><td>92.0</td><td>8.0</td><td>BRG063:28, BRG089:21, BRG037:43</td></tr> <tr><td>17</td><td>89.0</td><td>11.0</td><td>BRG091:55, BRG067:34</td></tr> <tr><td>18</td><td>100.0</td><td>0.0</td><td>BRG032:24, BRG033:57, BRG007:19</td></tr> <tr><td>19</td><td>99.0</td><td>1.0</td><td>BRG024:45, BRG077:36, BRG012:18</td></tr> <tr><td>20</td><td>97.0</td><td>3.0</td><td>BRG038:21, BRG068:29, BRG066:47</td></tr> <tr><td>21</td><td>95.0</td><td>5.0</td><td>BRG053:34, BRG072:38, BRG047:23</td></tr> <tr><td>22</td><td>98.0</td><td>2.0</td><td>BRG011:60, BRG019:23, BRG061:15</td></tr> <tr><td>23</td><td>87.0</td><td>13.0</td><td>BRG004:41, BRG099:46</td></tr> <tr><td>24</td><td>98.0</td><td>2.0</td><td>BRG031:33, BRG014:21, BRG043:29, BRG001:15</td></tr> <tr><td>25</td><td>99.0</td><td>1.0</td><td>BRG009:31, BRG095:50, BRG045:18</td></tr> <tr><td>26</td><td>97.0</td><td>3.0</td><td>BRG076:20, BRG075:45, BRG100:32</td></tr> <tr><td>27</td><td>100.0</td><td>0.0</td><td>BRG080:40, BRG071:42, BRG096:18</td></tr> <tr><td>28</td><td>88.0</td><td>12.0</td><td>BRG049:32, BRG023:32, BRG083:24</td></tr> <tr><td>29</td><td>97.0</td><td>3.0</td><td>BRG062:53, BRG005:28, BRG035:16</td></tr> <tr><td>30</td><td>92.0</td><td>8.0</td><td>BRG002:22, BRG070:23, BRG073:27, BRG025:20</td></tr> <tr><td>31</td><td>96.0</td><td>4.0</td><td>BRG058:25, BRG046:41, BRG085:30</td></tr> <tr><td>32</td><td>96.0</td><td>4.0</td><td>BRG003:37, BRG021:38, BRG065:21</td></tr> <tr><td>33</td><td>90.0</td><td>10.0</td><td>BRG097:41, BRG055:49</td></tr> <tr><td>34</td><td>93.0</td><td>7.0</td><td>BRG034:30, BRG057:36, BRG052:27</td></tr> <tr><td>35</td><td>95.0</td><td>5.0</td><td>BRG015:47, BRG039:48</td></tr> <tr><td>36</td><td>92.0</td><td>8.0</td><td>BRG050:19, BRG094:29, BRG059:44</td></tr> </tbody> </table>	No	Load	Sisa	Isi Barang	1	100.0	0.0	BRG036:35, BRG028:26, BRG013:39	2	96.0	4.0	BRG020:42, BRG027:54	3	99.0	1.0	BRG030:17, BRG029:40, BRG056:20, BRG054:22	4	100.0	0.0	BRG078:54, BRG017:29, BRG081:17	5	92.0	8.0	BRG006:53, BRG064:39	6	97.0	3.0	BRG048:46, BRG087:35, BRG086:16	7	94.0	6.0	BRG044:50, BRG008:44	8	91.0	9.0	BRG092:26, BRG022:27, BRG051:38	9	98.0	2.0	BRG040:55, BRG088:43	10	99.0	1.0	BRG090:48, BRG079:26, BRG010:25	11	93.0	7.0	BRG018:56, BRG042:37	12	93.0	7.0	BRG084:57, BRG026:36	13	91.0	9.0	BRG060:31, BRG016:34, BRG041:26	14	93.0	7.0	BRG082:33, BRG093:37, BRG098:23	15	88.0	12.0	BRG069:56, BRG074:32	16	92.0	8.0	BRG063:28, BRG089:21, BRG037:43	17	89.0	11.0	BRG091:55, BRG067:34	18	100.0	0.0	BRG032:24, BRG033:57, BRG007:19	19	99.0	1.0	BRG024:45, BRG077:36, BRG012:18	20	97.0	3.0	BRG038:21, BRG068:29, BRG066:47	21	95.0	5.0	BRG053:34, BRG072:38, BRG047:23	22	98.0	2.0	BRG011:60, BRG019:23, BRG061:15	23	87.0	13.0	BRG004:41, BRG099:46	24	98.0	2.0	BRG031:33, BRG014:21, BRG043:29, BRG001:15	25	99.0	1.0	BRG009:31, BRG095:50, BRG045:18	26	97.0	3.0	BRG076:20, BRG075:45, BRG100:32	27	100.0	0.0	BRG080:40, BRG071:42, BRG096:18	28	88.0	12.0	BRG049:32, BRG023:32, BRG083:24	29	97.0	3.0	BRG062:53, BRG005:28, BRG035:16	30	92.0	8.0	BRG002:22, BRG070:23, BRG073:27, BRG025:20	31	96.0	4.0	BRG058:25, BRG046:41, BRG085:30	32	96.0	4.0	BRG003:37, BRG021:38, BRG065:21	33	90.0	10.0	BRG097:41, BRG055:49	34	93.0	7.0	BRG034:30, BRG057:36, BRG052:27	35	95.0	5.0	BRG015:47, BRG039:48	36	92.0	8.0	BRG050:19, BRG094:29, BRG059:44
No	Load	Sisa	Isi Barang																																																																																																																																																		
1	100.0	0.0	BRG036:35, BRG028:26, BRG013:39																																																																																																																																																		
2	96.0	4.0	BRG020:42, BRG027:54																																																																																																																																																		
3	99.0	1.0	BRG030:17, BRG029:40, BRG056:20, BRG054:22																																																																																																																																																		
4	100.0	0.0	BRG078:54, BRG017:29, BRG081:17																																																																																																																																																		
5	92.0	8.0	BRG006:53, BRG064:39																																																																																																																																																		
6	97.0	3.0	BRG048:46, BRG087:35, BRG086:16																																																																																																																																																		
7	94.0	6.0	BRG044:50, BRG008:44																																																																																																																																																		
8	91.0	9.0	BRG092:26, BRG022:27, BRG051:38																																																																																																																																																		
9	98.0	2.0	BRG040:55, BRG088:43																																																																																																																																																		
10	99.0	1.0	BRG090:48, BRG079:26, BRG010:25																																																																																																																																																		
11	93.0	7.0	BRG018:56, BRG042:37																																																																																																																																																		
12	93.0	7.0	BRG084:57, BRG026:36																																																																																																																																																		
13	91.0	9.0	BRG060:31, BRG016:34, BRG041:26																																																																																																																																																		
14	93.0	7.0	BRG082:33, BRG093:37, BRG098:23																																																																																																																																																		
15	88.0	12.0	BRG069:56, BRG074:32																																																																																																																																																		
16	92.0	8.0	BRG063:28, BRG089:21, BRG037:43																																																																																																																																																		
17	89.0	11.0	BRG091:55, BRG067:34																																																																																																																																																		
18	100.0	0.0	BRG032:24, BRG033:57, BRG007:19																																																																																																																																																		
19	99.0	1.0	BRG024:45, BRG077:36, BRG012:18																																																																																																																																																		
20	97.0	3.0	BRG038:21, BRG068:29, BRG066:47																																																																																																																																																		
21	95.0	5.0	BRG053:34, BRG072:38, BRG047:23																																																																																																																																																		
22	98.0	2.0	BRG011:60, BRG019:23, BRG061:15																																																																																																																																																		
23	87.0	13.0	BRG004:41, BRG099:46																																																																																																																																																		
24	98.0	2.0	BRG031:33, BRG014:21, BRG043:29, BRG001:15																																																																																																																																																		
25	99.0	1.0	BRG009:31, BRG095:50, BRG045:18																																																																																																																																																		
26	97.0	3.0	BRG076:20, BRG075:45, BRG100:32																																																																																																																																																		
27	100.0	0.0	BRG080:40, BRG071:42, BRG096:18																																																																																																																																																		
28	88.0	12.0	BRG049:32, BRG023:32, BRG083:24																																																																																																																																																		
29	97.0	3.0	BRG062:53, BRG005:28, BRG035:16																																																																																																																																																		
30	92.0	8.0	BRG002:22, BRG070:23, BRG073:27, BRG025:20																																																																																																																																																		
31	96.0	4.0	BRG058:25, BRG046:41, BRG085:30																																																																																																																																																		
32	96.0	4.0	BRG003:37, BRG021:38, BRG065:21																																																																																																																																																		
33	90.0	10.0	BRG097:41, BRG055:49																																																																																																																																																		
34	93.0	7.0	BRG034:30, BRG057:36, BRG052:27																																																																																																																																																		
35	95.0	5.0	BRG015:47, BRG039:48																																																																																																																																																		
36	92.0	8.0	BRG050:19, BRG094:29, BRG059:44																																																																																																																																																		
Objektif Akhir	3924.28																																																																																																																																																				
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 0.5340 detik (533.95 ms) Jumlah Iterasi : 100 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.28 Improvement : 747.76 (16.00%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.50 [?] Generating plots... [?] Objective history: ./output\plots\Genetic_objective.png [?] GA progression: ./output\plots\Genetic_progression.png</pre>																																																																																																																																																				
Durasi	0.5340 detik																																																																																																																																																				



2. Pengujian Kedua

Maksimal iterasi : 1000

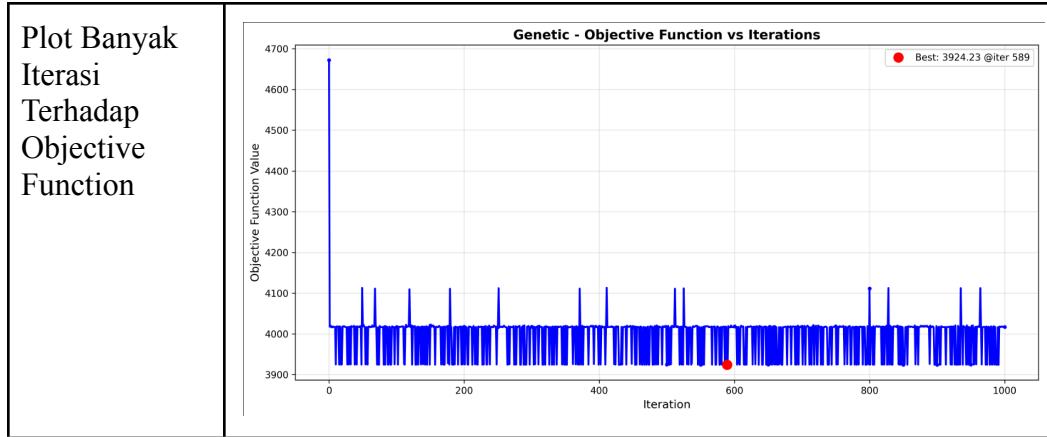
Populasi : 50

Probabilitas Mutasi : 0.5

Tabel 2.3.6.5 Hasil Pengujian 2 Populasi Kontrol Dengan Probabilitas Mutasi 0.5

State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03																																																																																																																																																				
State Akhir	<p style="text-align: center;">Final State - Genetic Algorithm</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>No</th> <th>Load</th> <th>Sisa</th> <th>Tsi Barang</th> </tr> </thead> <tbody> <tr><td>1</td><td>86.0</td><td>14.0</td><td>BRG038:21, BRG056:20, BRG075:45</td></tr> <tr><td>2</td><td>94.0</td><td>6.0</td><td>BRG011:60, BRG053:34</td></tr> <tr><td>3</td><td>92.0</td><td>8.0</td><td>BRG099:46, BRG052:27, BRG050:19</td></tr> <tr><td>4</td><td>93.0</td><td>7.0</td><td>BRG072:38, BRG063:28, BRG073:27</td></tr> <tr><td>5</td><td>98.0</td><td>2.0</td><td>BRG029:40, BRG097:41, BRG081:17</td></tr> <tr><td>6</td><td>94.0</td><td>6.0</td><td>BRG059:44, BRG095:50</td></tr> <tr><td>7</td><td>100.0</td><td>0.0</td><td>BRG040:55, BRG085:30, BRG061:15</td></tr> <tr><td>8</td><td>92.0</td><td>8.0</td><td>BRG022:27, BRG064:39, BRG041:26</td></tr> <tr><td>9</td><td>96.0</td><td>4.0</td><td>BRG091:55, BRG065:21, BRG025:20</td></tr> <tr><td>10</td><td>93.0</td><td>7.0</td><td>BRG024:45, BRG039:48</td></tr> <tr><td>11</td><td>91.0</td><td>9.0</td><td>BRG054:22, BRG079:26, BRG037:43</td></tr> <tr><td>12</td><td>98.0</td><td>2.0</td><td>BRG018:56, BRG083:24, BRG045:18</td></tr> <tr><td>13</td><td>92.0</td><td>8.0</td><td>BRG014:21, BRG042:37, BRG016:34</td></tr> <tr><td>14</td><td>95.0</td><td>5.0</td><td>BRG092:26, BRG003:37, BRG100:32</td></tr> <tr><td>15</td><td>96.0</td><td>4.0</td><td>BRG044:50, BRG048:46</td></tr> <tr><td>16</td><td>96.0</td><td>4.0</td><td>BRG019:23, BRG027:54, BRG007:19</td></tr> <tr><td>17</td><td>100.0</td><td>0.0</td><td>BRG033:57, BRG005:28, BRG001:15</td></tr> <tr><td>18</td><td>97.0</td><td>3.0</td><td>BRG034:30, BRG087:35, BRG049:32</td></tr> <tr><td>19</td><td>99.0</td><td>1.0</td><td>BRG021:38, BRG002:22, BRG089:21, BRG096:18</td></tr> <tr><td>20</td><td>93.0</td><td>7.0</td><td>BRG071:42, BRG067:34, BRG030:17</td></tr> <tr><td>21</td><td>100.0</td><td>0.0</td><td>BRG031:33, BRG051:38, BRG094:29</td></tr> <tr><td>22</td><td>100.0</td><td>0.0</td><td>BRG066:47, BRG082:33, BRG076:20</td></tr> <tr><td>23</td><td>93.0</td><td>7.0</td><td>BRG013:39, BRG060:31, BRG070:23</td></tr> <tr><td>24</td><td>95.0</td><td>5.0</td><td>BRG036:35, BRG008:44, BRG086:16</td></tr> <tr><td>25</td><td>100.0</td><td>0.0</td><td>BRG009:31, BRG006:53, BRG035:16</td></tr> <tr><td>26</td><td>97.0</td><td>3.0</td><td>BRG023:32, BRG046:41, BRG032:24</td></tr> <tr><td>27</td><td>89.0</td><td>11.0</td><td>BRG004:41, BRG047:23, BRG010:25</td></tr> <tr><td>28</td><td>99.0</td><td>1.0</td><td>BRG055:49, BRG074:32, BRG012:18</td></tr> <tr><td>29</td><td>88.0</td><td>12.0</td><td>BRG068:29, BRG026:36, BRG098:23</td></tr> <tr><td>30</td><td>96.0</td><td>4.0</td><td>BRG069:56, BRG080:40</td></tr> <tr><td>31</td><td>92.0</td><td>8.0</td><td>BRG093:37, BRG028:26, BRG017:29</td></tr> <tr><td>32</td><td>95.0</td><td>5.0</td><td>BRG015:47, BRG090:48</td></tr> <tr><td>33</td><td>93.0</td><td>7.0</td><td>BRG077:36, BRG084:57</td></tr> <tr><td>34</td><td>96.0</td><td>4.0</td><td>BRG078:54, BRG020:42</td></tr> <tr><td>35</td><td>97.0</td><td>3.0</td><td>BRG043:29, BRG088:43, BRG058:25</td></tr> <tr><td>36</td><td>89.0</td><td>11.0</td><td>BRG057:36, BRG062:53</td></tr> </tbody> </table>	No	Load	Sisa	Tsi Barang	1	86.0	14.0	BRG038:21, BRG056:20, BRG075:45	2	94.0	6.0	BRG011:60, BRG053:34	3	92.0	8.0	BRG099:46, BRG052:27, BRG050:19	4	93.0	7.0	BRG072:38, BRG063:28, BRG073:27	5	98.0	2.0	BRG029:40, BRG097:41, BRG081:17	6	94.0	6.0	BRG059:44, BRG095:50	7	100.0	0.0	BRG040:55, BRG085:30, BRG061:15	8	92.0	8.0	BRG022:27, BRG064:39, BRG041:26	9	96.0	4.0	BRG091:55, BRG065:21, BRG025:20	10	93.0	7.0	BRG024:45, BRG039:48	11	91.0	9.0	BRG054:22, BRG079:26, BRG037:43	12	98.0	2.0	BRG018:56, BRG083:24, BRG045:18	13	92.0	8.0	BRG014:21, BRG042:37, BRG016:34	14	95.0	5.0	BRG092:26, BRG003:37, BRG100:32	15	96.0	4.0	BRG044:50, BRG048:46	16	96.0	4.0	BRG019:23, BRG027:54, BRG007:19	17	100.0	0.0	BRG033:57, BRG005:28, BRG001:15	18	97.0	3.0	BRG034:30, BRG087:35, BRG049:32	19	99.0	1.0	BRG021:38, BRG002:22, BRG089:21, BRG096:18	20	93.0	7.0	BRG071:42, BRG067:34, BRG030:17	21	100.0	0.0	BRG031:33, BRG051:38, BRG094:29	22	100.0	0.0	BRG066:47, BRG082:33, BRG076:20	23	93.0	7.0	BRG013:39, BRG060:31, BRG070:23	24	95.0	5.0	BRG036:35, BRG008:44, BRG086:16	25	100.0	0.0	BRG009:31, BRG006:53, BRG035:16	26	97.0	3.0	BRG023:32, BRG046:41, BRG032:24	27	89.0	11.0	BRG004:41, BRG047:23, BRG010:25	28	99.0	1.0	BRG055:49, BRG074:32, BRG012:18	29	88.0	12.0	BRG068:29, BRG026:36, BRG098:23	30	96.0	4.0	BRG069:56, BRG080:40	31	92.0	8.0	BRG093:37, BRG028:26, BRG017:29	32	95.0	5.0	BRG015:47, BRG090:48	33	93.0	7.0	BRG077:36, BRG084:57	34	96.0	4.0	BRG078:54, BRG020:42	35	97.0	3.0	BRG043:29, BRG088:43, BRG058:25	36	89.0	11.0	BRG057:36, BRG062:53
No	Load	Sisa	Tsi Barang																																																																																																																																																		
1	86.0	14.0	BRG038:21, BRG056:20, BRG075:45																																																																																																																																																		
2	94.0	6.0	BRG011:60, BRG053:34																																																																																																																																																		
3	92.0	8.0	BRG099:46, BRG052:27, BRG050:19																																																																																																																																																		
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6	94.0	6.0	BRG059:44, BRG095:50																																																																																																																																																		
7	100.0	0.0	BRG040:55, BRG085:30, BRG061:15																																																																																																																																																		
8	92.0	8.0	BRG022:27, BRG064:39, BRG041:26																																																																																																																																																		
9	96.0	4.0	BRG091:55, BRG065:21, BRG025:20																																																																																																																																																		
10	93.0	7.0	BRG024:45, BRG039:48																																																																																																																																																		
11	91.0	9.0	BRG054:22, BRG079:26, BRG037:43																																																																																																																																																		
12	98.0	2.0	BRG018:56, BRG083:24, BRG045:18																																																																																																																																																		
13	92.0	8.0	BRG014:21, BRG042:37, BRG016:34																																																																																																																																																		
14	95.0	5.0	BRG092:26, BRG003:37, BRG100:32																																																																																																																																																		
15	96.0	4.0	BRG044:50, BRG048:46																																																																																																																																																		
16	96.0	4.0	BRG019:23, BRG027:54, BRG007:19																																																																																																																																																		
17	100.0	0.0	BRG033:57, BRG005:28, BRG001:15																																																																																																																																																		
18	97.0	3.0	BRG034:30, BRG087:35, BRG049:32																																																																																																																																																		
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20	93.0	7.0	BRG071:42, BRG067:34, BRG030:17																																																																																																																																																		
21	100.0	0.0	BRG031:33, BRG051:38, BRG094:29																																																																																																																																																		
22	100.0	0.0	BRG066:47, BRG082:33, BRG076:20																																																																																																																																																		
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25	100.0	0.0	BRG009:31, BRG006:53, BRG035:16																																																																																																																																																		
26	97.0	3.0	BRG023:32, BRG046:41, BRG032:24																																																																																																																																																		
27	89.0	11.0	BRG004:41, BRG047:23, BRG010:25																																																																																																																																																		
28	99.0	1.0	BRG055:49, BRG074:32, BRG012:18																																																																																																																																																		
29	88.0	12.0	BRG068:29, BRG026:36, BRG098:23																																																																																																																																																		
30	96.0	4.0	BRG069:56, BRG080:40																																																																																																																																																		
31	92.0	8.0	BRG093:37, BRG028:26, BRG017:29																																																																																																																																																		
32	95.0	5.0	BRG015:47, BRG090:48																																																																																																																																																		
33	93.0	7.0	BRG077:36, BRG084:57																																																																																																																																																		
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35	97.0	3.0	BRG043:29, BRG088:43, BRG058:25																																																																																																																																																		
36	89.0	11.0	BRG057:36, BRG062:53																																																																																																																																																		
Objektif Akhir	3924.23																																																																																																																																																				
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 4.3164 detik (4316.38 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.23 Improvement : 747.81 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.50</pre>																																																																																																																																																				
Durasi Pencarian	4.3164 detik																																																																																																																																																				



3. Pengujian Pertama

Maksimal iterasi : 10000

Populasi : 50

Probabilitas Mutasi : 0.5

Tabel 2.3.6.6 Hasil Pengujian 3 Populasi Kontrol Dengan Probabilitas Mutasi 0.5

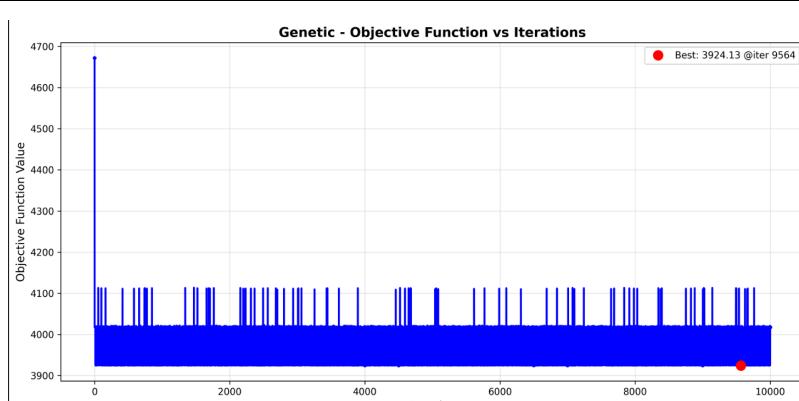
State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	68.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir			
Final State - Genetic Algorithm			
No	Load	Sisa	Isi Barang
1	97.0	3.0	BRG081:17, BRG007:19, BRG098:23, BRG072:38
2	96.0	4.0	BRG061:15, BRG083:24, BRG016:34, BRG019:23
3	98.0	2.0	BRG024:45, BRG041:26, BRG052:27
4	100.0	0.0	BRG074:32, BRG058:25, BRG022:27, BRG086:16
5	92.0	8.0	BRG089:21, BRG088:43, BRG005:28
6	95.0	5.0	BRG029:40, BRG065:21, BRG053:34
7	94.0	6.0	BRG027:54, BRG080:40
8	94.0	6.0	BRG046:41, BRG028:26, BRG073:27
9	94.0	6.0	BRG098:48, BRG099:46
10	94.0	6.0	BRG047:23, BRG009:31, BRG096:18, BRG054:22
11	90.0	10.0	BRG068:29, BRG043:29, BRG100:32
12	100.0	0.0	BRG066:47, BRG021:38, BRG001:15
13	99.0	1.0	BRG044:50, BRG055:49
14	100.0	0.0	BRG012:18, BRG097:41, BRG070:23, BRG045:18
15	97.0	3.0	BRG075:45, BRG076:20, BRG049:32
16	88.0	12.0	BRG004:41, BRG079:26, BRG014:21
17	91.0	9.0	BRG087:35, BRG069:56
18	92.0	8.0	BRG095:50, BRG071:42
19	90.0	10.0	BRG034:30, BRG017:29, BRG060:31
20	92.0	8.0	BRG013:39, BRG094:29, BRG032:24
21	98.0	2.0	BRG031:33, BRG082:33, BRG023:32
22	93.0	7.0	BRG018:56, BRG093:37
23	92.0	8.0	BRG084:57, BRG036:35
24	98.0	2.0	BRG063:28, BRG078:54, BRG035:16
25	93.0	7.0	BRG003:37, BRG067:34, BRG002:22
26	99.0	1.0	BRG006:53, BRG092:26, BRG025:20
27	93.0	7.0	BRG048:46, BRG015:47
28	96.0	4.0	BRG011:60, BRG077:36
29	91.0	9.0	BRG039:48, BRG037:43
30	96.0	4.0	BRG038:21, BRG042:37, BRG051:38
31	97.0	3.0	BRG040:55, BRG020:42
32	99.0	1.0	BRG091:55, BRG008:44
33	98.0	2.0	BRG010:25, BRG056:20, BRG062:53
34	92.0	8.0	BRG026:36, BRG030:17, BRG064:39
35	93.0	7.0	BRG033:57, BRG057:36
36	93.0	7.0	BRG050:19, BRG059:44, BRG085:30

Objektif Akhir	3924.13
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Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 43.6726 detik (43672.63 ms) Jumlah Iterasi : 10000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.13 Improvement : 747.90 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.50 @ Generating plots... @ Objective history: ./output\plots\Genetic_objective.png @ GA progression: ./output\plots\Genetic_progression.png Jumlah kontainer akhir: 36</pre>
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Durasi Pencarian	43.6726 detik
Plot Banyak Iterasi Terhadap Objective Function	 <p>Genetic - Objective Function vs Iterations</p> <p>Best: 3924.13 @iter 9564</p>

C. Populasi Sebagai Kontrol dan Probabilitas Mutasi 0.7

1. Pengujian Pertama

Maksimal iterasi : 1000

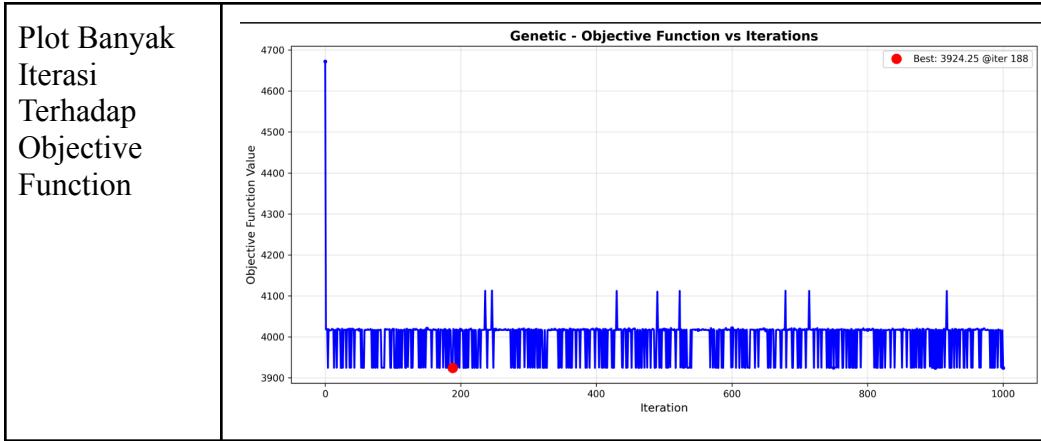
Populasi : 100

Probabilitas Mutasi : 0.7

Tabel 2.3.6.7 Hasil Pengujian 1 Iterasi Kontrol Dengan Probabilitas Mutasi 0.7

State Awal	No	Load	Sisa	Isi Barang
	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
	2	69.0	31.0	BRG004:41, BRG005:28
	3	72.0	28.0	BRG006:53, BRG007:19
	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
	5	78.0	22.0	BRG011:60, BRG012:18
	6	60.0	40.0	BRG013:39, BRG014:21
	7	81.0	19.0	BRG015:47, BRG016:34
	8	85.0	15.0	BRG017:29, BRG018:56
	9	65.0	35.0	BRG019:23, BRG020:42
	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
	11	65.0	35.0	BRG024:45, BRG025:20
	12	90.0	10.0	BRG026:36, BRG027:54
	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
	14	57.0	43.0	BRG031:33, BRG032:24
	15	87.0	13.0	BRG033:57, BRG034:30
	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
	17	69.0	31.0	BRG038:21, BRG039:48
	18	81.0	19.0	BRG040:55, BRG041:26
	19	66.0	34.0	BRG042:37, BRG043:29
	20	68.0	32.0	BRG044:50, BRG045:18
	21	64.0	36.0	BRG046:41, BRG047:23
	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
	25	61.0	39.0	BRG057:36, BRG058:25
	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
	27	81.0	19.0	BRG062:53, BRG063:28
	28	60.0	40.0	BRG064:39, BRG065:21
	29	81.0	19.0	BRG066:47, BRG067:34
	30	85.0	15.0	BRG068:29, BRG069:56
	31	65.0	35.0	BRG070:23, BRG071:42
	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
	33	65.0	35.0	BRG075:45, BRG076:20
	34	90.0	10.0	BRG077:36, BRG078:54
	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
	36	57.0	43.0	BRG082:33, BRG083:24
	37	87.0	13.0	BRG084:57, BRG085:30
	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
	39	69.0	31.0	BRG089:21, BRG090:48
	40	81.0	19.0	BRG091:55, BRG092:26
	41	66.0	34.0	BRG093:37, BRG094:29
	42	68.0	32.0	BRG095:50, BRG096:18
	43	64.0	36.0	BRG097:41, BRG098:23
	44	78.0	22.0	BRG099:46, BRG100:32
Objektif Awal	4672.03			

State Akhir	<table border="1"> <thead> <tr> <th colspan="4">Final State - Genetic Algorithm</th> </tr> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>93.0</td><td>7.0</td><td>BRG022:27, BRG049:32, BRG016:34</td></tr> <tr><td>2</td><td>98.0</td><td>2.0</td><td>BRG024:45, BRG087:35, BRG045:18</td></tr> <tr><td>3</td><td>93.0</td><td>7.0</td><td>BRG010:25, BRG092:26, BRG079:26, BRG086:16</td></tr> <tr><td>4</td><td>98.0</td><td>2.0</td><td>BRG015:47, BRG083:24, BRG073:27</td></tr> <tr><td>5</td><td>100.0</td><td>0.0</td><td>BRG039:48, BRG036:35, BRG030:17</td></tr> <tr><td>6</td><td>98.0</td><td>2.0</td><td>BRG063:28, BRG066:47, BRG019:23</td></tr> <tr><td>7</td><td>97.0</td><td>3.0</td><td>BRG072:38, BRG012:18, BRG004:41</td></tr> <tr><td>8</td><td>91.0</td><td>9.0</td><td>BRG023:32, BRG071:42, BRG081:17</td></tr> <tr><td>9</td><td>92.0</td><td>8.0</td><td>BRG100:32, BRG093:37, BRG047:23</td></tr> <tr><td>10</td><td>100.0</td><td>0.0</td><td>BRG046:41, BRG013:39, BRG056:20</td></tr> <tr><td>11</td><td>98.0</td><td>2.0</td><td>BRG090:48, BRG095:50</td></tr> <tr><td>12</td><td>95.0</td><td>5.0</td><td>BRG028:26, BRG055:49, BRG025:20</td></tr> <tr><td>13</td><td>93.0</td><td>7.0</td><td>BRG005:28, BRG059:44, BRG014:21</td></tr> <tr><td>14</td><td>100.0</td><td>0.0</td><td>BRG008:44, BRG069:56</td></tr> <tr><td>15</td><td>91.0</td><td>9.0</td><td>BRG040:55, BRG077:36</td></tr> <tr><td>16</td><td>90.0</td><td>10.0</td><td>BRG031:33, BRG057:36, BRG065:21</td></tr> <tr><td>17</td><td>100.0</td><td>0.0</td><td>BRG084:57, BRG058:25, BRG096:18</td></tr> <tr><td>18</td><td>98.0</td><td>2.0</td><td>BRG006:53, BRG075:45</td></tr> <tr><td>19</td><td>97.0</td><td>3.0</td><td>BRG085:30, BRG048:46, BRG089:21</td></tr> <tr><td>20</td><td>90.0</td><td>10.0</td><td>BRG053:34, BRG007:19, BRG003:37</td></tr> <tr><td>21</td><td>98.0</td><td>2.0</td><td>BRG078:54, BRG068:29, BRG061:15</td></tr> <tr><td>22</td><td>100.0</td><td>0.0</td><td>BRG018:56, BRG043:29, BRG001:15</td></tr> <tr><td>23</td><td>91.0</td><td>9.0</td><td>BRG091:55, BRG026:36</td></tr> <tr><td>24</td><td>94.0</td><td>6.0</td><td>BRG011:60, BRG067:34</td></tr> <tr><td>25</td><td>93.0</td><td>7.0</td><td>BRG029:40, BRG017:29, BRG032:24</td></tr> <tr><td>26</td><td>98.0</td><td>2.0</td><td>BRG062:53, BRG041:26, BRG050:19</td></tr> <tr><td>27</td><td>94.0</td><td>6.0</td><td>BRG097:41, BRG070:23, BRG034:30</td></tr> <tr><td>28</td><td>96.0</td><td>4.0</td><td>BRG088:43, BRG060:31, BRG002:22</td></tr> <tr><td>29</td><td>93.0</td><td>7.0</td><td>BRG064:39, BRG009:31, BRG098:23</td></tr> <tr><td>30</td><td>87.0</td><td>13.0</td><td>BRG044:50, BRG042:37</td></tr> <tr><td>31</td><td>97.0</td><td>3.0</td><td>BRG037:43, BRG074:32, BRG054:22</td></tr> <tr><td>32</td><td>90.0</td><td>10.0</td><td>BRG033:57, BRG082:33</td></tr> <tr><td>33</td><td>88.0</td><td>12.0</td><td>BRG020:42, BRG099:46</td></tr> <tr><td>34</td><td>94.0</td><td>6.0</td><td>BRG051:38, BRG094:29, BRG052:27</td></tr> <tr><td>35</td><td>91.0</td><td>9.0</td><td>BRG038:21, BRG027:54, BRG035:16</td></tr> <tr><td>36</td><td>98.0</td><td>2.0</td><td>BRG021:38, BRG080:40, BRG076:20</td></tr> </tbody> </table>	Final State - Genetic Algorithm				No	Load	Sisa	Isi Barang	1	93.0	7.0	BRG022:27, BRG049:32, BRG016:34	2	98.0	2.0	BRG024:45, BRG087:35, BRG045:18	3	93.0	7.0	BRG010:25, BRG092:26, BRG079:26, BRG086:16	4	98.0	2.0	BRG015:47, BRG083:24, BRG073:27	5	100.0	0.0	BRG039:48, BRG036:35, BRG030:17	6	98.0	2.0	BRG063:28, BRG066:47, BRG019:23	7	97.0	3.0	BRG072:38, BRG012:18, BRG004:41	8	91.0	9.0	BRG023:32, BRG071:42, BRG081:17	9	92.0	8.0	BRG100:32, BRG093:37, BRG047:23	10	100.0	0.0	BRG046:41, BRG013:39, BRG056:20	11	98.0	2.0	BRG090:48, BRG095:50	12	95.0	5.0	BRG028:26, BRG055:49, BRG025:20	13	93.0	7.0	BRG005:28, BRG059:44, BRG014:21	14	100.0	0.0	BRG008:44, BRG069:56	15	91.0	9.0	BRG040:55, BRG077:36	16	90.0	10.0	BRG031:33, BRG057:36, BRG065:21	17	100.0	0.0	BRG084:57, BRG058:25, BRG096:18	18	98.0	2.0	BRG006:53, BRG075:45	19	97.0	3.0	BRG085:30, BRG048:46, BRG089:21	20	90.0	10.0	BRG053:34, BRG007:19, BRG003:37	21	98.0	2.0	BRG078:54, BRG068:29, BRG061:15	22	100.0	0.0	BRG018:56, BRG043:29, BRG001:15	23	91.0	9.0	BRG091:55, BRG026:36	24	94.0	6.0	BRG011:60, BRG067:34	25	93.0	7.0	BRG029:40, BRG017:29, BRG032:24	26	98.0	2.0	BRG062:53, BRG041:26, BRG050:19	27	94.0	6.0	BRG097:41, BRG070:23, BRG034:30	28	96.0	4.0	BRG088:43, BRG060:31, BRG002:22	29	93.0	7.0	BRG064:39, BRG009:31, BRG098:23	30	87.0	13.0	BRG044:50, BRG042:37	31	97.0	3.0	BRG037:43, BRG074:32, BRG054:22	32	90.0	10.0	BRG033:57, BRG082:33	33	88.0	12.0	BRG020:42, BRG099:46	34	94.0	6.0	BRG051:38, BRG094:29, BRG052:27	35	91.0	9.0	BRG038:21, BRG027:54, BRG035:16	36	98.0	2.0	BRG021:38, BRG080:40, BRG076:20
Final State - Genetic Algorithm																																																																																																																																																									
No	Load	Sisa	Isi Barang																																																																																																																																																						
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10	100.0	0.0	BRG046:41, BRG013:39, BRG056:20																																																																																																																																																						
11	98.0	2.0	BRG090:48, BRG095:50																																																																																																																																																						
12	95.0	5.0	BRG028:26, BRG055:49, BRG025:20																																																																																																																																																						
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16	90.0	10.0	BRG031:33, BRG057:36, BRG065:21																																																																																																																																																						
17	100.0	0.0	BRG084:57, BRG058:25, BRG096:18																																																																																																																																																						
18	98.0	2.0	BRG006:53, BRG075:45																																																																																																																																																						
19	97.0	3.0	BRG085:30, BRG048:46, BRG089:21																																																																																																																																																						
20	90.0	10.0	BRG053:34, BRG007:19, BRG003:37																																																																																																																																																						
21	98.0	2.0	BRG078:54, BRG068:29, BRG061:15																																																																																																																																																						
22	100.0	0.0	BRG018:56, BRG043:29, BRG001:15																																																																																																																																																						
23	91.0	9.0	BRG091:55, BRG026:36																																																																																																																																																						
24	94.0	6.0	BRG011:60, BRG067:34																																																																																																																																																						
25	93.0	7.0	BRG029:40, BRG017:29, BRG032:24																																																																																																																																																						
26	98.0	2.0	BRG062:53, BRG041:26, BRG050:19																																																																																																																																																						
27	94.0	6.0	BRG097:41, BRG070:23, BRG034:30																																																																																																																																																						
28	96.0	4.0	BRG088:43, BRG060:31, BRG002:22																																																																																																																																																						
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30	87.0	13.0	BRG044:50, BRG042:37																																																																																																																																																						
31	97.0	3.0	BRG037:43, BRG074:32, BRG054:22																																																																																																																																																						
32	90.0	10.0	BRG033:57, BRG082:33																																																																																																																																																						
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Objektif Akhir	3924.25																																																																																																																																																								
Hasil Eksperimen	<pre> ===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 4.8031 detik (4803.11 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.25 Improvement : 747.78 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 100 Mutation Rate : 0.70 </pre>																																																																																																																																																								
Durasi Pencarian	4.9031 detik																																																																																																																																																								



2. Pengujian Kedua

Maksimal iterasi : 1000

Populasi : 500

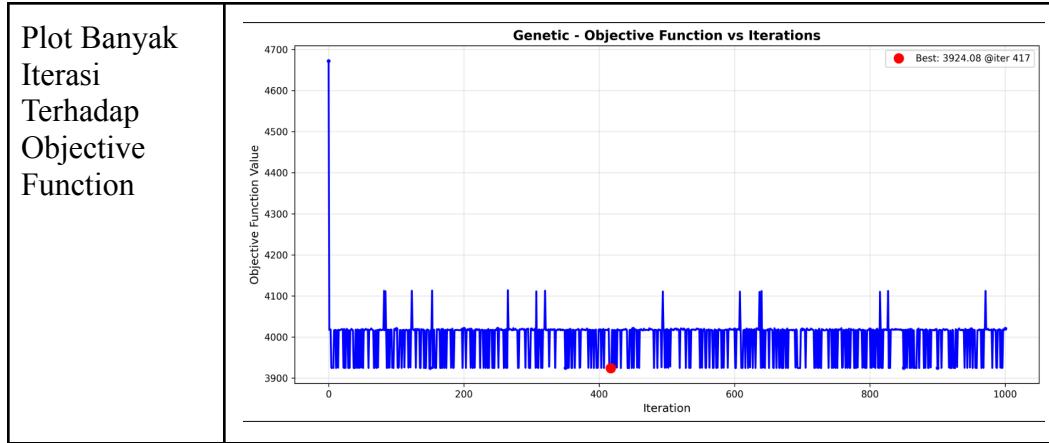
Probabilitas Mutasi : 0.7

Tabel 2.3.6.8 Hasil Pengujian 2 Iterasi Kontrol dengan Probabilitas Mutasi 0.7

State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir	<p style="text-align: center;">Final State - Genetic Algorithm</p> <table border="1"> <thead> <tr> <th>No</th><th>Load</th><th>Sisa</th><th>Isi Barang</th></tr> </thead> <tbody> <tr><td>1</td><td>100.0</td><td>0.0</td><td>BRG081:17, BRG024:45, BRG051:38</td></tr> <tr><td>2</td><td>91.0</td><td>9.0</td><td>BRG070:23, BRG099:46, BRG054:22</td></tr> <tr><td>3</td><td>97.0</td><td>3.0</td><td>BRG037:43, BRG027:54</td></tr> <tr><td>4</td><td>95.0</td><td>5.0</td><td>BRG072:38, BRG084:57</td></tr> <tr><td>5</td><td>97.0</td><td>3.0</td><td>BRG018:56, BRG004:41</td></tr> <tr><td>6</td><td>98.0</td><td>2.0</td><td>BRG047:23, BRG093:37, BRG019:23, BRG061:15</td></tr> <tr><td>7</td><td>91.0</td><td>9.0</td><td>BRG011:60, BRG009:31</td></tr> <tr><td>8</td><td>90.0</td><td>10.0</td><td>BRG088:43, BRG015:47</td></tr> <tr><td>9</td><td>97.0</td><td>3.0</td><td>BRG066:47, BRG074:32, BRG045:18</td></tr> <tr><td>10</td><td>96.0</td><td>4.0</td><td>BRG046:41, BRG022:27, BRG005:28</td></tr> <tr><td>11</td><td>95.0</td><td>5.0</td><td>BRG071:42, BRG006:53</td></tr> <tr><td>12</td><td>100.0</td><td>0.0</td><td>BRG095:50, BRG031:33, BRG030:17</td></tr> <tr><td>13</td><td>89.0</td><td>11.0</td><td>BRG078:54, BRG087:35</td></tr> <tr><td>14</td><td>98.0</td><td>2.0</td><td>BRG023:32, BRG085:30, BRG057:36</td></tr> <tr><td>15</td><td>96.0</td><td>4.0</td><td>BRG068:29, BRG050:19, BRG034:39, BRG012:18</td></tr> <tr><td>16</td><td>92.0</td><td>8.0</td><td>BRG036:35, BRG100:32, BRG010:25</td></tr> <tr><td>17</td><td>93.0</td><td>7.0</td><td>BRG039:48, BRG028:26, BRG007:19</td></tr> <tr><td>18</td><td>93.0</td><td>7.0</td><td>BRG052:27, BRG013:39, BRG073:27</td></tr> <tr><td>19</td><td>90.0</td><td>10.0</td><td>BRG063:28, BRG038:21, BRG097:41</td></tr> <tr><td>20</td><td>90.0</td><td>10.0</td><td>BRG089:21, BRG003:37, BRG049:32</td></tr> <tr><td>21</td><td>99.0</td><td>1.0</td><td>BRG086:16, BRG044:50, BRG082:33</td></tr> <tr><td>22</td><td>94.0</td><td>6.0</td><td>BRG035:16, BRG091:55, BRG098:23</td></tr> <tr><td>23</td><td>96.0</td><td>4.0</td><td>BRG080:40, BRG067:34, BRG002:22</td></tr> <tr><td>24</td><td>97.0</td><td>3.0</td><td>BRG043:29, BRG062:53, BRG001:15</td></tr> <tr><td>25</td><td>95.0</td><td>5.0</td><td>BRG077:36, BRG064:39, BRG056:20</td></tr> <tr><td>26</td><td>100.0</td><td>0.0</td><td>BRG092:26, BRG083:24, BRG094:29, BRG014:21</td></tr> <tr><td>27</td><td>94.0</td><td>6.0</td><td>BRG041:26, BRG020:42, BRG079:26</td></tr> <tr><td>28</td><td>95.0</td><td>5.0</td><td>BRG048:46, BRG055:49</td></tr> <tr><td>29</td><td>95.0</td><td>5.0</td><td>BRG053:34, BRG032:24, BRG042:37</td></tr> <tr><td>30</td><td>98.0</td><td>2.0</td><td>BRG008:44, BRG017:29, BRG058:25</td></tr> <tr><td>31</td><td>93.0</td><td>7.0</td><td>BRG075:45, BRG090:48</td></tr> <tr><td>32</td><td>91.0</td><td>9.0</td><td>BRG033:57, BRG016:34</td></tr> <tr><td>33</td><td>95.0</td><td>5.0</td><td>BRG059:44, BRG025:20, BRG060:31</td></tr> <tr><td>34</td><td>96.0</td><td>4.0</td><td>BRG069:56, BRG029:40</td></tr> <tr><td>35</td><td>93.0</td><td>7.0</td><td>BRG040:55, BRG021:38</td></tr> <tr><td>36</td><td>95.0</td><td>5.0</td><td>BRG065:21, BRG076:20, BRG026:36, BRG096:18</td></tr> </tbody> </table>	No	Load	Sisa	Isi Barang	1	100.0	0.0	BRG081:17, BRG024:45, BRG051:38	2	91.0	9.0	BRG070:23, BRG099:46, BRG054:22	3	97.0	3.0	BRG037:43, BRG027:54	4	95.0	5.0	BRG072:38, BRG084:57	5	97.0	3.0	BRG018:56, BRG004:41	6	98.0	2.0	BRG047:23, BRG093:37, BRG019:23, BRG061:15	7	91.0	9.0	BRG011:60, BRG009:31	8	90.0	10.0	BRG088:43, BRG015:47	9	97.0	3.0	BRG066:47, BRG074:32, BRG045:18	10	96.0	4.0	BRG046:41, BRG022:27, BRG005:28	11	95.0	5.0	BRG071:42, BRG006:53	12	100.0	0.0	BRG095:50, BRG031:33, BRG030:17	13	89.0	11.0	BRG078:54, BRG087:35	14	98.0	2.0	BRG023:32, BRG085:30, BRG057:36	15	96.0	4.0	BRG068:29, BRG050:19, BRG034:39, BRG012:18	16	92.0	8.0	BRG036:35, BRG100:32, BRG010:25	17	93.0	7.0	BRG039:48, BRG028:26, BRG007:19	18	93.0	7.0	BRG052:27, BRG013:39, BRG073:27	19	90.0	10.0	BRG063:28, BRG038:21, BRG097:41	20	90.0	10.0	BRG089:21, BRG003:37, BRG049:32	21	99.0	1.0	BRG086:16, BRG044:50, BRG082:33	22	94.0	6.0	BRG035:16, BRG091:55, BRG098:23	23	96.0	4.0	BRG080:40, BRG067:34, BRG002:22	24	97.0	3.0	BRG043:29, BRG062:53, BRG001:15	25	95.0	5.0	BRG077:36, BRG064:39, BRG056:20	26	100.0	0.0	BRG092:26, BRG083:24, BRG094:29, BRG014:21	27	94.0	6.0	BRG041:26, BRG020:42, BRG079:26	28	95.0	5.0	BRG048:46, BRG055:49	29	95.0	5.0	BRG053:34, BRG032:24, BRG042:37	30	98.0	2.0	BRG008:44, BRG017:29, BRG058:25	31	93.0	7.0	BRG075:45, BRG090:48	32	91.0	9.0	BRG033:57, BRG016:34	33	95.0	5.0	BRG059:44, BRG025:20, BRG060:31	34	96.0	4.0	BRG069:56, BRG029:40	35	93.0	7.0	BRG040:55, BRG021:38	36	95.0	5.0	BRG065:21, BRG076:20, BRG026:36, BRG096:18
No	Load	Sisa	Isi Barang																																																																																																																																																		
1	100.0	0.0	BRG081:17, BRG024:45, BRG051:38																																																																																																																																																		
2	91.0	9.0	BRG070:23, BRG099:46, BRG054:22																																																																																																																																																		
3	97.0	3.0	BRG037:43, BRG027:54																																																																																																																																																		
4	95.0	5.0	BRG072:38, BRG084:57																																																																																																																																																		
5	97.0	3.0	BRG018:56, BRG004:41																																																																																																																																																		
6	98.0	2.0	BRG047:23, BRG093:37, BRG019:23, BRG061:15																																																																																																																																																		
7	91.0	9.0	BRG011:60, BRG009:31																																																																																																																																																		
8	90.0	10.0	BRG088:43, BRG015:47																																																																																																																																																		
9	97.0	3.0	BRG066:47, BRG074:32, BRG045:18																																																																																																																																																		
10	96.0	4.0	BRG046:41, BRG022:27, BRG005:28																																																																																																																																																		
11	95.0	5.0	BRG071:42, BRG006:53																																																																																																																																																		
12	100.0	0.0	BRG095:50, BRG031:33, BRG030:17																																																																																																																																																		
13	89.0	11.0	BRG078:54, BRG087:35																																																																																																																																																		
14	98.0	2.0	BRG023:32, BRG085:30, BRG057:36																																																																																																																																																		
15	96.0	4.0	BRG068:29, BRG050:19, BRG034:39, BRG012:18																																																																																																																																																		
16	92.0	8.0	BRG036:35, BRG100:32, BRG010:25																																																																																																																																																		
17	93.0	7.0	BRG039:48, BRG028:26, BRG007:19																																																																																																																																																		
18	93.0	7.0	BRG052:27, BRG013:39, BRG073:27																																																																																																																																																		
19	90.0	10.0	BRG063:28, BRG038:21, BRG097:41																																																																																																																																																		
20	90.0	10.0	BRG089:21, BRG003:37, BRG049:32																																																																																																																																																		
21	99.0	1.0	BRG086:16, BRG044:50, BRG082:33																																																																																																																																																		
22	94.0	6.0	BRG035:16, BRG091:55, BRG098:23																																																																																																																																																		
23	96.0	4.0	BRG080:40, BRG067:34, BRG002:22																																																																																																																																																		
24	97.0	3.0	BRG043:29, BRG062:53, BRG001:15																																																																																																																																																		
25	95.0	5.0	BRG077:36, BRG064:39, BRG056:20																																																																																																																																																		
26	100.0	0.0	BRG092:26, BRG083:24, BRG094:29, BRG014:21																																																																																																																																																		
27	94.0	6.0	BRG041:26, BRG020:42, BRG079:26																																																																																																																																																		
28	95.0	5.0	BRG048:46, BRG055:49																																																																																																																																																		
29	95.0	5.0	BRG053:34, BRG032:24, BRG042:37																																																																																																																																																		
30	98.0	2.0	BRG008:44, BRG017:29, BRG058:25																																																																																																																																																		
31	93.0	7.0	BRG075:45, BRG090:48																																																																																																																																																		
32	91.0	9.0	BRG033:57, BRG016:34																																																																																																																																																		
33	95.0	5.0	BRG059:44, BRG025:20, BRG060:31																																																																																																																																																		
34	96.0	4.0	BRG069:56, BRG029:40																																																																																																																																																		
35	93.0	7.0	BRG040:55, BRG021:38																																																																																																																																																		
36	95.0	5.0	BRG065:21, BRG076:20, BRG026:36, BRG096:18																																																																																																																																																		
Objektif Akhir	3924.08																																																																																																																																																				
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 5.6517 detik (5651.75 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.08 Improvement : 747.95 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 500 Mutation Rate : 0.70</pre>																																																																																																																																																				
Durasi Pencarian	5.617 detik																																																																																																																																																				



3. Pengujian Ketiga

Maksimal iterasi : 1000

Populasi : 1000

Probabilitas Mutasi : 0.7

Tabel 2.3.6.9 Hasil Pengujian 3 Iterasi Kontrol Dengan Probabilitas Mutasi 0.5

State Awal	Isi Barang			
	No	Load	Sisa	Isi Barang
	1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
	2	69.0	31.0	BRG004:41, BRG005:28
	3	72.0	28.0	BRG006:53, BRG007:19
	4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
	5	78.0	22.0	BRG011:60, BRG012:18
	6	60.0	40.0	BRG013:39, BRG014:21
	7	81.0	19.0	BRG015:47, BRG016:34
	8	85.0	15.0	BRG017:29, BRG018:56
	9	65.0	35.0	BRG019:23, BRG020:42
	10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
	11	65.0	35.0	BRG024:45, BRG025:20
	12	90.0	10.0	BRG026:36, BRG027:54
	13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
	14	57.0	43.0	BRG031:33, BRG032:24
	15	87.0	13.0	BRG033:57, BRG034:30
	16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
	17	69.0	31.0	BRG038:21, BRG039:48
	18	81.0	19.0	BRG040:55, BRG041:26
	19	66.0	34.0	BRG042:37, BRG043:29
	20	68.0	32.0	BRG044:50, BRG045:18
	21	64.0	36.0	BRG046:41, BRG047:23
	22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
	23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
	24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
	25	61.0	39.0	BRG057:36, BRG058:25
	26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
	27	81.0	19.0	BRG062:53, BRG063:28
	28	60.0	40.0	BRG064:39, BRG065:21
	29	81.0	19.0	BRG066:47, BRG067:34
	30	85.0	15.0	BRG068:29, BRG069:56
	31	65.0	35.0	BRG070:23, BRG071:42
	32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
	33	65.0	35.0	BRG075:45, BRG076:20
	34	90.0	10.0	BRG077:36, BRG078:54
	35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
	36	57.0	43.0	BRG082:33, BRG083:24
	37	87.0	13.0	BRG084:57, BRG085:30
	38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
	39	69.0	31.0	BRG089:21, BRG090:48
	40	81.0	19.0	BRG091:55, BRG092:26
	41	66.0	34.0	BRG093:37, BRG094:29
	42	68.0	32.0	BRG095:50, BRG096:18
	43	64.0	36.0	BRG097:41, BRG098:23
	44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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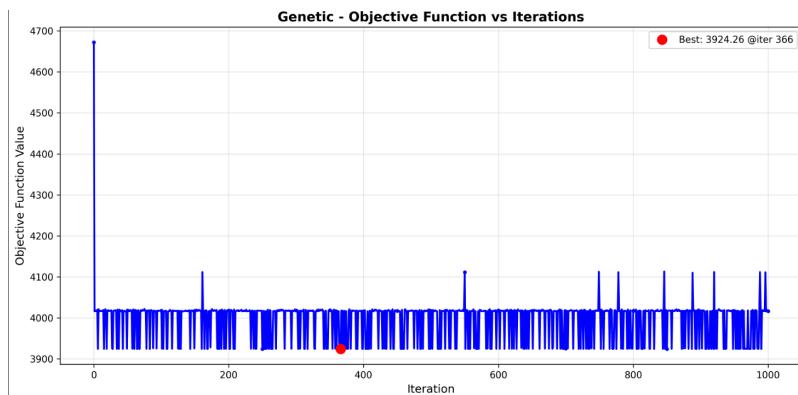
State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
1	89.0	11.0	BRG060:31, BRG079:26, BRG049:32	
2	91.0	9.0	BRG044:50, BRG004:41	
3	96.0	4.0	BRG021:38, BRG089:21, BRG025:20, BRG081:17	
4	99.0	1.0	BRG026:36, BRG020:42, BRG014:21	
5	93.0	7.0	BRG099:46, BRG019:23, BRG032:24	
6	100.0	0.0	BRG075:45, BRG082:33, BRG054:22	
7	91.0	9.0	BRG090:48, BRG088:43	
8	97.0	3.0	BRG016:34, BRG087:35, BRG063:28	
9	100.0	0.0	BRG066:47, BRG042:37, BRG035:16	
10	88.0	12.0	BRG030:17, BRG062:53, BRG012:18	
11	95.0	5.0	BRG003:37, BRG029:40, BRG096:18	
12	97.0	3.0	BRG006:53, BRG017:29, BRG061:15	
13	100.0	0.0	BRG010:25, BRG065:21, BRG056:20, BRG067:34	
14	91.0	9.0	BRG046:41, BRG083:24, BRG092:26	
15	94.0	6.0	BRG093:37, BRG033:57	
16	100.0	0.0	BRG024:45, BRG064:39, BRG086:16	
17	92.0	8.0	BRG057:36, BRG036:35, BRG038:21	
18	97.0	3.0	BRG098:23, BRG034:30, BRG059:44	
19	96.0	4.0	BRG040:55, BRG097:41	
20	91.0	9.0	BRG009:31, BRG052:27, BRG031:33	
21	100.0	0.0	BRG071:42, BRG085:30, BRG005:28	
22	93.0	7.0	BRG100:32, BRG074:32, BRG043:29	
23	91.0	9.0	BRG084:57, BRG053:34	
24	92.0	8.0	BRG078:54, BRG072:38	
25	97.0	3.0	BRG091:55, BRG047:23, BRG050:19	
26	90.0	10.0	BRG048:46, BRG008:44	
27	91.0	9.0	BRG023:32, BRG013:39, BRG076:20	
28	89.0	11.0	BRG011:60, BRG068:29	
29	98.0	2.0	BRG069:56, BRG022:27, BRG001:15	
30	97.0	3.0	BRG058:25, BRG027:54, BRG045:18	
31	99.0	1.0	BRG055:49, BRG073:27, BRG070:23	
32	93.0	7.0	BRG095:50, BRG037:43	
33	98.0	2.0	BRG094:29, BRG015:47, BRG002:22	
34	100.0	0.0	BRG039:48, BRG041:26, BRG028:26	
35	96.0	4.0	BRG018:56, BRG080:40	
36	93.0	7.0	BRG077:36, BRG051:38, BRG007:19	

Objektif Akhir	3924.26
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Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 6.1567 detik (6156.74 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.26 Improvement : 747.77 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 1000 Mutation Rate : 0.70</pre>
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Durasi Pencarian	6.1567 detik
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Plot Banyak Iterasi Terhadap Objective Function



D. Populasi Sebagai Kontrol dan Probabilitas Mutasi 0.7

1. Pengujian Pertama

Maksimal iterasi : 100

Populasi : 50

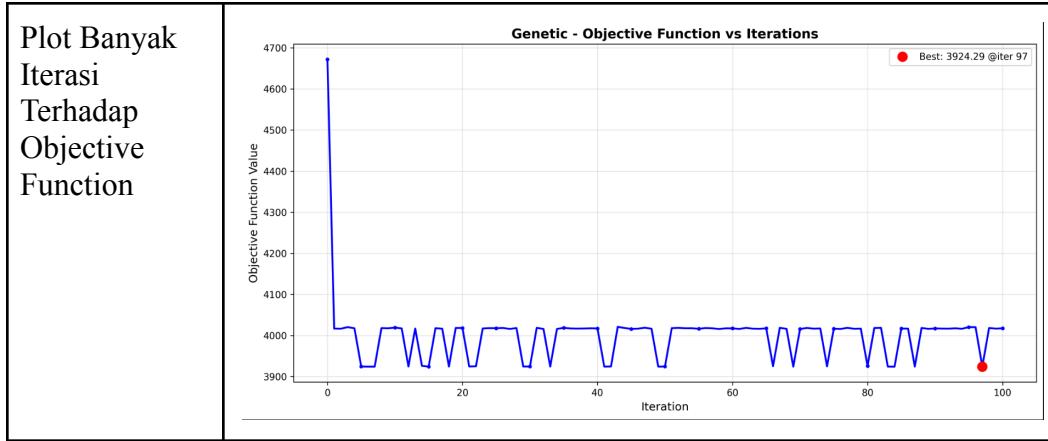
Probabilitas Mutasi : 0.7

Tabel 2.3.6.10 Hasil Pengujian 1 Populasi Kontrol Dengan Probabilitas Mutasi 0.7

State Awal

No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03																																																																																																																																																				
State Akhir	<p style="text-align: center;">Final State - Genetic Algorithm</p> <table border="1"> <thead> <tr> <th>No</th> <th>Load</th> <th>Sisa</th> <th>Isi Barang</th> </tr> </thead> <tbody> <tr><td>1</td><td>95.0</td><td>5.0</td><td>BRG055:49, BRG094:29, BRG081:17</td></tr> <tr><td>2</td><td>100.0</td><td>0.0</td><td>BRG032:24, BRG064:39, BRG014:21, BRG035:16</td></tr> <tr><td>3</td><td>95.0</td><td>5.0</td><td>BRG033:57, BRG072:38</td></tr> <tr><td>4</td><td>93.0</td><td>7.0</td><td>BRG090:48, BRG075:45</td></tr> <tr><td>5</td><td>91.0</td><td>9.0</td><td>BRG030:17, BRG040:55, BRG050:19</td></tr> <tr><td>6</td><td>97.0</td><td>3.0</td><td>BRG071:42, BRG017:29, BRG079:26</td></tr> <tr><td>7</td><td>96.0</td><td>4.0</td><td>BRG080:40, BRG051:38, BRG096:18</td></tr> <tr><td>8</td><td>95.0</td><td>5.0</td><td>BRG073:27, BRG067:34, BRG016:34</td></tr> <tr><td>9</td><td>100.0</td><td>0.0</td><td>BRG008:44, BRG097:41, BRG061:15</td></tr> <tr><td>10</td><td>89.0</td><td>11.0</td><td>BRG048:46, BRG037:43</td></tr> <tr><td>11</td><td>100.0</td><td>0.0</td><td>BRG021:38, BRG002:22, BRG065:21, BRG007:19</td></tr> <tr><td>12</td><td>100.0</td><td>0.0</td><td>BRG004:41, BRG013:39, BRG076:20</td></tr> <tr><td>13</td><td>89.0</td><td>11.0</td><td>BRG011:60, BRG043:29</td></tr> <tr><td>14</td><td>100.0</td><td>0.0</td><td>BRG066:47, BRG100:32, BRG089:21</td></tr> <tr><td>15</td><td>98.0</td><td>2.0</td><td>BRG099:46, BRG068:29, BRG047:23</td></tr> <tr><td>16</td><td>98.0</td><td>2.0</td><td>BRG022:27, BRG069:56, BRG001:15</td></tr> <tr><td>17</td><td>97.0</td><td>3.0</td><td>BRG044:50, BRG041:26, BRG038:21</td></tr> <tr><td>18</td><td>100.0</td><td>0.0</td><td>BRG018:56, BRG092:26, BRG012:18</td></tr> <tr><td>19</td><td>100.0</td><td>0.0</td><td>BRG015:47, BRG006:53</td></tr> <tr><td>20</td><td>97.0</td><td>3.0</td><td>BRG005:28, BRG074:32, BRG003:37</td></tr> <tr><td>21</td><td>93.0</td><td>7.0</td><td>BRG029:40, BRG062:53</td></tr> <tr><td>22</td><td>88.0</td><td>12.0</td><td>BRG042:37, BRG010:25, BRG028:26</td></tr> <tr><td>23</td><td>92.0</td><td>8.0</td><td>BRG039:48, BRG059:44</td></tr> <tr><td>24</td><td>91.0</td><td>9.0</td><td>BRG084:57, BRG053:34</td></tr> <tr><td>25</td><td>99.0</td><td>1.0</td><td>BRG078:54, BRG024:45</td></tr> <tr><td>26</td><td>97.0</td><td>3.0</td><td>BRG056:20, BRG019:23, BRG023:32, BRG054:22</td></tr> <tr><td>27</td><td>93.0</td><td>7.0</td><td>BRG087:35, BRG058:25, BRG082:33</td></tr> <tr><td>28</td><td>86.0</td><td>14.0</td><td>BRG034:30, BRG025:20, BRG077:36</td></tr> <tr><td>29</td><td>95.0</td><td>5.0</td><td>BRG070:23, BRG027:54, BRG045:18</td></tr> <tr><td>30</td><td>92.0</td><td>8.0</td><td>BRG026:36, BRG049:32, BRG083:24</td></tr> <tr><td>31</td><td>93.0</td><td>7.0</td><td>BRG036:35, BRG086:16, BRG020:42</td></tr> <tr><td>32</td><td>93.0</td><td>7.0</td><td>BRG088:43, BRG095:50</td></tr> <tr><td>33</td><td>96.0</td><td>4.0</td><td>BRG046:41, BRG052:27, BRG063:28</td></tr> <tr><td>34</td><td>91.0</td><td>9.0</td><td>BRG093:37, BRG009:31, BRG098:23</td></tr> <tr><td>35</td><td>91.0</td><td>9.0</td><td>BRG057:36, BRG091:55</td></tr> <tr><td>36</td><td>94.0</td><td>6.0</td><td>BRG031:33, BRG060:31, BRG085:30</td></tr> </tbody> </table>	No	Load	Sisa	Isi Barang	1	95.0	5.0	BRG055:49, BRG094:29, BRG081:17	2	100.0	0.0	BRG032:24, BRG064:39, BRG014:21, BRG035:16	3	95.0	5.0	BRG033:57, BRG072:38	4	93.0	7.0	BRG090:48, BRG075:45	5	91.0	9.0	BRG030:17, BRG040:55, BRG050:19	6	97.0	3.0	BRG071:42, BRG017:29, BRG079:26	7	96.0	4.0	BRG080:40, BRG051:38, BRG096:18	8	95.0	5.0	BRG073:27, BRG067:34, BRG016:34	9	100.0	0.0	BRG008:44, BRG097:41, BRG061:15	10	89.0	11.0	BRG048:46, BRG037:43	11	100.0	0.0	BRG021:38, BRG002:22, BRG065:21, BRG007:19	12	100.0	0.0	BRG004:41, BRG013:39, BRG076:20	13	89.0	11.0	BRG011:60, BRG043:29	14	100.0	0.0	BRG066:47, BRG100:32, BRG089:21	15	98.0	2.0	BRG099:46, BRG068:29, BRG047:23	16	98.0	2.0	BRG022:27, BRG069:56, BRG001:15	17	97.0	3.0	BRG044:50, BRG041:26, BRG038:21	18	100.0	0.0	BRG018:56, BRG092:26, BRG012:18	19	100.0	0.0	BRG015:47, BRG006:53	20	97.0	3.0	BRG005:28, BRG074:32, BRG003:37	21	93.0	7.0	BRG029:40, BRG062:53	22	88.0	12.0	BRG042:37, BRG010:25, BRG028:26	23	92.0	8.0	BRG039:48, BRG059:44	24	91.0	9.0	BRG084:57, BRG053:34	25	99.0	1.0	BRG078:54, BRG024:45	26	97.0	3.0	BRG056:20, BRG019:23, BRG023:32, BRG054:22	27	93.0	7.0	BRG087:35, BRG058:25, BRG082:33	28	86.0	14.0	BRG034:30, BRG025:20, BRG077:36	29	95.0	5.0	BRG070:23, BRG027:54, BRG045:18	30	92.0	8.0	BRG026:36, BRG049:32, BRG083:24	31	93.0	7.0	BRG036:35, BRG086:16, BRG020:42	32	93.0	7.0	BRG088:43, BRG095:50	33	96.0	4.0	BRG046:41, BRG052:27, BRG063:28	34	91.0	9.0	BRG093:37, BRG009:31, BRG098:23	35	91.0	9.0	BRG057:36, BRG091:55	36	94.0	6.0	BRG031:33, BRG060:31, BRG085:30
No	Load	Sisa	Isi Barang																																																																																																																																																		
1	95.0	5.0	BRG055:49, BRG094:29, BRG081:17																																																																																																																																																		
2	100.0	0.0	BRG032:24, BRG064:39, BRG014:21, BRG035:16																																																																																																																																																		
3	95.0	5.0	BRG033:57, BRG072:38																																																																																																																																																		
4	93.0	7.0	BRG090:48, BRG075:45																																																																																																																																																		
5	91.0	9.0	BRG030:17, BRG040:55, BRG050:19																																																																																																																																																		
6	97.0	3.0	BRG071:42, BRG017:29, BRG079:26																																																																																																																																																		
7	96.0	4.0	BRG080:40, BRG051:38, BRG096:18																																																																																																																																																		
8	95.0	5.0	BRG073:27, BRG067:34, BRG016:34																																																																																																																																																		
9	100.0	0.0	BRG008:44, BRG097:41, BRG061:15																																																																																																																																																		
10	89.0	11.0	BRG048:46, BRG037:43																																																																																																																																																		
11	100.0	0.0	BRG021:38, BRG002:22, BRG065:21, BRG007:19																																																																																																																																																		
12	100.0	0.0	BRG004:41, BRG013:39, BRG076:20																																																																																																																																																		
13	89.0	11.0	BRG011:60, BRG043:29																																																																																																																																																		
14	100.0	0.0	BRG066:47, BRG100:32, BRG089:21																																																																																																																																																		
15	98.0	2.0	BRG099:46, BRG068:29, BRG047:23																																																																																																																																																		
16	98.0	2.0	BRG022:27, BRG069:56, BRG001:15																																																																																																																																																		
17	97.0	3.0	BRG044:50, BRG041:26, BRG038:21																																																																																																																																																		
18	100.0	0.0	BRG018:56, BRG092:26, BRG012:18																																																																																																																																																		
19	100.0	0.0	BRG015:47, BRG006:53																																																																																																																																																		
20	97.0	3.0	BRG005:28, BRG074:32, BRG003:37																																																																																																																																																		
21	93.0	7.0	BRG029:40, BRG062:53																																																																																																																																																		
22	88.0	12.0	BRG042:37, BRG010:25, BRG028:26																																																																																																																																																		
23	92.0	8.0	BRG039:48, BRG059:44																																																																																																																																																		
24	91.0	9.0	BRG084:57, BRG053:34																																																																																																																																																		
25	99.0	1.0	BRG078:54, BRG024:45																																																																																																																																																		
26	97.0	3.0	BRG056:20, BRG019:23, BRG023:32, BRG054:22																																																																																																																																																		
27	93.0	7.0	BRG087:35, BRG058:25, BRG082:33																																																																																																																																																		
28	86.0	14.0	BRG034:30, BRG025:20, BRG077:36																																																																																																																																																		
29	95.0	5.0	BRG070:23, BRG027:54, BRG045:18																																																																																																																																																		
30	92.0	8.0	BRG026:36, BRG049:32, BRG083:24																																																																																																																																																		
31	93.0	7.0	BRG036:35, BRG086:16, BRG020:42																																																																																																																																																		
32	93.0	7.0	BRG088:43, BRG095:50																																																																																																																																																		
33	96.0	4.0	BRG046:41, BRG052:27, BRG063:28																																																																																																																																																		
34	91.0	9.0	BRG093:37, BRG009:31, BRG098:23																																																																																																																																																		
35	91.0	9.0	BRG057:36, BRG091:55																																																																																																																																																		
36	94.0	6.0	BRG031:33, BRG060:31, BRG085:30																																																																																																																																																		
Objektif Akhir	3924.29																																																																																																																																																				
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 0.4887 detik (488.68 ms) Jumlah Iterasi : 100 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.29 Improvement : 747.74 (16.00%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.70</pre>																																																																																																																																																				
Durasi Pencarian	0.4887 detik																																																																																																																																																				



2. Pengujian Kedua

Maksimal iterasi : 1000

Populasi : 50

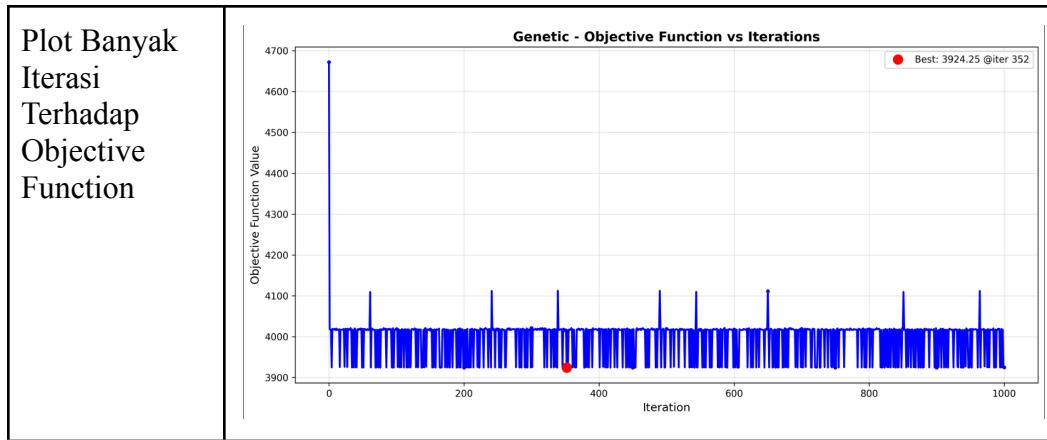
Probabilitas Mutasi : 0.7

Tabel 2.3.6.11 Hasil Pengujian 2 Populasi Kontrol Dengan Probabilitas Mutasi 0.7

State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

Objektif Awal	4672.03
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State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
	1	91.0	9.0	BRG021:38, BRG010:25, BRG005:28
	2	92.0	8.0	BRG039:48, BRG070:23, BRG014:21
	3	100.0	0.0	BRG093:37, BRG075:45, BRG096:18
	4	95.0	5.0	BRG097:41, BRG074:32, BRG054:22
	5	97.0	3.0	BRG060:31, BRG048:46, BRG056:20
	6	99.0	1.0	BRG033:57, BRG071:42
	7	91.0	9.0	BRG007:19, BRG059:44, BRG063:28
	8	99.0	1.0	BRG090:48, BRG087:35, BRG086:16
	9	99.0	1.0	BRG044:50, BRG019:23, BRG041:26
	10	93.0	7.0	BRG027:54, BRG064:39
	11	93.0	7.0	BRG066:47, BRG076:20, BRG079:26
	12	98.0	2.0	BRG091:55, BRG088:43
	13	96.0	4.0	BRG016:34, BRG092:26, BRG026:36
	14	99.0	1.0	BRG037:43, BRG036:35, BRG065:21
	15	99.0	1.0	BRG046:41, BRG077:36, BRG002:22
	16	90.0	10.0	BRG032:24, BRG003:37, BRG094:29
	17	100.0	0.0	BRG020:42, BRG073:27, BRG001:15, BRG035:16
	18	90.0	10.0	BRG018:56, BRG067:34
	19	90.0	10.0	BRG006:53, BRG042:37
	20	91.0	9.0	BRG004:41, BRG028:26, BRG083:24
	21	94.0	6.0	BRG011:68, BRG053:34
	22	96.0	4.0	BRG015:47, BRG055:49
	23	93.0	7.0	BRG051:38, BRG100:32, BRG047:23
	24	96.0	4.0	BRG043:29, BRG034:30, BRG025:20, BRG081:17
	25	100.0	0.0	BRG069:56, BRG052:27, BRG030:17
	26	99.0	1.0	BRG040:55, BRG068:29, BRG061:15
	27	94.0	6.0	BRG008:44, BRG045:18, BRG023:32
	28	90.0	10.0	BRG084:57, BRG031:33
	29	88.0	12.0	BRG072:38, BRG095:50
	30	100.0	0.0	BRG098:23, BRG049:32, BRG024:45
	31	98.0	2.0	BRG099:46, BRG038:21, BRG009:31
	32	93.0	7.0	BRG089:21, BRG062:53, BRG050:19
	33	90.0	10.0	BRG057:36, BRG078:54
	34	92.0	8.0	BRG058:25, BRG022:27, BRG080:40
	35	92.0	8.0	BRG017:29, BRG085:30, BRG082:33
	36	97.0	3.0	BRG013:39, BRG029:40, BRG012:18
Objektif Akhir	3924.25			
Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 4.7832 detik (4783.22 ms) Jumlah Iterasi : 1000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.25 Improvement : 747.78 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.70</pre>			
Durasi Pencarian	4.7832 detik			



3. Pengujian Ketiga

Maksimal iterasi : 10000

Populasi : 50

Probabilitas Mutasi : 0.7

Tabel 2.3.6.12 Hasil Pengujian 3 Populasi Kontrol Dengan Probabilitas Mutasi 0.7

State Awal			
No	Load	Sisa	Isi Barang
1	74.0	26.0	BRG001:15, BRG002:22, BRG003:37
2	69.0	31.0	BRG004:41, BRG005:28
3	72.0	28.0	BRG006:53, BRG007:19
4	100.0	0.0	BRG008:44, BRG009:31, BRG010:25
5	78.0	22.0	BRG011:60, BRG012:18
6	60.0	40.0	BRG013:39, BRG014:21
7	81.0	19.0	BRG015:47, BRG016:34
8	85.0	15.0	BRG017:29, BRG018:56
9	65.0	35.0	BRG019:23, BRG020:42
10	97.0	3.0	BRG021:38, BRG022:27, BRG023:32
11	65.0	35.0	BRG024:45, BRG025:20
12	90.0	10.0	BRG026:36, BRG027:54
13	83.0	17.0	BRG028:26, BRG029:40, BRG030:17
14	57.0	43.0	BRG031:33, BRG032:24
15	87.0	13.0	BRG033:57, BRG034:30
16	94.0	6.0	BRG035:16, BRG036:35, BRG037:43
17	69.0	31.0	BRG038:21, BRG039:48
18	81.0	19.0	BRG040:55, BRG041:26
19	66.0	34.0	BRG042:37, BRG043:29
20	68.0	32.0	BRG044:50, BRG045:18
21	64.0	36.0	BRG046:41, BRG047:23
22	97.0	3.0	BRG048:46, BRG049:32, BRG050:19
23	99.0	1.0	BRG051:38, BRG052:27, BRG053:34
24	91.0	9.0	BRG054:22, BRG055:49, BRG056:20
25	61.0	39.0	BRG057:36, BRG058:25
26	90.0	10.0	BRG059:44, BRG060:31, BRG061:15
27	81.0	19.0	BRG062:53, BRG063:28
28	60.0	40.0	BRG064:39, BRG065:21
29	81.0	19.0	BRG066:47, BRG067:34
30	85.0	15.0	BRG068:29, BRG069:56
31	65.0	35.0	BRG070:23, BRG071:42
32	97.0	3.0	BRG072:38, BRG073:27, BRG074:32
33	65.0	35.0	BRG075:45, BRG076:20
34	90.0	10.0	BRG077:36, BRG078:54
35	83.0	17.0	BRG079:26, BRG080:40, BRG081:17
36	57.0	43.0	BRG082:33, BRG083:24
37	87.0	13.0	BRG084:57, BRG085:30
38	94.0	6.0	BRG086:16, BRG087:35, BRG088:43
39	69.0	31.0	BRG089:21, BRG090:48
40	81.0	19.0	BRG091:55, BRG092:26
41	66.0	34.0	BRG093:37, BRG094:29
42	68.0	32.0	BRG095:50, BRG096:18
43	64.0	36.0	BRG097:41, BRG098:23
44	78.0	22.0	BRG099:46, BRG100:32

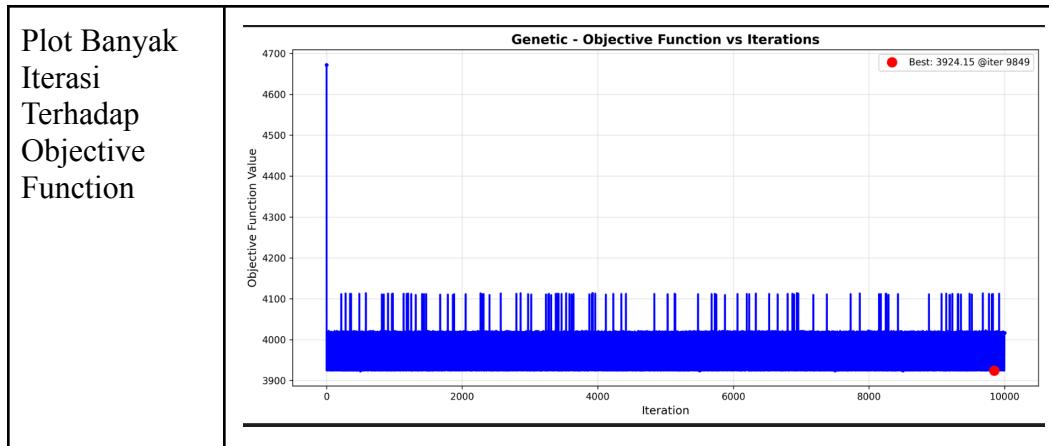
Objektif Awal	4672.03
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State Akhir	Final State - Genetic Algorithm			
	No	Load	Sisa	Isi Barang
	1	100.0	0.0	BRG042:37, BRG013:39, BRG083:24
	2	94.0	6.0	BRG044:50, BRG059:44
	3	93.0	7.0	BRG024:45, BRG039:48
	4	94.0	6.0	BRG049:32, BRG004:41, BRG014:21
	5	92.0	8.0	BRG100:32, BRG016:34, BRG028:26
	6	95.0	5.0	BRG023:32, BRG092:26, BRG093:37
	7	95.0	5.0	BRG053:34, BRG029:40, BRG065:21
	8	93.0	7.0	BRG046:41, BRG087:35, BRG030:17
	9	96.0	4.0	BRG080:40, BRG021:38, BRG045:18
	10	96.0	4.0	BRG009:31, BRG057:36, BRG017:29
	11	91.0	9.0	BRG067:34, BRG033:57
	12	97.0	3.0	BRG064:39, BRG056:20, BRG051:38
	13	96.0	4.0	BRG058:25, BRG006:53, BRG012:18
	14	93.0	7.0	BRG007:19, BRG085:30, BRG047:23, BRG038:21
	15	97.0	3.0	BRG076:20, BRG099:46, BRG060:31
	16	97.0	3.0	BRG096:18, BRG037:43, BRG077:36
	17	91.0	9.0	BRG095:50, BRG097:41
	18	94.0	6.0	BRG054:22, BRG025:20, BRG070:23, BRG043:29
	19	97.0	3.0	BRG078:54, BRG073:27, BRG035:16
	20	93.0	7.0	BRG075:45, BRG094:29, BRG050:19
	21	97.0	3.0	BRG040:55, BRG020:42
	22	95.0	5.0	BRG003:37, BRG010:25, BRG031:33
	23	98.0	2.0	BRG011:60, BRG002:22, BRG086:16
	24	97.0	3.0	BRG048:46, BRG052:27, BRG032:24
	25	94.0	6.0	BRG018:56, BRG072:38
	26	99.0	1.0	BRG027:54, BRG005:28, BRG081:17
	27	99.0	1.0	BRG015:47, BRG068:29, BRG098:23
	28	89.0	11.0	BRG084:57, BRG074:32
	29	86.0	14.0	BRG071:42, BRG008:44
	30	98.0	2.0	BRG055:49, BRG019:23, BRG079:26
	31	86.0	14.0	BRG034:30, BRG069:56
	32	95.0	5.0	BRG066:47, BRG090:48
	33	96.0	4.0	BRG091:55, BRG041:26, BRG061:15
	34	100.0	0.0	BRG026:36, BRG088:43, BRG089:21
	35	95.0	5.0	BRG022:27, BRG062:53, BRG001:15
	36	96.0	4.0	BRG063:28, BRG036:35, BRG082:33

Objektif Akhir	3924.15
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Hasil Eksperimen	<pre>===== HASIL ALGORITMA: Genetic ===== Waktu Eksekusi : 46.6432 detik (46643.23 ms) Jumlah Iterasi : 10000 Solusi Valid : Ya --- Performa --- Objective Awal : 4672.03 Objective Akhir : 3924.15 Improvement : 747.89 (16.01%) --- Kontainer --- Kontainer Awal : 44 Kontainer Akhir : 36 Pengurangan : 8 kontainer --- Genetic Algorithm Hyperparameters --- Population Size : 50 Mutation Rate : 0.70</pre>
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Durasi Pencarian	46.6432 detik
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Hasil Analisis Genetic Algorithm (GA)

Berdasarkan hasil eksperimen, Genetic Algorithm (GA) menunjukkan sejumlah karakteristik kinerja yang unik pada kasus Bin Packing Problem, di antaranya:

1. Efisiensi Komputasi

Dari sisi efisiensi, GA menunjukkan waktu eksekusi yang kompetitif bahkan pada ukuran populasi yang besar. Misalnya, untuk populasi 100 hingga 1000 dengan 1000 iterasi, durasi pencarian tetap dalam kisaran 3–6 detik. Hal ini dikarenakan mekanisme seleksi, crossover, dan mutasi yang bersifat paralel di tingkat populasi, sehingga tiap generasi dapat diproses secara efisien tanpa perlu evaluasi menyeluruh seperti pada pendekatan exhaustif.

2. Robustness Terhadap Local Optimum

GA secara konsisten mampu menemukan solusi dengan nilai objective function akhir yang jauh lebih baik daripada solusi awal, terlepas dari variasi parameter populasi dan iterasi. Hal ini menegaskan keunggulan mekanisme evolusi dalam GA yang menggabungkan eksplorasi (melalui inisialisasi populasi beragam dan mutasi) dan eksloitasi (melalui seleksi dan crossover), sehingga tidak mudah terjebak pada local optimum.

3. Pengaruh Parameter Populasi vs. Iterasi

Analisis parameter menunjukkan beberapa temuan menarik:

- Peningkatan ukuran populasi (misal, dari 100 ke 1000 dengan iterasi tetap 1000) ternyata tidak selalu menghasilkan solusi yang lebih baik secara signifikan. Pada data uji, objective function akhir relatif stabil (sekitar 3924.xx), bahkan kadang sedikit memburuk. Ini mengindikasikan bahwa setelah titik tertentu, menambah populasi hanya meningkatkan keragaman solusi, namun tidak menjamin

eksplorasi solusi yang lebih baik dalam batas iterasi yang sama (diminishing return).

- Meningkatkan jumlah iterasi (misal, dari 100 ke 10000 pada populasi 50) secara konsisten memperbaiki kualitas solusi akhir. Hal ini menunjukkan bahwa waktu evolusi (jumlah generasi) lebih berperan dalam memperbaiki solusi dibanding hanya memperbesar populasi.

4. Pengaruh Probabilitas Mutasi

Peningkatan probabilitas mutasi dari 0.5 ke 0.7 tidak berdampak signifikan terhadap kualitas solusi akhir pada eksperimen kali ini (objective function akhir tetap di kisaran 3924.xx). Namun, mutasi tetap penting untuk menjaga keragaman populasi dan mencegah stagnasi, terutama pada iterasi awal.

5. Karakteristik Konvergensi

Plot objective function terhadap iterasi menunjukkan bahwa perbaikan solusi terjadi sangat cepat pada generasi awal, lalu melambat dan cenderung stagnan mendekati akhir iterasi. Ini menunjukkan bahwa GA sangat efektif dalam eksplorasi awal, namun butuh variasi (misal, mutasi lebih agresif atau re-inisialisasi) untuk keluar dari stagnasi pada generasi lanjut.

2.3.7 Hasil Perbandingan Algoritma

Berikut merupakan tabel hasil perbandingan untuk setiap algoritma:

Max Iterasi	Algoritma	Objektif Awal	Objektif Akhir	Durasi (detik)
100	Simulated Annealing	4672.03	4584.51	0.0112
	Genetic (populasi sebagai kontrol, mutasi 0.5)	4672.03	3924.28	0.5340
	Genetic (populasi sebagai kontrol, mutasi 0.7)	4672.03	3924.29	0.4887
	Steepest hill Climbing	4672.03	4664.91	38.4861
	Hill- Climbing with Sideways Move	4672.03	4664.91	107.7621

	Random Restart Hill-Climbing	4672.03	4291.40	424.9000
	Stochastic Hill-Climbing	4672.03	4664.92	150.1573
1000	Simulated Annealing	4672.03	4295.17	0.1093
	Genetic (populasi sebagai kontrol, mutasi 0.5)	4672.03	3924.23	4.3164
	Genetic (populasi sebagai kontrol, mutasi 0.7)	4672.03	3924.25	4.7832
	Steepest hill Climbing	4672.03	4664.91	40.6891
	Hill- Climbing with Sideways Move	4672.03	4664.91	196.2592
	Random Restart Hill-Climbing	4672.03	4384.30	548.1897
	Stochastic Hill-Climbing	4672.03	4664.92	218.7890
10000	Simulated Annealing	4672.03	4291.45	1.3112
	Genetic (populasi sebagai kontrol, mutasi 0.5)	4672.03	3924.13	43.6726
	Genetic (populasi sebagai kontrol, mutasi 0.7)	4672.03	3924.15	46.6432
	Steepest hill Climbing	4672.03	4664.91	44.9149
	Hill- Climbing with Sideways Move	4672.03	4664.91	273.0174
	Stochastic Hill-Climbing	4672.03	4664.92	229.0047

BAB III

Kesimpulan dan Saran

3.1 Kesimpulan

Eksperimen dalam pencarian solusi Bin Packing Problem (BPP) menggunakan enam algoritma local search telah berhasil diimplementasikan dan dievaluasi. Berdasarkan hasil analisis, dapat ditarik beberapa kesimpulan:

1. Inefektivitas Algoritma Hill-Climbing Sederhana

Algoritma Hill-Climbing dasar (Steepest Ascent, Hill-Climbing with Sideways Move, dan Stochastic Hill-Climbing) terbukti tidak memadai untuk permasalahan BPP ini. Ketiga algoritma tersebut secara konsisten terjebak pada local optimum yang sama (nilai objektif $\sim 4664.9x$) dan gagal menemukan solusi yang lebih baik. Peningkatan iterasi maksimum atau penambahan sideways move tidak memberikan perbaikan solusi, melainkan hanya memperpanjang durasi eksekusi.

2. Keberhasilan Algoritma Meta-heuristik

Metode yang dirancang untuk melarikan diri dari local optima (Random Restart, Simulated Annealing, dan Genetic Algorithm) secara signifikan mengungguli varian Hill-Climbing sederhana. Ketiganya berhasil menemukan solusi dengan kualitas yang jauh lebih tinggi (nilai objektif < 4300), yang mengindikasikan keberhasilan mereka dalam mengeksplorasi lanskap pencarian yang lebih luas.

3. Perbandingan Efisiensi dan Efektivitas:

- Genetic Algorithm (GA) secara konsisten menghasilkan solusi terbaik (nilai objektif $\sim 3924.x$) dengan durasi eksekusi yang sangat efisien (3-6 detik untuk 1000 iterasi). GA menunjukkan keseimbangan superior antara eksplorasi (melalui populasi dan mutasi) dan eksloitasi.
- Simulated Annealing (SA) terbukti sebagai algoritma tercepat secara absolut (0.1 - 1.3 detik) sekaligus sangat efektif dalam melompati local optima untuk mencapai solusi yang baik ($\sim 4291.x$). Analisis menunjukkan bahwa Temperatur Awal adalah parameter yang lebih krusial daripada jumlah iterasi untuk kesuksesannya.
- Random Restart Hill-Climbing berhasil menemukan solusi yang sebanding dengan SA ($\sim 4291.x$), namun dengan durasi eksekusi yang jauh lebih lama (ratusan detik), menjadikannya metode yang paling tidak efisien di antara ketiga algoritma yang berhasil.

4. Rekomendasi Algoritma

Genetic Algorithm dan Simulated Annealing terbukti sebagai pendekatan yang paling superior untuk kasus BPP ini. GA direkomendasikan jika tujuannya adalah kualitas solusi terbaik (efektivitas), sementara SA direkomendasikan jika tujuannya adalah kecepatan komputasi (efisiensi) dengan hasil yang masih sangat baik.

3.2 Saran

Berdasarkan eksperimen yang telah dilakukan, berikut adalah saran untuk pengembangan atau analisis selanjutnya:

1. Tuning Parameter Lanjutan

Efektivitas SA dan GA sangat bergantung pada tuning parameter. Eksperimen lebih lanjut dapat dilakukan untuk menemukan jadwal pendinginan (cooling schedule) yang optimal untuk SA, atau kombinasi laju mutasi dan ukuran populasi yang ideal untuk GA.

2. Operator "Move" yang Lebih Kompleks

Eksperimen ini hanya menggunakan dua operator move sederhana (pindah dan tukar). Penelitian di masa depan dapat mengeksplorasi operator yang lebih kompleks, seperti "memindahkan 2 barang" atau "menukar 3 barang", yang mungkin dapat melompati local optima yang lebih sulit.

3. Hibridisasi Algoritma

Dapat dicoba pendekatan hibrida. Misalnya, menggunakan Genetic Algorithm untuk mengeksplorasi pencarian secara global selama beberapa generasi, kemudian mengambil individu terbaik dari populasi akhir dan menjalankannya melalui Simulated Annealing atau Steepest Ascent untuk penyempurnaan lokal (local tuning).

4. Eksperimen pada Skala dan Variasi Data yang Lebih Luas:

Algoritma sebaiknya diuji pada berbagai skala data (jumlah item, sebaran ukuran item, kapasitas container) untuk melihat generalisasi dan limitasi pendekatan.

Pembagian Tugas Kelompok

Tabel 4.1 Tabel Pembagian Tugas tiap Anggota Kelompok

NIM	Nama	Tugas
18223120	Leonard Arif Sutiono	<ul style="list-style-type: none">• Membuat README• Mengimplementasikan kode untuk algoritma Genetic Algorithm• Mendesain tampilan visual output state pada CLI• Mengintegrasikan data-data hasil output pada setiap algoritma ke main• Mengerjakan laporan bagian hasil dan pembahasan untuk <i>Genetic Algorithm</i>, saran, dan kesimpulan
18223129	Izhar Alif Akbar	<ul style="list-style-type: none">• Inisialisasi struktur kode• Membuat <i>pipeline</i> untuk integrasi keseluruhan kode• Mengimplementasikan kode untuk algoritma <i>Simulated Annealing</i>• Membantu mengimplementasikan keseluruhan kode untuk algoritma <i>Hill-Climbing</i>• Mendefinisikan <i>objective function</i>• Mengerjakan laporan bagian pendahuluan, hasil dan pembahasan untuk Simulated Annealing, kesimpulan, dan saran
18223136	Geraldo Linggom Samuel T.	<ul style="list-style-type: none">• Mengimplementasikan kode untuk algoritma <i>Hill Climbing</i>• Mengerjakan laporan bagian pendahuluan, hasil dan pembahasan untuk Hill Climbing, kesimpulan, dan saran

Lampiran

Referensi

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- <https://research.monash.edu/en/publications/different-local-search-algorithms-in-stage-for-solving-bin-packing/>
- <https://www.geeksforgeeks.org/artificial-intelligence/local-search-algorithm-in-artificial-intelligence/>
- <https://medium.com/data-science/local-search-with-simulated-annealing-from-scratch-9f8dcb6c2e06>
- <https://medium.com/data-science/ai-search-algorithms-every-data-scientist-should-know-ed0968a43a7a>

Link Github

Berikut terlampir link github kelompok kami :

<https://github.com/Izhrr/3Outliers-bin-packing>