**Appendix A: Total cost of optimal solutions and running times for the AR instances with 12, 24 and 30 customers**

**Table 1:** Total cost of optimal solutions and running times for instances with 12 customers

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Instance | Total cost | duration | penalties | running time until proven optimality in seconds | running time until optimal solution was encountered in seconds | Total cost of best solution after 5 minutes |
| 1 | 108,462 | 25,609 | 82,853 | 1 | 1 | 108,462 |
| 2 | 23,422 | 22,876 | 546 | 1 | 1 | 23,422 |
| 3 | 22,352 | 22,017 | 335 | 1 | 1 | 22,352 |
| 4 | 61,159 | 25,073 | 36,086 | 1 | 1 | 61,159 |
| 5 | 138,560 | 24,934 | 113,626 | 1 | 1 | 138,560 |
| 6 | 859,629 | 26,446 | 833,183 | 1 | 1 | 859,629 |
| 7 | 336,506 | 27,318 | 309,188 | 1 | 1 | 336,506 |
| 8 | 108,572 | 24,308 | 84,264 | 1 | 1 | 108,572 |
| 9 | 40,758 | 23,508 | 17,250 | 1 | 1 | 40,758 |
| 10 | 437,940 | 26,842 | 411,098 | 1 | 1 | 437,940 |
| 11 | 58,178 | 25,358 | 32,820 | 1 | 1 | 58,178 |
| 12 | 274,220 | 26,432 | 247,788 | 2 | 2 | 274,220 |
| 13 | 27,299 | 25,371 | 1,928 | 1 | 1 | 27,299 |
| 14 | 94,257 | 25,310 | 68,947 | 1 | 1 | 94,257 |
| 15 | 369,258 | 27,414 | 341,844 | 1 | 1 | 369,258 |
| 16 | 377,499 | 25,953 | 351,546 | 1 | 1 | 377,499 |
| 17 | 139,984 | 27,382 | 112,602 | 1 | 1 | 139,984 |
| 18 | 68,548 | 22,543 | 46,005 | 1 | 1 | 68,548 |
| 19 | 59,758 | 25,231 | 34,527 | 1 | 1 | 59,758 |
| 20 | 23,455 | 23,319 | 136 | 1 | 1 | 23,455 |
|  |  |  | average | 1 | 1 |  |
|  |  |  | median | 1 | 1 |  |
|  |  |  | min | 1 | 1 |  |
|  |  |  | max | 2 | 2 |  |

**Table 2:** Total cost of optimal solutions and running times for instances with 24 customers

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Instance | Total cost | duration | penalties | running time until proven optimality in seconds | running time until optimal solution was encountered in seconds | Total cost of best solution after 5 minutes |
| 1 | 22,490 | 22,172 | 318 | 3,493 | 3,493 | 29,713 |
| 2 | 25,504 | 23,165 | 2,339 | 732 | 252 | 25,504 |
| 3 | 154,482 | 24,616 | 129,866 | 797 | 554 | 1,078,136 |
| 4 | 41,776 | 22,809 | 18,967 | 607 | 607 | 44,970 |
| 5 | 21,381 | 21,381 | 0 | 50 | 50 | 21,381 |
| 6 | 30,799 | 23,084 | 7,715 | 154 | 154 | 30,799 |
| 7 | 22,347 | 21,193 | 1,154 | 359 | 359 | 23,191 |
| 8 | 21,660 | 21,609 | 51 | 42 | 42 | 21,660 |
| 9 | 25,521 | 22,327 | 3,194 | 1,424 | 698 | 27,038 |
| 10 | 39,993 | 24,648 | 15,345 | 826 | 826 | 56,417 |
| 11 | 24,572 | 22,878 | 1,694 | 176 | 42 | 24,572 |
| 12 | 33,025 | 23,672 | 9,353 | 302 | 302 | 37,222 |
| 13 | 20,552 | 20,551 | 1 | 81 | 81 | 20,552 |
| 14 | 31,915 | 23,046 | 8,869 | 329 | 329 | 39,975 |
| 15 | 28,060 | 23,046 | 5,014 | 251 | 98 | 28,060 |
| 16 | 49,429 | 24,026 | 25,403 | 850 | 607 | 100,057 |
| 17 | 25,253 | 22,999 | 2,254 | 341 | 92 | 25,253 |
| 18 | 29,267 | 23,165 | 6,102 | 79 | 69 | 29,267 |
| 19 | 48,369 | 22,632 | 25,737 | 524 | 426 | 64,712 |
| 20 | 23,679 | 22,212 | 1,467 | 458 | 458 | 24,029 |
|  |  |  | average | 594 | 477 |  |
|  |  |  | median | 350 | 316 |  |
|  |  |  | min | 42 | 42 |  |
|  |  |  | max | 3,493 | 3,493 |  |

**Table 3:** Total cost of optimal solutions and running times for instances with 30 customers

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Instance | Total cost | duration | penalties | running time until proven optimality in seconds | running time until optimal solution was encountered in seconds | Total cost of best solution after 5 minutes |
| 1 | 24,452 | 22,025 | 2,427 | 11,627 | 1,593 | 82,751 |
| 2 | 77,235 | 23,970 | 53,265 | 174,467 | 174,467 | 265,251 |
| 3 | 76,136 | 24,248 | 51,888 | 63,484 | 63,484 | 6,182,625 |
| 4 | 33,269 | 22,474 | 10,795 | 22,220 | 22,220 | 134,254 |
| 5 | 21,360 | 21,358 | 2 | 8,203 | 4,222 | 69,829 |
| 6 | 22,106 | 21,557 | 549 | 1,069 | 770 | 92,771 |
| 7 | 24,287 | 21,486 | 2,801 | 58,114 | 58,114 | 42,684 |
| 8 | 22,527 | 21,988 | 539 | 823 | 665 | 41,941 |
| 9 | 21,407 | 21,407 | 0 | 2,292 | 2,292 | 289,766 |
| 10 | 75,752 | 23,063 | 52,689 | 165,902 | 112,211 | 370,123 |
| 11 | 21,610 | 21,529 | 81 | 713 | 691 | 855,789 |
| 12 | 32,954 | 23,558 | 9,396 | 13,451 | 13,451 | 110,158 |
| 13 | 21,239 | 21,230 | 9 | 1,924 | 1,877 | 81,979 |
| 14 | 169,894 | 24,360 | 145,534 | 63,094 | 63,094 | 1,478,914 |
| 15 | 114,029 | 24,271 | 89,758 | 64,741 | 64,741 | 2,295,529 |
| 16 | 85,268 | 24,195 | 61,073 | 252,537 | 193,704 | 1,109,448 |
| 17 | 47,892 | 23,917 | 23,975 | 325,438 | 131,423 | 691,760 |
| 18 | 24,344 | 22,304 | 2,040 | 53,408 | 53,408 | 140,579 |
| 19 | 33,774 | 22,860 | 10,914 | 43,870 | 43,870 | 211,675 |
| 20 | 46,972 | 22,856 | 24,116 | 219,000 | 219,000 | 284,481 |
|  |  |  | average | 77,319 | 61,265 |  |
|  |  |  | median | 48,639 | 48,639 |  |
|  |  |  | min | 713 | 665 |  |
|  |  |  | max | 325,438 | 219,000 |  |

**Appendix B: Optimal solutions for the AR instances with 12, 24 and 30 customers**

**Table 4:** Optimal solutions for instances with 12 customers

|  |  |
| --- | --- |
| Instance | optimal solution |
| 1 | [0, 5, 9, 8, 10, 12, 11, 6, 3, 1, 4, 2, 7, 0] |
| 2 | [0, 6, 2, 8, 7, 10, 3, 12, 1, 4, 9, 5, 11, 0] |
| 3 | [0, 5, 1, 8, 4, 2, 3, 10, 12, 9, 6, 7, 11, 0] |
| 4 | [0, 3, 10, 2, 11, 12, 4, 6, 8, 1, 5, 7, 9, 0] |
| 5 | [0, 3, 11, 2, 1, 9, 5, 10, 7, 4, 6, 8, 12, 0] |
| 6 | [0, 2, 8, 3, 12, 5, 6, 9, 1, 7, 4, 11, 10, 0] |
| 7 | [0, 6, 1, 5, 9, 12, 2, 11, 10, 8, 3, 7, 4, 0] |
| 8 | [0, 11, 1, 6, 7, 4, 3, 12, 2, 8, 5, 10, 9, 0] |
| 9 | [0, 10, 12, 6, 2, 5, 7, 3, 4, 1, 9, 8, 11, 0] |
| 10 | [0, 10, 4, 9, 8, 7, 6, 3, 11, 2, 12, 1, 5, 0] |
| 11 | [0, 10, 2, 3, 9, 8, 1, 12, 4, 5, 11, 6, 7, 0] |
| 12 | [0, 1, 12, 11, 10, 4, 7, 9, 2, 6, 5, 3, 8, 0] |
| 13 | [0, 9, 11, 12, 3, 1, 5, 8, 4, 2, 7, 6, 10, 0] |
| 14 | [0, 3, 8, 5, 6, 12, 1, 4, 2, 10, 7, 9, 11, 0] |
| 15 | [0, 7, 1, 9, 3, 12, 11, 10, 2, 5, 8, 4, 6, 0] |
| 16 | [0, 1, 7, 10, 9, 4, 5, 2, 3, 11, 12, 6, 8, 0] |
| 17 | [0, 2, 10, 9, 7, 5, 3, 6, 11, 8, 12, 1, 4, 0] |
| 18 | [0, 1, 6, 12, 9, 7, 2, 3, 11, 4, 5, 8, 10, 0] |
| 19 | [0, 6, 9, 7, 11, 1, 8, 10, 12, 4, 5, 3, 2, 0] |
| 20 | [0, 10, 3, 9, 8, 1, 11, 7, 5, 12, 2, 4, 6, 0] |

**Table 5:** Optimal solutions for instances with 24 customers

|  |  |
| --- | --- |
| Instance | optimal solution |
| 1 | [0, 8, 19, 4, 10, 1, 16, 3, 5, 9, 24, 7, 15, 18, 17, 13, 2, 6, 11, 12, 22, 21, 23, 20, 14, 0] |
| 2 | [0, 9, 4, 11, 13, 24, 18, 5, 14, 20, 10, 15, 12, 7, 8, 1, 2, 16, 6, 23, 19, 3, 22, 17, 21, 0] |
| 3 | [0, 3, 21, 2, 19, 12, 8, 1, 23, 10, 15, 6, 14, 20, 9, 22, 4, 11, 18, 24, 5, 16, 13, 7, 17, 0] |
| 4 | [0, 2, 21, 18, 9, 15, 16, 11, 1, 10, 22, 14, 4, 20, 24, 19, 3, 23, 6, 7, 13, 8, 12, 17, 5, 0] |
| 5 | [0, 23, 11, 1, 9, 18, 10, 24, 17, 5, 4, 8, 13, 2, 6, 7, 15, 3, 14, 16, 21, 19, 22, 12, 20, 0] |
| 6 | [0, 24, 7, 8, 12, 9, 18, 10, 2, 1, 15, 16, 13, 11, 22, 6, 4, 20, 19, 23, 14, 17, 5, 21, 3, 0] |
| 7 | [0, 13, 16, 20, 2, 14, 23, 15, 19, 21, 12, 17, 4, 24, 9, 1, 6, 7, 18, 22, 3, 8, 11, 10, 5, 0] |
| 8 | [0, 5, 8, 9, 22, 14, 12, 15, 19, 1, 24, 23, 11, 20, 4, 18, 10, 17, 2, 13, 7, 6, 21, 16, 3, 0] |
| 9 | [0, 8, 4, 18, 21, 19, 5, 20, 6, 12, 13, 3, 1, 17, 9, 24, 11, 2, 23, 22, 15, 7, 10, 14, 16, 0] |
| 10 | [0, 20, 12, 21, 17, 24, 22, 14, 15, 18, 23, 9, 3, 5, 13, 4, 16, 2, 19, 7, 1, 11, 6, 10, 8, 0] |
| 11 | [0, 9, 24, 11, 19, 8, 15, 1, 17, 3, 10, 12, 23, 2, 14, 18, 13, 4, 21, 22, 5, 7, 6, 16, 20, 0] |
| 12 | [0, 7, 1, 9, 19, 8, 5, 10, 18, 13, 23, 17, 15, 11, 12, 4, 21, 24, 14, 2, 20, 3, 22, 16, 6, 0] |
| 13 | [0, 7, 18, 2, 24, 6, 11, 3, 22, 5, 23, 1, 4, 12, 10, 21, 8, 17, 16, 14, 13, 15, 20, 19, 9, 0] |
| 14 | [0, 8, 2, 14, 19, 16, 13, 23, 12, 9, 11, 15, 3, 17, 6, 7, 1, 24, 5, 10, 22, 18, 21, 20, 4, 0] |
| 15 | [0, 5, 19, 22, 9, 13, 4, 8, 2, 17, 14, 16, 11, 20, 7, 10, 18, 23, 21, 1, 3, 15, 12, 6, 24, 0] |
| 16 | [0, 24, 17, 2, 18, 1, 11, 16, 14, 12, 5, 19, 9, 6, 15, 3, 13, 20, 8, 4, 21, 7, 22, 10, 23, 0] |
| 17 | [0, 9, 19, 11, 23, 7, 4, 14, 10, 1, 3, 2, 5, 17, 15, 22, 20, 18, 24, 8, 12, 16, 6, 13, 21, 0] |
| 18 | [0, 18, 19, 20, 13, 9, 10, 1, 6, 2, 12, 5, 14, 21, 16, 11, 3, 8, 24, 22, 17, 4, 15, 7, 23, 0] |
| 19 | [0, 23, 2, 4, 24, 8, 22, 6, 20, 9, 15, 19, 10, 3, 14, 21, 11, 16, 13, 17, 7, 12, 18, 1, 5, 0] |
| 20 | [0, 24, 21, 2, 22, 3, 16, 19, 11, 9, 5, 20, 23, 1, 14, 15, 12, 10, 18, 17, 4, 13, 8, 7, 6, 0] |

**Table 6:** Optimal solutions for instances with 30 customers

|  |  |
| --- | --- |
| Instance | optimal solution |
| 1 | [0, 8, 13, 28, 17, 18, 24, 9, 7, 15, 25, 14, 2, 6, 11, 22, 12, 21, 27, 23, 20, 4, 29, 10, 1, 16, 3, 30, 5, 19, 26, 0] |
| 2 | [0, 9, 11, 4, 14, 15, 20, 18, 28, 5, 13, 30, 19, 29, 25, 6, 23, 3, 22, 17, 21, 16, 2, 1, 27, 8, 7, 12, 10, 26, 24, 0] |
| 3 | [0, 13, 28, 3, 27, 30, 21, 2, 19, 12, 7, 29, 11, 4, 22, 10, 15, 6, 14, 20, 9, 24, 5, 16, 18, 8, 26, 23, 17, 25, 1, 0] |
| 4 | [0, 19, 3, 23, 6, 27, 28, 25, 5, 26, 17, 10, 11, 1, 15, 16, 29, 9, 2, 21, 18, 30, 7, 13, 8, 12, 22, 14, 24, 20, 4, 0] |
| 5 | [0, 23, 11, 1, 9, 18, 29, 10, 24, 17, 5, 30, 13, 4, 8, 2, 26, 28, 6, 7, 15, 3, 14, 16, 21, 19, 22, 27, 25, 12, 20, 0] |
| 6 | [0, 24, 7, 8, 12, 9, 18, 21, 10, 3, 2, 30, 1, 27, 13, 4, 6, 22, 11, 28, 15, 16, 20, 29, 19, 26, 23, 14, 17, 5, 25, 0] |
| 7 | [0, 25, 20, 2, 14, 23, 27, 15, 19, 13, 16, 6, 1, 26, 24, 9, 21, 12, 17, 29, 4, 28, 10, 11, 3, 30, 22, 8, 7, 18, 5, 0] |
| 8 | [0, 29, 27, 1, 25, 19, 28, 15, 12, 30, 24, 11, 23, 20, 4, 18, 10, 26, 5, 8, 14, 9, 22, 21, 16, 13, 6, 7, 17, 2, 3, 0] |
| 9 | [0, 6, 8, 4, 18, 21, 19, 5, 27, 25, 15, 2, 30, 11, 24, 17, 1, 9, 26, 12, 13, 3, 23, 22, 20, 10, 14, 28, 29, 16, 7, 0] |
| 10 | [0, 26, 25, 29, 19, 10, 8, 6, 1, 11, 15, 2, 27, 16, 4, 13, 18, 23, 9, 3, 5, 28, 12, 21, 17, 24, 22, 14, 30, 7, 20, 0] |
| 11 | [0, 9, 24, 8, 15, 1, 17, 19, 11, 27, 3, 10, 29, 12, 23, 2, 14, 18, 4, 13, 21, 22, 26, 6, 16, 20, 7, 30, 28, 5, 25, 0] |
| 12 | [0, 17, 30, 13, 2, 29, 23, 25, 7, 15, 11, 8, 19, 10, 18, 1, 9, 5, 28, 27, 4, 26, 12, 21, 20, 22, 16, 3, 14, 24, 6, 0] |
| 13 | [0, 9, 29, 22, 3, 11, 18, 6, 24, 2, 7, 10, 17, 28, 1, 23, 27, 5, 4, 12, 8, 21, 16, 30, 14, 13, 26, 15, 20, 19, 25, 0] |
| 14 | [0, 20, 27, 26, 5, 10, 22, 18, 21, 1, 24, 4, 17, 3, 6, 7, 14, 23, 9, 12, 25, 16, 19, 2, 8, 11, 30, 29, 28, 15, 13, 0] |
| 15 | [0, 27, 19, 5, 29, 22, 9, 30, 13, 4, 2, 17, 26, 8, 14, 16, 11, 20, 7, 10, 18, 23, 25, 1, 3, 15, 12, 21, 6, 28, 24, 0] |
| 16 | [0, 3, 6, 9, 28, 27, 26, 19, 30, 5, 12, 25, 17, 2, 18, 1, 11, 24, 16, 14, 15, 13, 29, 20, 8, 4, 21, 7, 22, 10, 23, 0] |
| 17 | [0, 25, 11, 9, 27, 18, 19, 28, 22, 20, 29, 24, 8, 12, 26, 13, 21, 6, 30, 16, 14, 10, 4, 7, 23, 15, 1, 3, 2, 5, 17, 0] |
| 18 | [0, 19, 18, 13, 20, 27, 9, 10, 1, 6, 25, 8, 24, 11, 3, 30, 16, 14, 21, 5, 2, 12, 17, 4, 15, 29, 26, 23, 7, 28, 22, 0] |
| 19 | [0, 25, 10, 26, 9, 15, 19, 14, 3, 12, 18, 30, 28, 24, 4, 2, 23, 6, 20, 8, 1, 22, 5, 7, 17, 13, 11, 27, 16, 29, 21, 0] |
| 20 | [0, 10, 25, 6, 8, 7, 13, 4, 17, 18, 21, 24, 28, 2, 19, 11, 30, 3, 22, 16, 27, 29, 23, 1, 14, 20, 5, 9, 26, 15, 12, 0] |

**Appendix C: Total cost of optimal solutions and running times for the AGGG instances with 15, 20, 30 and 40 customers and narrow time window**

**Table 7:** Total cost of optimal solutions and running times for AGGG instances with narrow time window

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | Width in Arigliano et al. (2015) | Delta in Arigliano et al. (2015) | Pattern in Arigliano et al. (2015) | Instance in Arigliano et al. (2015) | Total cost | duration | penalties | running time until proven optimality in seconds | running time until optimal solution was encountered in seconds | Total cost of best solution after 5 minutes |
| 15 | 100 | 70 | A | B4 | 38,267 | 29,598 | 8,669 | 4 | 4 | 38,267 |
| 15 | 70 | B | C6 | 107,477 | 47,792 | 59,685 | 3 | 3 | 107,477 |
| 15 | 90 | A | C7 | 96,124 | 47,836 | 48,288 | 3 | 3 | 96,124 |
| 15 | 90 | B | A3 | 23,701 | 23,636 | 65 | 3 | 3 | 23,701 |
| 15 | 98 | A | B8 | 53,673 | 34,057 | 19,616 | 3 | 3 | 53,673 |
| 15 | 98 | B | A2 | 23,901 | 22,378 | 1,523 | 3 | 3 | 23,901 |
| 20 | 70 | A | B9 | 43,282 | 38,872 | 4,410 | 5 | 5 | 43,282 |
| 20 | 70 | B | B10 | 52,391 | 42,416 | 9,975 | 5 | 5 | 52,391 |
| 20 | 90 | A | A5 | 25,593 | 25,578 | 15 | 15 | 8 | 25,593 |
| 20 | 90 | B | C7 | 62,860 | 43,238 | 19,622 | 5 | 5 | 62,860 |
| 20 | 98 | A | A7 | 44,336 | 35,775 | 8,561 | 5 | 5 | 44,336 |
| 20 | 98 | B | C8 | 50,901 | 48,318 | 2,583 | 5 | 5 | 50,901 |
| 30 | 70 | A | C7 | 73,581 | 61,818 | 11,763 | 13 | 13 | 73,581 |
| 30 | 70 | B | A9 | 46,944 | 46,944 | 0 | 15 | 13 | 46,944 |
| 30 | 90 | A | A5 | 69,706 | 43,044 | 26,662 | 13 | 13 | 69,706 |
| 30 | 90 | B | A10 | 51,847 | 44,120 | 7,727 | 16 | 15 | 51,847 |
| 30 | 98 | A | C5 | 105,102 | 55,695 | 49,407 | 13 | 13 | 105,102 |
| 30 | 98 | B | A1 | 44,145 | 44,024 | 121 | 13 | 13 | 44,145 |
| 40 | 70 | A | C1 | 83,747 | 74,503 | 9,244 | 41 | 41 | 83,747 |
| 40 | 70 | B | B3 | 96,014 | 65,489 | 30,525 | 48 | 43 | 96,014 |
| 40 | 90 | A | B2 | 54,853 | 54,853 | 0 | 158 | 125 | 54,853 |
| 40 | 90 | B | A3 | 50,165 | 50,129 | 36 | 49 | 43 | 50,165 |
| 40 | 98 | A | A5 | 43,377 | 42,415 | 962 | 106 | 75 | 43,377 |
| 40 | 98 | B | B9 | 48,763 | 48,763 | 0 | 71 | 36 | 48,763 |

**Appendix D: Optimal solutions for the AGGG instances with 15, 20, 30 and 40 customers and narrow time window**

**Table 8:** optimal solutions for AGGG instances with narrow time window

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N | Width in Arigliano et al. (2015) | Delta in Arigliano et al. (2015) | Pattern in Arigliano et al. (2015) | Instance in Arigliano et al. (2015) | Optimal Solution |
| 15 | 100 | 70 | A | B4 | [0, 2, 1, 3, 4, 5, 6, 9, 8, 7, 11, 10, 12, 13, 14, 15, 0] |
| 15 | 70 | B | C6 | [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 0] |
| 15 | 90 | A | C7 | [0, 1, 2, 3, 4, 5, 7, 6, 8, 9, 10, 11, 12, 13, 15, 14, 0] |
| 15 | 90 | B | A3 | [0, 3, 1, 2, 4, 5, 6, 7, 9, 8, 13, 10, 11, 12, 15, 14, 0] |
| 15 | 98 | A | B8 | [0, 1, 2, 3, 4, 5, 6, 7, 8, 11, 10, 9, 12, 13, 14, 15, 0] |
| 15 | 98 | B | A2 | [0, 1, 5, 6, 2, 3, 4, 7, 8, 9, 11, 10, 12, 13, 14, 15, 0] |
| 20 | 70 | A | B9 | [0, 1, 3, 4, 2, 5, 6, 7, 8, 9, 10, 11, 12, 15, 13, 14, 16, 17, 18, 19, 20, 0] |
| 20 | 70 | B | B10 | [0, 1, 2, 3, 4, 5, 7, 6, 8, 9, 10, 11, 13, 12, 14, 15, 16, 17, 18, 19, 20, 0] |
| 20 | 90 | A | A5 | [0, 2, 1, 5, 6, 3, 4, 8, 7, 9, 12, 13, 10, 11, 14, 17, 15, 16, 19, 18, 20, 0] |
| 20 | 90 | B | C7 | [0, 1, 2, 3, 4, 5, 6, 8, 7, 9, 11, 10, 12, 13, 15, 14, 16, 17, 18, 19, 20, 0] |
| 20 | 98 | A | A7 | [0, 1, 2, 3, 5, 4, 6, 7, 8, 9, 10, 11, 12, 13, 16, 14, 15, 17, 19, 18, 20, 0] |
| 20 | 98 | B | C8 | [0, 1, 3, 2, 4, 5, 6, 7, 8, 10, 9, 11, 12, 14, 13, 15, 16, 17, 18, 19, 20, 0] |
| 30 | 70 | A | C7 | [0, 1, 2, 3, 4, 5, 6, 7, 9, 8, 10, 11, 12, 13, 14, 16, 15, 17, 19, 18, 20, 22, 21, 24, 23, 25, 26, 27, 28, 29, 30, 0] |
| 30 | 70 | B | A9 | [0, 2, 1, 3, 4, 5, 7, 6, 8, 9, 11, 10, 12, 13, 14, 16, 15, 17, 19, 20, 18, 21, 22, 23, 24, 25, 26, 28, 27, 29, 30, 0] |
| 30 | 90 | A | A5 | [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 16, 21, 18, 19, 20, 22, 23, 24, 26, 25, 27, 30, 29, 28, 0] |
| 30 | 90 | B | A10 | [0, 1, 2, 3, 5, 4, 6, 8, 7, 10, 9, 11, 12, 13, 14, 16, 15, 18, 17, 19, 22, 20, 21, 23, 25, 24, 26, 28, 29, 27, 30, 0] |
| 30 | 98 | A | C5 | [0, 1, 2, 3, 4, 5, 6, 8, 7, 9, 10, 12, 11, 13, 14, 15, 16, 18, 17, 19, 22, 20, 21, 23, 25, 24, 26, 28, 27, 29, 30, 0] |
| 30 | 98 | B | A1 | [0, 2, 1, 3, 4, 5, 7, 6, 8, 10, 9, 11, 12, 13, 15, 14, 16, 17, 19, 20, 18, 21, 22, 23, 25, 24, 28, 27, 26, 30, 29, 0] |
| 40 | 70 | A | C1 | [0, 2, 1, 3, 4, 5, 6, 7, 8, 9, 11, 10, 12, 13, 14, 15, 16, 17, 19, 18, 20, 22, 21, 23, 25, 24, 26, 27, 28, 29, 31, 30, 32, 33, 35, 34, 36, 37, 38, 39, 40, 0] |
| 40 | 70 | B | B3 | [0, 1, 2, 3, 4, 7, 5, 6, 8, 9, 10, 11, 12, 14, 13, 16, 15, 17, 18, 20, 19, 21, 22, 24, 23, 25, 27, 26, 29, 28, 30, 31, 34, 32, 33, 35, 37, 36, 38, 39, 40, 0] |
| 40 | 90 | A | B2 | [0, 3, 1, 2, 4, 5, 6, 8, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 17, 19, 20, 21, 22, 23, 24, 27, 25, 26, 28, 30, 31, 29, 32, 33, 35, 36, 34, 37, 39, 38, 40, 0] |
| 40 | 90 | B | A3 | [0, 3, 2, 1, 4, 5, 6, 8, 7, 9, 10, 12, 13, 11, 15, 14, 16, 18, 19, 17, 20, 21, 22, 23, 24, 26, 25, 27, 28, 29, 30, 31, 35, 33, 32, 36, 34, 38, 39, 37, 40, 0] |
| 40 | 98 | A | A5 | [0, 4, 1, 6, 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 16, 14, 15, 18, 17, 20, 22, 19, 21, 23, 24, 26, 25, 28, 27, 29, 30, 33, 32, 31, 34, 35, 37, 36, 39, 40, 38, 0] |
| 40 | 98 | B | B9 | [0, 2, 1, 3, 4, 5, 6, 7, 8, 9, 12, 13, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 22, 25, 27, 26, 28, 29, 30, 31, 32, 34, 33, 36, 35, 37, 38, 39, 40, 0] |

**Appendix E: Total cost of optimal solutions and running times for the AGGG instances with 15 and 20 customers and wide time window**

**Table 9:** Total cost of optimal solutions and running times for AGGG instances with wide time window

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | Width in Arigliano et al. (2015) | Delta in Arigliano et al. (2015) | Pattern in Arigliano et al. (2015) | Instance in Arigliano et al. (2015) | Total cost | duration | penalties | running time until proven optimality in seconds | running time until optimal solution was encountered in seconds | Total cost of best solution after 5 minutes |
| 15 | 50 | 70 | A | C9 | 37,894 | 35,189 | 2,705 | 6 | 6 | 37,894 |
| 15 | 70 | B | A5 | 29,659 | 29,244 | 415 | 11 | 11 | 29,659 |
| 15 | 90 | A | B9 | 28,922 | 27,880 | 1,042 | 6 | 6 | 28,922 |
| 15 | 90 | B | B6 | 21,956 | 21,956 | 0 | 7 | 7 | 21,956 |
| 15 | 98 | A | B5 | 22,122 | 21,277 | 845 | 5 | 5 | 22,122 |
| 15 | 98 | B | A1 | 18,194 | 18,194 | 0 | 9 | 9 | 18,194 |
| 20 | 70 | A | C6 | 40,585 | 35,189 | 5,396 | 38 | 34 | 40,585 |
| 20 | 70 | B | A2 | 26,797 | 26,381 | 416 | 285 | 239 | 26,797 |
| 20 | 90 | A | A9 | 29,352 | 25,334 | 4,018 | 849 | 612 | 30,466 |
| 20 | 90 | B | B4 | 39,129 | 27,187 | 11,942 | 21 | 15 | 39,129 |
| 20 | 98 | A | A8 | 21,486 | 21,446 | 40 | 149 | 133 | 21,486 |
| 20 | 98 | B | C9 | 38,571 | 32,293 | 6,278 | 11 | 7 | 38,571 |

**Appendix F: optimal solutions for the AGGG instances with 15 and 20 customers and wide time window**

**Table 10:** optimal solutions for the AGGG instances with wide time window

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N | Width in Arigliano et al. (2015) | Delta in Arigliano et al. (2015) | Pattern in Arigliano et al. (2015) | Instance in Arigliano et al. (2015) | Optimal solution |
| 15 | 50 | 70 | A | C9 | [0, 1, 3, 2, 4, 6, 5, 9, 11, 7, 15, 12, 10, 13, 8, 14, 0] |
| 15 | 70 | B | A5 | [0, 2, 1, 7, 5, 3, 11, 4, 14, 6, 8, 9, 10, 12, 15, 13, 0] |
| 15 | 90 | A | B9 | [0, 3, 1, 2, 4, 7, 5, 9, 10, 6, 15, 14, 8, 13, 11, 12, 0] |
| 15 | 90 | B | B6 | [0, 2, 1, 5, 3, 4, 6, 7, 13, 15, 9, 14, 8, 10, 12, 11, 0] |
| 15 | 98 | A | B5 | [0, 3, 1, 2, 4, 7, 6, 5, 10, 13, 8, 14, 9, 15, 11, 12, 0] |
| 15 | 98 | B | A1 | [0, 5, 3, 1, 2, 4, 7, 9, 6, 14, 15, 8, 11, 12, 13, 10, 0] |
| 20 | 70 | A | C6 | [0, 1, 2, 4, 3, 6, 7, 5, 10, 9, 11, 8, 13, 20, 15, 14, 19, 12, 18, 17, 16, 0] |
| 20 | 70 | B | A2 | [0, 2, 1, 6, 4, 3, 5, 7, 8, 13, 9, 11, 12, 19, 10, 20, 14, 18, 16, 15, 17, 0] |
| 20 | 90 | A | A9 | [0, 4, 1, 2, 3, 6, 7, 5, 13, 8, 10, 9, 18, 12, 14, 11, 20, 15, 17, 19, 16, 0] |
| 20 | 90 | B | B4 | [0, 3, 1, 2, 6, 5, 4, 11, 9, 7, 12, 8, 16, 10, 17, 15, 13, 19, 18, 14, 20, 0] |
| 20 | 98 | A | A8 | [0, 1, 6, 4, 9, 2, 3, 5, 12, 8, 7, 16, 18, 19, 10, 11, 15, 14, 13, 20, 17, 0] |
| 20 | 98 | B | C9 | [0, 1, 2, 3, 4, 10, 5, 6, 7, 9, 8, 11, 13, 16, 18, 12, 20, 15, 14, 17, 19, 0] |

**Appendix G: Best known solutions for the AGGG instances with 30 and 40 customers and wide time window**

**Table 11:** best known solutions for the AGGG instances with wide time window with 30 and 40 customers

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N | Width in Arigliano et al. (2015) | Delta in Arigliano et al. (2015) | Pattern in Arigliano et al. (2015) | Instance in Arigliano et al. (2015) | Best known solution | value |
| 30 | 50 | 70 | A | A7 | [0, 1, 4, 7, 2, 3, 6, 5, 10, 11, 8, 16, 20, 9, 12, 25, 14, 19, 13, 24, 23, 30, 18, 15, 21, 22, 17, 26, 29, 28, 27] | 29,440 |
| 30 | 70 | B | C2 | [0, 1, 2, 3, 4, 6, 5, 9, 7, 10, 8, 12, 23, 17, 26, 19, 11, 13, 29, 20, 14, 21, 15, 16, 25, 24, 27, 18, 22, 30, 28] | 47,344 |
| 30 | 90 | A | C4 | [0, 3, 2, 1, 4, 6, 8, 7, 11, 13, 5, 10, 18, 9, 21, 12, 15, 14, 17, 20, 25, 16, 27, 26, 29, 23, 30, 22, 28, 24, 19] | 31,796 |
| 30 | 90 | B | B2 | [0, 3, 2, 4, 1, 5, 8, 6, 11, 15, 14, 16, 7, 9, 10, 12, 18, 17, 20, 22, 29, 21, 13, 23, 24, 19, 30, 26, 28, 25, 27] | 35,369 |
| 30 | 98 | A | C9 | [0, 1, 2, 3, 4, 7, 10, 5, 6, 9, 8, 16, 13, 11, 18, 21, 19, 12, 24, 14, 15, 29, 22, 20, 28, 25, 26, 30, 27, 17, 23] | 39,260 |
| 30 | 98 | B | B5 | [0, 1, 3, 2, 4, 6, 8, 7, 11, 5, 10, 9, 14, 12, 26, 15, 13, 18, 22, 30, 17, 23, 16, 25, 27, 21, 24, 19, 20, 29, 28] | 35,954 |
| 40 | 70 | A | B10 | [0, 1, 2, 4, 3, 5, 6, 7, 8, 10, 11, 14, 13, 9, 12, 15, 17, 21, 16, 19, 24, 20, 28, 32, 25, 18, 26, 37, 36, 34, 38, 30, 22, 40, 35, 31, 33, 27, 29, 23, 39] | 37,818 |
| 40 | 70 | B | C5 | [0, 2, 1, 3, 10, 4, 5, 6, 12, 7, 8, 13, 9, 21, 14, 28, 11, 35, 32, 33, 15, 16, 18, 19, 38, 22, 23, 26, 17, 40, 37, 20, 29, 34, 24, 39, 27, 31, 30, 36, 25] | 62,533 |
| 40 | 90 | A | A6 | [0, 3, 4, 2, 1, 5, 8, 12, 6, 14, 7, 9, 11, 10, 13, 24, 21, 15, 26, 29, 25, 16, 17, 35, 22, 20, 38, 18, 31, 40, 19, 32, 28, 30, 23, 34, 39, 36, 33, 27, 37] | 31,337 |
| 40 | 90 | B | C7 | [0, 4, 1, 2, 3, 5, 6, 7, 8, 10, 9, 15, 11, 12, 13, 14, 25, 16, 17, 19, 24, 20, 30, 31, 18, 21, 23, 35, 33, 22, 39, 37, 36, 28, 40, 32, 38, 34, 26, 29, 27] | 45,752 |
| 40 | 98 | A | A8 | [0, 3, 2, 8, 1, 4, 5, 6, 10, 7, 12, 9, 11, 17, 13, 19, 15, 14, 16, 18, 30, 22, 21, 32, 20, 25, 31, 24, 37, 23, 28, 40, 33, 36, 34, 26, 38, 39, 27, 35, 29] | 35,105 |
| 40 | 98 | B | C9 | [0, 1, 3, 2, 6, 4, 5, 7, 10, 9, 14, 8, 11, 17, 24, 16, 12, 25, 31, 27, 20, 13, 28, 18, 15, 26, 19, 34, 32, 36, 23, 21, 37, 40, 30, 33, 38, 39, 29, 22, 35] | 45,367 |

**Appendix H: Best known solutions for the AR instances with 36 customers**

**Table 12:** best known solutions for the AR instances with 36 customers

|  |  |  |
| --- | --- | --- |
| Instance | Best known solution | value |
| 1 | [0, 8, 13, 17, 18, 24, 9, 7, 15, 28, 36, 2, 25, 27, 21, 23, 20, 14, 31, 11, 6, 22, 12, 34, 33, 5, 30, 3, 1, 16, 10, 29, 4, 35, 19, 32, 26] | 24,430 |
| 2 | [0, 11, 9, 4, 14, 36, 15, 20, 34, 28, 18, 5, 13, 30, 19, 33, 29, 25, 6, 35, 23, 3, 22, 17, 21, 16, 31, 2, 1, 27, 8, 7, 26, 10, 12, 32, 24] | 34,222 |
| 3 | [0, 16, 24, 5, 18, 33, 13, 28, 3, 27, 30, 36, 21, 35, 10, 15, 6, 14, 31, 9, 20, 29, 11, 22, 4, 7, 17, 25, 1, 23, 26, 8, 32, 34, 12, 19, 2] | 44,154 |
| 4 | [0, 30, 21, 2, 18, 9, 29, 15, 16, 11, 1, 10, 7, 13, 36, 8, 12, 17, 22, 14, 4, 34, 20, 24, 19, 35, 3, 23, 32, 6, 27, 28, 25, 31, 33, 5, 26] | 33,976 |
| 5 | [0, 23, 11, 1, 9, 18, 24, 10, 36, 29, 31, 17, 5, 30, 4, 13, 8, 35, 26, 2, 34, 6, 28, 7, 27, 15, 33, 3, 14, 16, 21, 19, 22, 32, 25, 12, 20] | 22,878 |
| 6 | [0, 24, 7, 35, 8, 12, 9, 18, 2, 3, 21, 10, 26, 19, 23, 14, 36, 5, 30, 25, 34, 32, 1, 27, 15, 16, 31, 13, 33, 4, 6, 22, 11, 28, 29, 20, 17] | 24,433 |
| 7 | [0, 1, 21, 5, 10, 28, 30, 3, 11, 22, 8, 18, 7, 23, 14, 31, 15, 19, 27, 2, 20, 35, 25, 16, 13, 34, 36, 4, 24, 32, 17, 29, 12, 9, 26, 33, 6] | 21,215 |
| 8 | [0, 11, 23, 29, 27, 1, 25, 19, 28, 35, 15, 12, 32, 14, 30, 8, 10, 18, 24, 36, 5, 33, 9, 22, 21, 3, 16, 2, 13, 7, 6, 31, 34, 17, 26, 4, 20] | 22,505 |
| 9 | [0, 15, 36, 25, 27, 18, 21, 19, 5, 4, 8, 20, 6, 12, 35, 26, 13, 3, 34, 9, 17, 1, 24, 11, 2, 30, 32, 22, 23, 31, 16, 33, 28, 10, 14, 29, 7] | 21,270 |
| 10 | [0, 26, 25, 19, 29, 35, 10, 8, 6, 1, 11, 2, 27, 16, 31, 4, 36, 18, 23, 9, 33, 13, 3, 34, 5, 15, 7, 30, 14, 22, 24, 17, 21, 12, 28, 20, 32] | 28,075 |
| 11 | [0, 15, 1, 17, 27, 3, 35, 33, 21, 31, 13, 4, 22, 34, 29, 10, 12, 2, 23, 32, 14, 25, 5, 9, 18, 19, 8, 11, 24, 28, 30, 36, 7, 26, 6, 16, 20] | 22,644 |
| 12 | [0, 7, 18, 1, 9, 10, 28, 5, 27, 8, 19, 35, 4, 26, 12, 11, 33, 31, 32, 21, 22, 16, 36, 24, 6, 14, 2, 34, 13, 29, 23, 25, 17, 15, 30, 20, 3] | 24,114 |
| 13 | [0, 9, 22, 3, 11, 18, 6, 24, 2, 20, 7, 29, 31, 27, 5, 23, 1, 28, 16, 17, 10, 4, 12, 34, 8, 21, 36, 35, 33, 30, 14, 13, 26, 15, 19, 32, 25] | 21,352 |
| 14 | [0, 7, 3, 35, 17, 6, 32, 12, 9, 25, 14, 23, 36, 27, 20, 31, 18, 26, 5, 10, 22, 21, 1, 24, 4, 33, 34, 29, 30, 28, 11, 8, 2, 19, 16, 13, 15] | 86,872 |
| 15 | [0, 27, 19, 5, 29, 22, 9, 30, 13, 4, 8, 2, 17, 26, 34, 14, 16, 11, 20, 32, 7, 10, 18, 12, 23, 25, 33, 35, 1, 3, 31, 15, 21, 6, 36, 28, 24] | 46,934 |
| 16 | [0, 16, 33, 2, 18, 1, 11, 24, 25, 17, 34, 14, 12, 5, 26, 27, 28, 9, 6, 3, 15, 35, 31, 36, 13, 29, 20, 8, 4, 19, 30, 21, 32, 7, 22, 23, 10] | 49,715 |
| 17 | [0, 25, 11, 35, 9, 19, 18, 27, 28, 29, 7, 36, 10, 16, 26, 13, 21, 6, 34, 24, 8, 33, 12, 30, 32, 31, 14, 4, 23, 20, 22, 15, 1, 3, 2, 5, 17] | 214,510 |
| 18 | [0, 2, 18, 19, 20, 13, 27, 9, 10, 6, 1, 25, 16, 3, 35, 8, 24, 11, 34, 30, 31, 5, 14, 21, 36, 28, 22, 23, 7, 33, 29, 15, 26, 32, 4, 17, 12] | 23,680 |
| 19 | [0, 25, 10, 26, 34, 9, 15, 19, 14, 33, 3, 12, 18, 6, 20, 31, 8, 32, 30, 28, 36, 24, 4, 2, 23, 22, 1, 7, 5, 17, 13, 11, 27, 35, 16, 29, 21] | 26,049 |
| 20 | [0, 10, 25, 6, 26, 13, 8, 7, 4, 35, 17, 18, 21, 12, 33, 15, 11, 14, 32, 20, 5, 9, 23, 1, 29, 16, 19, 3, 22, 31, 27, 36, 34, 30, 24, 28, 2] | 23,414 |

**Appendix I: Solution values and average running times for the ALNS heuristic for the AR instances with 24, 30 and 36 customers**

**Table 13:** solution values and running times for the ALNS heuristic over 10 runs - instances with 24 customers

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instance | #run | | | | | | | | | | Average running time (sec.) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 22,490 | 313 |
| 2 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 25,504 | 340 |
| 3 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 154,482 | 263 |
| 4 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 41,776 | 248 |
| 5 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 21,381 | 256 |
| 6 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 30,799 | 243 |
| 7 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 22,347 | 250 |
| 8 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 21,660 | 256 |
| 9 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 25,521 | 242 |
| 10 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 39,993 | 233 |
| 11 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 24,572 | 293 |
| 12 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 33,025 | 254 |
| 13 | 20,552 | 20,552 | 20,552 | 20,552 | 20,552 | 20,552 | 20,568 | 20,556 | 20,556 | 20,558 | 288 |
| 14 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 31,915 | 272 |
| 15 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 28,060 | 250 |
| 16 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 49,429 | 257 |
| 17 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 25,253 | 245 |
| 18 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 29,267 | 254 |
| 19 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 48,369 | 261 |
| 20 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 23,679 | 257 |

**Table 14:** solution values and running times for the ALNS heuristic over 10 runs - instances with 30 customers

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instance | #run | | | | | | | | | | Average running time (sec.) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 24,452 | 1,422 |
| 2 | 77,235 | 77,235 | 77,235 | 77,235 | 77,235 | 77,235 | 77,235 | 77,235 | 77,235 | 79,989 | 1,090 |
| 3 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 76,136 | 1,095 |
| 4 | 33,269 | 33,269 | 33,269 | 33,269 | 33,269 | 33,269 | 33,269 | 33,269 | 33,269 | 33,314 | 1,066 |
| 5 | 21,360 | 21,360 | 21,360 | 21,360 | 21,360 | 21,360 | 21,360 | 21,360 | 21,371 | 21,371 | 1,110 |
| 6 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 22,106 | 1,083 |
| 7 | 24,287 | 24,287 | 24,287 | 24,287 | 24,287 | 24,287 | 24,287 | 24,287 | 24,299 | 24,299 | 1,085 |
| 8 | 22,527 | 22,527 | 22,527 | 22,527 | 22,527 | 22,527 | 22,527 | 22,527 | 22,534 | 22,534 | 1,089 |
| 9 | 21,407 | 21,407 | 21,407 | 21,407 | 21,407 | 21,407 | 21,408 | 21,408 | 21,419 | 21,419 | 1,135 |
| 10 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 75,752 | 1,094 |
| 11 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 21,620 | 1,140 |
| 12 | 34,045 | 33,949 | 33,717 | 35,734 | 35,821 | 34,283 | 34,392 | 33,717 | 34,629 | 34,013 | 1,098 |
| 13 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 21,255 | 1,132 |
| 14 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 169,894 | 1,073 |
| 15 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 114,029 | 1,054 |
| 16 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 85,268 | 1,040 |
| 17 | 47,892 | 47,892 | 47,892 | 47,892 | 47,892 | 47,892 | 47,892 | 47,892 | 47,892 | 48,065 | 1,031 |
| 18 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 24,344 | 1,097 |
| 19 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 33,774 | 1,036 |
| 20 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 46,972 | 1,071 |

**Table 15:** solution values and running times for the ALNS heuristic over 10 runs - instances with 36 customers

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instance | #run | | | | | | | | | | Average running time (sec.) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | 24,430 | 24,430 | 24,430 | 24,430 | 24,430 | 24,517 | 24,430 | 24,430 | 24,430 | 24,430 | 3,298 |
| 2 | 34,222 | 34,379 | 34,222 | 34,222 | 34,222 | 34,222 | 34,379 | 34,379 | 34,379 | 34,379 | 4,277 |
| 3 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 44,154 | 4,424 |
| 4 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 33,976 | 4,368 |
| 5 | 22,907 | 22,906 | 22,972 | 22,878 | 22,909 | 22,892 | 22,907 | 22,947 | 22,925 | 22,905 | 4,456 |
| 6 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 24,433 | 4,245 |
| 7 | 21,316 | 21,325 | 21,215 | 21,267 | 21,263 | 21,324 | 21,286 | 21,276 | 21,280 | 21,281 | 4,540 |
| 8 | 22,607 | 22,631 | 22,505 | 22,568 | 22,622 | 22,637 | 22,724 | 22,736 | 22,597 | 22,640 | 4,398 |
| 9 | 21,270 | 21,338 | 21,373 | 21,287 | 21,409 | 21,335 | 21,365 | 21,366 | 21,339 | 21,389 | 4,615 |
| 10 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 28,075 | 4,358 |
| 11 | 22,772 | 22,644 | 22,799 | 22,774 | 22,735 | 22,735 | 22,886 | 22,644 | 22,689 | 22,771 | 4,369 |
| 12 | 24,390 | 24,114 | 24,201 | 24,114 | 24,387 | 24,284 | 24,123 | 24,390 | 24,114 | 24,123 | 4,230 |
| 13 | 21,356 | 21,373 | 21,363 | 21,352 | 21,356 | 21,370 | 21,353 | 21,369 | 21,379 | 21,376 | 4,470 |
| 14 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 86,872 | 4,212 |
| 15 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 46,934 | 4,257 |
| 16 | 49,715 | 50,037 | 49,715 | 49,715 | 49,715 | 49,715 | 49,715 | 49,715 | 49,715 | 49,715 | 3,195 |
| 17 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 214,510 | 3,181 |
| 18 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 23,680 | 4,448 |
| 19 | 26,049 | 26,069 | 26,126 | 26,134 | 26,049 | 26,096 | 26,049 | 26,049 | 26,134 | 26,049 | 4,340 |
| 20 | 23,414 | 23,512 | 23,656 | 23,512 | 23,414 | 23,512 | 23,512 | 23,597 | 23,512 | 23,512 | 4,299 |

**Appendix J: Solution values and average running times for the ALNS heuristic for the AGGG instances with 20, 30 and 40 customers**

**Table 16:** solution values and running times for the ALNS heuristic over 10 runs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | Width | Delta | Pattern | Instance | #run | | | | | | | | | | Average running time (sec.) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 20 | 100 | 70 | A | B9 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 43,282 | 92 |
| B | B10 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 52,391 | 95 |
| 90 | A | A5 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 25,593 | 95 |
| B | C7 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 62,860 | 95 |
| 98 | A | A7 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 44,336 | 92 |
| B | C8 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 50,901 | 97 |
| 50 | 70 | A | C6 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 40,585 | 96 |
| B | A2 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 26,797 | 94 |
| 90 | A | A9 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 29,352 | 95 |
| B | B4 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 39,129 | 94 |
| 98 | A | A8 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 21,486 | 93 |
| B | C9 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 38,571 | 95 |
| 30 | 100 | 70 | A | C7 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 73,581 | 1,209 |
| B | A9 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 46,944 | 1,213 |
| 90 | A | A5 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 69,706 | 1,143 |
| B | A10 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 51,847 | 1,198 |
| 98 | A | C5 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 105,102 | 1,192 |
| B | A1 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 44,145 | 1,195 |
| 50 | 70 | A | A7 | 29,440 | 29,440 | 29,440 | 29,440 | 29,440 | 29,440 | 29,440 | 29,440 | 29,459 | 29,590 | 1,172 |
| B | C2 | 47,366 | 47,351 | 47,366 | 47,366 | 47,366 | 47,344 | 47,353 | 47,366 | 47,366 | 47,366 | 1,165 |
| 90 | A | C4 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 31,796 | 1,168 |
| B | B2 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 35,369 | 1,175 |
| 98 | A | C9 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 39,260 | 1,173 |
| B | B5 | 35,954 | 35,954 | 35,954 | 35,954 | 35,967 | 35,954 | 36,002 | 35,954 | 35,954 | 36,018 | 1,168 |
| 40 | 100 | 70 | A | C1 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 83,747 | 6,899 |
| B | B3 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 96,014 | 6,732 |
| 90 | A | B2 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 54,853 | 6,942 |
| B | A3 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 50,165 | 6,607 |
| 98 | A | A5 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 43,377 | 6,361 |
| B | B9 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 48,763 | 6,885 |
| 50 | 70 | A | B10 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 37,818 | 6,184 |
| B | C5 | 62,533 | 62,577 | 62,558 | 62,598 | 62,558 | 62,533 | 62,586 | 62,558 | 62,558 | 62,558 | 6,252 |
| 90 | A | A6 | 31,434 | 31,337 | 31,421 | 31,466 | 31,486 | 31,459 | 31,417 | 31,388 | 31,499 | 31,375 | 5,993 |
| B | C7 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 45,752 | 6,558 |
| 98 | A | A8 | 35,105 | 35,105 | 35,105 | 35,105 | 35,105 | 35,105 | 35,112 | 35,105 | 35,105 | 35,112 | 6,251 |
| B | C9 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 45,367 | 6,426 |