

인공지능 5주차 과제

20186889 권용한

1.Level 1: beginning

-data1:

Execution Time: 6.402918338775635

Path: [0, 5, 13, 14, 15, 16, 24, 17, 12, 4, 11, 6, 7, 1, 2, 8, 9, 3, 10, 23, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 44, 52, 73, 67, 63, 74, 76, 77, 80, 81, 86, 87, 88, 92, 97, 111, 122, 129, 113, 117, 120, 123, 124, 125, 126, 127, 130, 110, 109, 115, 119, 116, 121, 128, 118, 114, 108, 107, 112, 106, 105, 104, 99, 100, 101, 98, 93, 91, 102, 103, 96, 95, 94, 89, 90, 72, 71, 79, 85, 84, 83, 82, 78, 75, 62, 66, 70, 69, 65, 61, 64, 68, 54, 53, 45, 46, 47, 48, 49, 51, 50, 55, 56, 57, 58, 59, 60, 43, 42, 22, 21, 20, 19, 18, 0]

Cost:

640.6655120317977



-data2:

Execution Time: 14.938683271408081

Path: [0, 22, 21, 54, 23, 1, 55, 63, 62, 60, 59, 67, 68, 78, 91, 90, 89, 118, 119, 121, 131, 137, 136, 130, 127, 148, 149, 144, 151, 152, 147, 146, 145, 138, 132, 128, 126, 170, 173, 204, 206, 207, 208, 175, 174, 226, 236, 237, 227, 250, 253, 252, 251, 263, 235, 225, 224, 203, 202, 201, 200, 199, 205, 198, 197, 196, 195, 194, 193, 192, 191, 190, 216, 217, 218, 234, 248, 247, 233, 246, 245, 232, 215, 189, 188, 187, 186, 185, 184, 183, 182, 213, 214, 223, 242, 243, 231, 264, 257, 258, 259, 260, 265, 266, 261, 268, 262, 267, 269, 297, 298, 270, 271, 272, 302, 303, 304, 300, 299, 309, 310, 311, 312, 316, 325, 334, 337, 336, 333, 324, 315, 323, 314, 313, 356, 386, 387, 388, 357, 389, 408, 419, 420, 436, 450, 446, 445, 444, 443, 442, 441, 440, 439, 438, 437, 428, 412, 413, 429, 435, 430, 414, 415, 431, 432, 416, 722, 822, 1069, 969, 968, 1040, 1029, 995, 996, 997, 998, 999, 967, 1002, 1001, 1020, 1030, 1042, 1031, 1046, 1045, 1060, 1082, 1081, 1068, 1067, 1080, 1061, 1028, 1039, 1038, 1022, 1070, 908, 922, 925, 911, 912, 926, 980, 1014, 1013, 1012, 1011, 1010, 979, 973, 1019, 1000, 1044, 1059, 1043, 1041, 1032, 1023, 1021, 1003, 970, 971, 972, 1004, 1005, 974, 975, 976, 977, 978, 1009, 1008, 1007, 1006, 1024, 1033, 1047, 1048, 1049, 1050, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079, 1066, 1065, 1064, 1063, 1062, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1051, 1034, 1025, 1026, 1035, 1036, 1037, 1027, 1018, 1017, 1016, 1015, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 932, 905, 930, 915, 916, 931, 965, 959, 958, 957, 956, 955, 954, 929, 914, 862, 861, 860, 859, 858, 857, 887, 888, 889, 890, 891, 913, 927, 964, 953, 952, 951, 950, 949, 948, 947, 946, 924, 910, 904, 909, 923, 945, 944, 943, 939, 936, 928, 898, 877, 880, 881, 882, 883, 884, 885, 886, 856, 855, 854, 853, 852, 851, 850, 849, 836, 827, 837, 824, 820, 800, 801, 786, 805, 809, 816, 817, 810, 806, 789, 788, 787, 747, 748, 749, 750, 751, 753, 752, 790, 811, 818, 828, 829, 830, 831,

821, 807, 835, 834, 833, 832, 819, 812, 758, 757, 756, 755, 754, 791, 792, 793, 794, 795, 796, 797, 707, 742, 741, 740, 739, 725, 724, 705, 704, 447, 448, 449, 368, 367, 366, 365, 362, 361, 360, 425, 394, 390, 403, 421, 422, 409, 404, 391, 364, 363, 354, 353, 352, 351, 348, 332, 326, 279, 278, 277, 276, 275, 274, 273, 301, 285, 244, 157, 129, 96, 154, 165, 210, 178, 177, 176, 219, 220, 238, 239, 221, 228, 229, 240, 255, 256, 241, 230, 222, 212, 211, 181, 180, 179, 164, 153, 150, 162, 143, 139, 122, 125, 120, 92, 93, 94, 95, 79, 69, 75, 66, 58, 57, 18, 24, 25, 2, 26, 49, 27, 28, 4, 29, 50, 30, 6, 31, 7, 8, 32, 51, 33, 9, 34, 10, 11, 16, 20, 48, 47, 19, 46, 17, 45, 44, 53, 43, 42, 41, 15, 40, 39, 37, 38, 14, 13, 12, 35, 52, 36, 56, 65, 61, 64, 72, 73, 74, 82, 83, 76, 87, 77, 88, 84, 116, 115, 114, 113, 112, 111, 110, 109, 108, 107, 106, 140, 167, 156, 171, 166, 155, 101, 100, 99, 98, 97, 70, 80, 85, 71, 81, 86, 102, 117, 103, 104, 105, 123, 124, 135, 142, 134, 133, 141, 158, 159, 168, 172, 249, 284, 283, 282, 308, 281, 280, 305, 306, 307, 335, 328, 318, 317, 327, 338, 339, 340, 345, 341, 329, 319, 320, 330, 346, 347, 331, 321, 322, 286, 287, 288, 289, 290, 291, 292, 343, 350, 344, 358, 359, 510, 496, 476, 461, 451, 452, 453, 462, 509, 533, 527, 532, 531, 601, 611, 610, 629, 614, 644, 645, 646, 681, 682, 683, 694, 685, 650, 717, 723, 746, 745, 815, 848, 878, 879, 903, 907, 921, 935, 937, 938, 942, 941, 940, 920, 919, 906, 918, 934, 966, 963, 962, 961, 960, 933, 917, 899, 900, 901, 902, 876, 875, 874, 873, 872, 871, 870, 869, 868, 867, 866, 897, 896, 895, 894, 893, 892, 863, 864, 865, 839, 840, 841, 842, 843, 844, 845, 846, 847, 838, 823, 813, 825, 826, 814, 808, 802, 803, 804, 785, 744, 743, 784, 783, 782, 781, 780, 779, 778, 777, 776, 775, 774, 773, 772, 771, 770, 769, 768, 767, 766, 765, 764, 763, 762, 799, 798, 761, 760, 759, 738, 737, 736, 735, 734, 733, 732, 731, 718, 627, 595, 566, 567, 568, 569, 570, 571, 572, 634, 643, 635, 636, 628, 613, 626, 619, 618, 625, 624, 605, 579, 578, 577, 576, 575, 574, 573, 604, 603, 612, 617, 623, 632, 622, 639, 640, 641, 642, 656, 655, 654, 653, 652, 651, 684, 693, 706, 719, 726, 727, 728, 729, 730, 703, 713, 692, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 680, 679, 678, 697, 708, 698, 709, 710, 711, 700, 701, 712, 720, 721, 714, 715, 716, 702, 699, 647, 687, 686, 695, 696, 688, 689, 691, 690, 648, 649, 638, 621, 602, 565, 564, 563, 562, 561, 600, 599, 598, 596, 597, 609, 608, 616, 620, 631, 637, 633, 630, 615, 594, 593, 592, 591, 590, 589, 588, 587, 586, 585, 584, 583, 582, 581, 607, 606, 580, 529, 545, 544, 543, 542, 541, 540, 539, 538, 537, 536, 535, 534, 463, 472, 517, 526, 528, 524, 511, 497, 486, 477, 464, 512, 498, 487, 478, 465, 513, 499, 488, 479, 466, 514, 500, 489, 480, 454, 467, 501, 515, 516, 502, 490, 471, 519, 504, 492, 482, 473, 520, 505, 493, 483, 474, 521, 506, 494, 484, 475, 485, 495, 507, 522, 508, 523, 530, 560, 559, 558, 557, 556, 555, 554, 553, 552, 551, 550, 549, 548, 547, 546, 525, 518, 503, 491, 481, 470, 469, 468, 455, 456, 457, 458, 459, 460, 411, 427, 426, 407, 424, 406, 423, 410, 405, 392, 369, 370, 371, 372, 373, 374, 375, 376, 377, 355, 349, 342, 379, 378, 393, 395, 396, 380, 383, 382, 381, 397, 398, 399, 400, 384, 385, 402, 401, 418, 434, 433, 417, 296, 295, 294, 293, 169, 161, 160, 163, 209, 254, 3, 5, 0]

Cost: 4681.446264075009



-data3:

Execution Time: 53.373918294906616

Path: [0, 209, 208, 582, 581, 580, 579, 578, 577, 206, 207, 204, 576, 575, 574, 573, 572, 571, 198, 199, 200, 202, 203, 864, 978, 1216, 1479, 1215, 977, 976, 1214, 863, 975, 1213, 1212, 974, 861, 1478, 1537, 1805, 1804, 1536, 1477, 1211, 973, 860, 972, 1210, 1209, 971, 859, 858, 970, 1207, 1206, 969, 857, 1205, 1204, 968, 967, 1203, 1532, 1533, 1534, 1535, 566, 567, 191, 192, 193, 194, 195, 569, 568, 190, 189, 188, 187, 186, 184, 183, 182, 181, 180, 563, 562, 561, 560, 178, 179, 852, 851, 559, 558, 557, 176, 175, 174, 173, 172, 171, 554, 553, 847, 848, 849, 850, 1475, 1527, 1774, 1887, 1886, 1773, 1772, 1885, 1884, 1771, 1525, 1472, 1197, 963, 1196, 1471, 1470, 1195, 962, 961, 1194, 1469, 1524, 1768, 1881, 1880, 1767, 1523, 1468, 1193, 960, 1191, 1466, 1465, 1190, 959, 958, 1189, 1464, 1766, 1765, 1764, 1461, 1187, 1188, 1462, 1463, 957, 838, 837, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 547, 166, 165, 164, 163, 839, 840, 841, 842, 548, 167, 168, 549, 550, 551, 552, 170, 169, 845, 846, 843, 1769, 1883, 1882, 2255, 2549, 2550, 2256, 2257, 2258, 2259, 2260, 2262, 2263, 2264, 2553, 2554, 2555, 2557, 2558, 2559, 2560, 2269, 2270, 1889, 1888, 2268, 2267, 2266, 2265, 2552, 2551, 2677, 2913, 3190, 3192, 2915, 2916, 3193, 3194, 2917, 2918, 3195, 3196, 2919, 2678, 3197, 2920, 2679, 3261, 3262, 3500, 3499, 3498, 3496, 3495, 3494, 3493, 3492, 3487, 3188, 2912, 2676, 3189, 3491, 3490, 3489, 3488, 3187, 3186, 1801, 832, 530, 161, 531, 162, 533, 532, 836, 835, 834, 833, 1185, 1458, 1460, 1186, 1459, 1763, 1762, 1761, 1760, 1752, 1456, 1183, 1184, 1457, 1522, 1759, 1758, 1757, 1756, 1755, 1754, 1753, 1455, 1182, 1181, 1454, 1750, 3648, 3633, 3634, 3469, 3470, 3176, 2901, 2899, 3174, 3255, 3175, 2900, 2668, 2243, 2242, 2532, 2531, 2529, 2530, 2241, 2240, 2239, 2238, 2236, 2528, 2527, 2526, 2235, 2234, 2233, 2231, 2230, 2523, 2522, 2521, 2520, 1878, 1879, 1742, 1743, 1745, 1746, 1747, 1748, 1749, 820, 819, 818, 817, 510, 508, 509, 816, 814, 813, 812, 952, 1521, 1441, 1169, 1171, 1443, 1444, 953, 1172, 1173, 1445, 1446, 1174, 1175, 1447, 1448, 1176, 1178, 1450, 1451, 954, 955, 1179, 1452, 1453, 1180, 956, 822, 823, 523, 824, 825, 526, 154, 155, 156, 157, 160, 159, 158, 528, 831, 830, 829, 828, 827, 826, 525, 153, 152, 151, 150, 147, 148, 149, 522, 521, 520, 519, 518, 517, 516, 146, 515, 514, 512, 511, 145, 144, 143, 142, 141, 140, 139, 138, 507, 506, 137, 504, 135, 134, 133, 132, 131, 130, 810, 809, 808, 949, 1167, 950, 1168, 951, 1440, 1740, 1739, 1738, 1520, 804, 805, 126, 496, 497, 498, 499, 127, 501, 500, 807, 806, 1166, 1439, 1519, 948, 1165, 1438, 1437, 1164, 947, 946, 1518, 1436, 1163, 1161, 1434, 1433, 1160, 1158, 1431, 1516, 1432, 1159, 944, 491, 492, 801, 802, 803, 495, 493, 124, 123, 122, 121, 120, 119, 118, 489, 800, 798, 1423, 1151, 1152, 1424, 1723, 1721, 3138, 2655, 2184, 2183, 2182, 2181, 2180, 2179, 2178, 2493, 2177, 2494, 2495, 3137, 3444, 3443, 3248, 2866, 3135, 3440, 3442, 3134, 2654, 2865, 2864, 3133, 3132, 2863, 2653, 2862, 3131, 3626, 3438, 3439, 2860, 3129, 3128, 2652, 3127, 3436, 3625, 3624, 3622, 3623, 3433, 3434, 3435, 3247, 2651, 2859, 3126, 3124, 3123, 2857, 2649, 2854, 3245, 3120, 3121, 2855, 2650, 2856, 3122, 3246, 3432, 3431, 3621, 3620, 3521, 3429, 3428, 2851, 3117, 3119, 2853, 2478, 2477, 2153, 2154, 2156, 2157, 2158, 2480, 2481, 2159, 2160, 2161, 2482, 2483, 2484, 2163, 2485, 2164, 2165, 2166, 2167, 2168, 2487, 2488, 2170, 2171, 2173, 2172, 2489, 2490, 2492, 2174, 2175, 2176, 1866, 1867, 1718, 1720, 105, 104, 468, 469, 784, 783, 937, 1512, 1414, 1143, 1142, 1413, 1412, 1141, 781, 782, 466, 465, 103, 464, 463, 780, 778, 777, 462, 101, 461, 776, 775, 773, 774, 459, 458, 457, 100, 98, 455, 454, 453, 452, 771, 770, 451, 450, 449, 769, 931, 1508, 1401, 1132, 1130, 1399, 1704, 1858, 1859, 1705, 1402, 1133, 932, 933, 1134, 1403, 1509, 1860, 1861, 1706, 1707, 1510, 1511, 1406, 1136, 936, 935, 1135, 1405, 1708, 1862, 1863, 1709, 1710, 1408, 1138, 1139, 1409, 1410, 1140, 1411, 1713, 1714, 1715, 1864, 1865, 1716, 1717, 1513, 1416, 1145, 938, 1146, 1417, 1418, 1147, 939, 1148, 1419, 1421, 1420, 1149, 940, 789, 788, 787, 785, 470, 471, 472, 473, 474, 106, 476, 477, 107, 478, 790, 792, 479, 109, 480, 793, 795, 796, 484, 483, 481, 110, 111, 112, 113, 114, 115, 117, 488, 487, 486, 485, 797, 943, 1430, 1514, 1429, 942, 1157, 1156, 1428, 1426, 1154, 1153, 1425, 1724, 1726, 1727, 1868, 1869, 1728, 1729, 1515, 1730, 1731, 1870, 1871, 1732, 1733, 1734, 1872, 1873, 1735, 1874, 1876, 1736, 1737, 1798, 3459, 3157, 2883, 3156, 3155, 3528, 3456, 3457, 3153, 2881, 2880, 3152, 3151, 2660, 2879, 2878, 3150, 3454, 3527, 3526, 3525, 3453, 3524, 3523, 3522, 3452, 3451, 2875, 3147, 3146, 2874, 2659, 2873, 3145, 3449, 3630,

3629, 3448, 3447, 3446, 3628, 3627, 3445, 3249, 3139, 2867, 2656, 2657, 2868, 3140, 3141, 2869, 2870, 3142, 3251, 3144, 2872, 2658, 2500, 2499, 2498, 2497, 2185, 2186, 2187, 2189, 2190, 2193, 2192, 2191, 2501, 2502, 2504, 2505, 2194, 2195, 2196, 2197, 2198, 2200, 2201, 2202, 2203, 2204, 2507, 2205, 2206, 2208, 2207, 2509, 2510, 2511, 2209, 2210, 2211, 2512, 2213, 2513, 2515, 2516, 2214, 2215, 2216, 2217, 2218, 2219, 2517, 2518, 2519, 2220, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2525, 2524, 3167, 2664, 2892, 2891, 3166, 3465, 3464, 3463, 3462, 3461, 3632, 3631, 3460, 3158, 2661, 2662, 2884, 3252, 3159, 3160, 2885, 2886, 3161, 3162, 2887, 2888, 3163, 3164, 2663, 2889, 2890, 3165, 3466, 3467, 3530, 3531, 3468, 3168, 2893, 2665, 2894, 3253, 3169, 3170, 2895, 2666, 2896, 3171, 3172, 2897, 2667, 2898, 3173, 3254, 3471, 3635, 3636, 3472, 3473, 3637, 3638, 3474, 3475, 3476, 3639, 3640, 3477, 3478, 3479, 3641, 3642, 3643, 3644, 3480, 3481, 3482, 2910, 2673, 2542, 2539, 2540, 2541, 2252, 2251, 2250, 2538, 2536, 2537, 2248, 2247, 2246, 2245, 2244, 2533, 2534, 2535, 2669, 2902, 3177, 3256, 3178, 2903, 2904, 3179, 3257, 3180, 2905, 2670, 2672, 2907, 3259, 3182, 3183, 2908, 2909, 3184, 3260, 3483, 3484, 3485, 3185, 2675, 2911, 2674, 2543, 2544, 2253, 2254, 2546, 2547, 2548, 1473, 1198, 964, 1199, 1474, 1526, 1775, 196, 570, 565, 564, 966, 1202, 1201, 965, 1200, 1476, 1776, 1777, 1528, 1529, 1530, 1531, 1779, 1890, 2277, 1898, 1899, 1806, 1807, 1538, 1539, 1540, 1541, 1542, 1480, 865, 979, 1217, 1218, 980, 981, 1219, 1548, 1221, 1481, 1220, 1547, 1546, 1545, 1543, 1811, 1810, 1809, 1808, 2934, 2692, 2691, 2933, 2932, 3539, 3540, 3273, 3274, 3275, 3276, 3277, 3501, 3502, 3503, 3504, 3505, 3279, 3278, 2693, 2935, 2936, 2938, 3280, 3506, 3507, 3283, 3542, 3541, 3281, 2695, 2939, 3202, 2940, 2696, 2568, 2569, 2697, 2941, 2942, 2570, 2698, 2943, 3203, 2944, 2699, 2700, 2945, 3204, 2946, 2571, 2701, 2702, 2947, 2948, 2703, 2572, 2704, 2949, 2951, 2574, 2952, 2575, 2706, 2707, 2953, 2954, 2708, 2306, 2305, 868, 1232, 1561, 1560, 1559, 1558, 1557, 1556, 1555, 1554, 1552, 1551, 1550, 1549, 1223, 1224, 983, 984, 1225, 1226, 1227, 985, 593, 217, 216, 215, 213, 4, 3, 2, 1, 212, 211, 583, 584, 585, 586, 588, 589, 590, 591, 592, 853, 866, 1228, 986, 1229, 987, 988, 1230, 1231, 989, 867, 595, 594, 218, 220, 221, 222, 223, 224, 225, 226, 596, 597, 598, 1235, 871, 992, 870, 991, 869, 990, 1233, 1562, 1563, 1564, 1565, 1938, 1936, 2309, 2308, 2307, 1935, 1934, 1933, 1932, 1931, 1930, 1929, 1928, 1926, 1925, 1924, 1923, 1922, 1921, 2299, 2298, 1919, 1920, 2297, 2296, 2295, 1918, 1917, 2294, 2292, 1916, 1915, 1914, 1913, 2291, 2290, 2289, 2288, 1911, 1910, 1909, 1908, 1907, 1906, 1905, 1903, 1904, 2287, 2286, 2285, 2284, 2283, 1902, 1900, 2282, 2280, 2279, 2278, 2688, 2929, 2930, 2689, 2567, 2690, 2931, 3201, 3272, 3271, 3270, 3269, 3538, 3537, 3264, 3265, 3266, 3267, 3535, 3536, 3268, 3200, 2928, 2687, 2566, 2565, 2686, 3199, 2927, 2926, 2685, 2684, 2925, 2923, 2682, 2273, 2274, 2275, 2276, 1897, 1896, 1895, 1894, 1892, 1891, 2272, 2271, 3198, 2921, 2680, 2562, 2563, 2681, 2922, 3263, 3534, 3533, 3284, 3543, 3544, 3285, 3286, 3545, 3546, 3288, 3289, 3290, 3291, 3292, 3293, 3294, 3295, 3508, 3547, 2955, 2304, 2303, 2302, 2301, 228, 229, 503, 502, 129, 2506, 2877, 3149, 1711, 102, 934, 1404, 97, 448, 95, 446, 768, 445, 94, 767, 444, 443, 442, 93, 766, 765, 764, 763, 439, 440, 91, 437, 762, 926, 1125, 1394, 1505, 1393, 925, 1392, 1697, 1850, 1849, 1504, 1391, 1124, 923, 922, 1123, 1390, 1389, 1122, 921, 920, 1121, 1387, 1386, 1120, 919, 1119, 1385, 1384, 1118, 1117, 1383, 1382, 1116, 1115, 1381, 1380, 1114, 1113, 1379, 1689, 1691, 1692, 1693, 1694, 1695, 1696, 756, 755, 754, 753, 752, 751, 749, 415, 416, 82, 83, 417, 418, 84, 419, 420, 422, 86, 423, 424, 425, 426, 427, 87, 428, 429, 430, 431, 88, 433, 434, 435, 436, 90, 761, 760, 759, 758, 757, 81, 80, 414, 79, 78, 412, 748, 747, 745, 744, 743, 742, 408, 76, 409, 410, 411, 77, 1111, 1376, 1377, 1375, 1110, 1109, 1374, 1373, 1372, 1108, 1107, 1371, 1370, 1106, 1105, 1369, 1680, 1681, 1682, 1683, 1684, 1685, 1687, 1688, 1797, 1848, 2125, 2126, 2127, 2129, 2130, 2131, 2459, 2460, 2461, 2132, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2465, 2464, 2644, 2843, 3107, 3241, 3106, 2842, 2841, 3105, 3240, 2643, 2840, 3104, 3103, 2839, 2838, 3102, 3101, 3100, 2837, 2642, 2641, 2836, 3099, 3098, 2835, 2834, 3097, 3096, 2833, 2832, 3095, 3410, 3411, 3412, 3413, 2457, 2456, 2455, 2124, 2122, 2454, 2453, 2452, 2451, 2120, 2119, 2118, 2117, 2450, 2449, 2116, 2115, 2114, 2448, 2447, 2446, 2444, 2111, 2112, 2113, 2637, 2828, 3088, 3237, 3087, 2827, 2636, 3236, 3086, 2826, 2825, 3085, 3235, 2635, 2824, 3084,

3401, 3516, 3515, 3603, 3604, 3402, 3403, 3404, 3605, 3606, 3405, 3406, 3238, 3090, 2830, 2638, 2829, 3089, 3091, 2831, 2639, 3239, 3407, 3608, 3607, 3609, 3610, 3408, 3092, 2640, 3093, 3094, 3409, 1679, 1678, 1367, 1103, 1104, 1368, 738, 402, 74, 401, 737, 736, 399, 73, 398, 735, 734, 397, 72, 396, 732, 731, 395, 71, 70, 393, 730, 729, 1095, 1359, 1361, 1097, 1098, 1362, 1363, 1099, 1100, 1364, 1365, 1101, 1677, 1676, 1675, 1673, 1672, 1671, 1670, 1503, 1669, 1358, 917, 390, 391, 392, 389, 388, 387, 386, 385, 384, 382, 381, 725, 726, 727, 916, 1094, 1357, 1355, 1092, 1091, 1354, 1666, 1667, 1795, 1796, 2101, 2100, 2099, 2098, 2097, 2096, 2095, 2438, 2437, 2435, 2434, 2433, 2091, 2092, 2093, 2094, 2629, 2819, 3079, 3234, 3078, 2818, 2817, 3077, 3076, 2816, 2628, 2815, 3075, 3073, 2813, 2627, 2812, 3072, 3233, 3390, 3389, 3598, 3597, 3387, 3596, 3595, 3231, 3069, 2809, 2624, 2625, 2810, 3070, 3071, 2811, 2626, 3232, 2427, 2426, 2083, 2084, 2085, 2086, 2087, 2430, 2429, 2431, 2432, 2089, 2090, 1847, 1846, 1662, 1663, 1794, 1664, 1665, 1353, 1090, 1089, 1352, 1351, 1350, 1088, 915, 1502, 1349, 1087, 914, 1086, 1348, 1346, 1084, 1083, 1345, 1344, 1501, 1082, 912, 911, 1081, 1343, 1500, 1342, 1080, 1079, 1341, 1340, 1078, 1076, 910, 1338, 1498, 1651, 1840, 1841, 1652, 1653, 1654, 1655, 1842, 1843, 1844, 1845, 1658, 1659, 1660, 1661, 718, 373, 374, 375, 376, 719, 720, 721, 377, 67, 68, 69, 378, 722, 724, 380, 66, 65, 64, 63, 62, 370, 371, 717, 716, 715, 714, 369, 368, 367, 366, 60, 365, 709, 710, 711, 712, 61, 363, 708, 707, 362, 361, 360, 704, 705, 1075, 1336, 1335, 1496, 1074, 909, 908, 1072, 1333, 1495, 1332, 1071, 1070, 1331, 1330, 1069, 907, 1068, 1329, 1328, 1067, 906, 1066, 1327, 1326, 1065, 1064, 1325, 905, 1063, 1324, 1322, 1061, 1640, 1641, 1642, 1643, 1644, 1645, 1646, 1836, 1837, 1838, 1839, 1648, 1649, 1793, 1337, 1497, 2072, 2073, 2074, 2420, 2419, 2418, 2071, 2070, 2069, 2068, 2067, 2065, 2064, 2415, 2416, 2417, 2622, 2802, 3061, 3060, 2801, 2621, 2619, 2799, 3058, 3057, 2798, 3381, 3380, 3594, 3593, 3592, 3591, 3377, 3376, 3375, 3374, 3227, 3051, 2792, 2791, 3050, 3049, 2790, 3372, 3373, 3053, 2794, 2795, 3054, 3055, 2796, 2617, 3228, 3229, 3056, 2797, 2618, 2413, 2063, 2062, 2061, 2060, 2410, 2409, 2408, 2058, 2057, 2056, 2406, 2407, 2055, 2054, 2404, 2403, 2402, 2401, 2400, 2049, 2050, 2051, 2052, 2616, 2788, 3046, 3226, 3045, 2787, 2786, 3044, 3043, 2785, 2784, 3042, 3366, 3367, 3368, 3369, 3589, 3590, 3370, 3048, 2048, 2047, 2046, 2045, 2044, 2043, 2042, 2041, 2040, 2039, 2038, 2037, 2394, 2393, 2392, 2391, 2390, 2389, 2388, 2032, 2033, 2034, 2036, 2779, 3035, 3036, 3360, 3361, 3512, 3037, 2613, 2614, 2780, 3038, 3039, 2781, 2782, 3040, 3041, 2783, 2615, 2397, 2396, 2395, 2398, 3364, 3363, 3362, 3033, 3032, 2777, 2776, 3031, 3030, 2775, 2774, 2611, 3029, 3224, 3028, 2773, 2610, 2609, 2772, 3027, 3223, 3354, 3582, 3581, 3353, 3352, 3351, 3580, 3579, 3221, 3022, 2767, 2606, 2769, 3024, 3025, 2770, 2771, 3026, 3222, 2608, 2383, 2382, 2381, 2024, 2025, 2026, 2027, 2384, 2385, 2386, 2029, 2030, 2028, 1834, 1835, 1626, 1625, 1493, 1305, 1051, 897, 896, 1050, 1304, 1492, 1303, 1049, 1048, 1302, 1301, 1300, 1047, 1046, 1299, 1298, 1045, 1044, 1297, 1296, 1043, 1042, 1295, 1294, 1041, 894, 1293, 1292, 1040, 1616, 1617, 1789, 1788, 2018, 2019, 2020, 2374, 2373, 2372, 2371, 2370, 2369, 2015, 2016, 2017, 2603, 2763, 3016, 3218, 3015, 2762, 2761, 3014, 3013, 2760, 2602, 2758, 3011, 3217, 3342, 3571, 3572, 3343, 3344, 3345, 3574, 3575, 3346, 3219, 3347, 3017, 2764, 2604, 2605, 2765, 3018, 3220, 3019, 2766, 3020, 3021, 3349, 3348, 3578, 3577, 2375, 2376, 2377, 2379, 2380, 2022, 1790, 1622, 1621, 1620, 1619, 1618, 895, 666, 665, 664, 305, 306, 307, 308, 309, 310, 311, 312, 31, 32, 33, 34, 314, 315, 316, 673, 672, 671, 313, 670, 669, 668, 667, 30, 28, 27, 26, 25, 24, 301, 300, 299, 298, 297, 661, 660, 659, 658, 657, 656, 290, 291, 292, 293, 294, 296, 1039, 1290, 1289, 1038, 1037, 1288, 1287, 1036, 893, 1035, 1286, 1611, 1787, 1610, 1609, 1608, 1284, 1034, 1033, 1283, 1282, 1032, 892, 652, 653, 654, 655, 289, 288, 287, 286, 285, 284, 283, 282, 281, 280, 279, 278, 648, 649, 650, 651, 1031, 1281, 1280, 1030, 891, 1029, 1279, 1278, 1028, 1605, 1606, 1607, 1786, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2368, 2367, 2366, 2365, 2363, 2362, 2361, 2360, 2359, 2358, 2357, 1996, 1995, 1994, 1997, 2596, 2749, 3002, 3001, 2748, 2747, 3000, 3336, 3337, 3338, 3005, 2752, 2597, 2751, 3004, 3006, 2753, 2754, 3007, 3008, 2755, 2598, 2599, 2756, 3009, 3010, 2757, 2600, 3340, 3339, 2999, 2595, 2746, 2594, 2744, 2593, 2353, 2354, 2355, 3334, 3333, 3332, 3331, 3215, 3329, 2997, 2592,

2350, 1988, 1989, 1990, 1991, 1992, 2352, 1986, 1985, 1984, 1983, 1982, 2347, 2348, 2349, 2591, 2742, 2995, 2994, 2741, 2590, 2740, 2993, 2992, 2739, 2738, 2991, 2990, 2737, 2736, 2989, 2988, 2735, 2734, 2987, 3214, 2589, 2733, 2986, 2985, 2732, 2588, 3213, 2984, 2731, 2587, 2586, 2730, 2983, 3212, 2982, 2729, 2728, 2585, 2981, 3211, 2980, 2727, 2726, 2979, 3315, 3316, 3563, 3564, 3317, 3318, 3565, 3566, 3319, 3567, 3568, 3320, 3321, 3569, 3570, 3322, 3323, 3324, 3325, 3326, 3327, 3328, 2346, 2345, 2344, 2343, 2342, 1978, 1979, 1980, 1981, 1784, 1785, 1598, 1272, 1024, 1023, 885, 1271, 1270, 1022, 1020, 1269, 1596, 1597, 1831, 1830, 1829, 1828, 1783, 1594, 1593, 1266, 1017, 1018, 1267, 1268, 1489, 1019, 884, 637, 638, 639, 640, 641, 268, 269, 270, 271, 272, 273, 274, 19, 18, 17, 16, 266, 267, 265, 264, 263, 15, 262, 261, 260, 259, 635, 634, 632, 631, 258, 630, 257, 256, 255, 254, 253, 252, 251, 628, 629, 881, 1015, 1261, 1260, 1014, 1589, 1827, 1826, 1825, 1824, 1588, 1587, 1586, 1585, 1584, 1823, 1822, 1821, 1820, 1583, 1487, 1255, 1009, 878, 877, 1008, 1254, 1486, 1253, 1007, 876, 620, 621, 245, 246, 244, 243, 242, 619, 875, 1006, 1252, 1485, 1582, 1581, 1251, 1005, 618, 241, 616, 615, 614, 613, 612, 239, 240, 14, 13, 12, 11, 237, 236, 235, 10, 610, 611, 609, 608, 607, 606, 234, 9, 8, 7, 605, 604, 233, 603, 602, 600, 599, 230, 231, 232, 6, 5, 227, 219, 214, 210, 205, 201, 197, 185, 177, 556, 555, 546, 534, 529, 527, 524, 513, 505, 136, 128, 125, 494, 490, 482, 475, 467, 460, 456, 447, 441, 438, 432, 421, 413, 407, 403, 400, 394, 383, 379, 372, 364, 358, 354, 57, 48, 44, 35, 333, 338, 340, 343, 700, 706, 713, 723, 728, 733, 855, 918, 1102, 1366, 1360, 1096, 1093, 1356, 1347, 1085, 913, 1077, 1339, 1334, 1073, 1062, 904, 1323, 902, 1311, 1637, 1650, 1656, 1668, 1674, 1686, 1690, 1378, 1112, 1388, 924, 930, 1131, 1400, 1407, 1137, 1144, 1415, 1422, 1150, 1155, 941, 1427, 1435, 1517, 1162, 945, 799, 791, 786, 779, 772, 99, 96, 92, 89, 85, 750, 746, 1702, 1712, 1719, 1722, 1875, 1877, 1741, 1744, 1751, 1799, 1800, 1802, 1770, 1803, 1778, 1544, 1553, 1780, 1812, 1813, 1566, 1567, 1569, 1483, 1238, 996, 873, 995, 1237, 1236, 994, 993, 872, 1234, 1482, 1222, 982, 862, 1208, 1467, 1192, 844, 821, 815, 811, 1170, 1442, 1449, 1177, 116, 108, 2188, 2199, 2212, 2221, 2232, 2237, 2249, 2545, 2556, 2261, 1893, 1901, 1912, 2293, 2281, 2564, 2683, 2924, 3191, 2914, 2906, 3181, 3258, 2671, 3486, 3497, 3646, 3645, 3532, 3529, 3458, 3455, 3450, 3148, 2876, 2871, 3143, 3136, 3130, 2861, 2858, 3125, 3118, 2852, 2844, 3108, 3421, 3519, 3518, 3517, 3083, 2823, 2634, 2814, 3074, 3068, 2808, 2800, 3059, 3052, 2793, 2789, 3047, 3034, 3225, 2778, 2612, 2607, 2768, 3023, 3012, 3216, 2759, 2601, 2750, 3003, 2998, 2745, 2743, 2996, 3330, 3335, 3341, 3573, 3576, 3350, 3587, 3588, 3365, 3371, 3378, 3388, 3395, 2620, 2412, 2405, 2399, 2053, 2059, 2066, 2075, 2080, 2088, 2436, 2428, 2421, 2103, 2110, 2445, 2121, 2123, 2128, 2133, 2141, 2468, 2479, 2486, 2491, 2496, 2503, 2508, 2514, 2882, 3154, 3441, 3437, 3430, 2162, 2169, 2155, 2035, 2031, 2023, 2378, 2387, 2013, 1999, 1993, 1987, 1977, 1974, 2330, 2319, 2300, 2561, 3250, 3063, 2476, 3287, 3303, 3312, 3511, 2351, 2356, 2364, 1599, 1592, 1580, 1568, 1725, 1499, 856, 794, 601, 617, 880, 1016, 883, 1021, 888, 1277, 642, 633, 20, 21, 22, 23, 295, 303, 29, 319, 59, 587, 1570, 1781, 1815, 1814, 1942, 1943, 1944, 2315, 2314, 2313, 2312, 1940, 1941, 1939, 2311, 2310, 1937, 1927, 2573, 2705, 2950, 2956, 2957, 2709, 2576, 2577, 2710, 2958, 3205, 2959, 2711, 2712, 2960, 2961, 2713, 2578, 3206, 3298, 3297, 3296, 3549, 3548, 3550, 3551, 3552, 3553, 3300, 3301, 3509, 2964, 2580, 2965, 2966, 2715, 2716, 2967, 2968, 2717, 2718, 2969, 2970, 3307, 3306, 3305, 3304, 3302, 2320, 2321, 1951, 1952, 2322, 2323, 1953, 1954, 2324, 1955, 1956, 2325, 2581, 2719, 2971, 3208, 3308, 3555, 3556, 3557, 3554, 3309, 3209, 2973, 2721, 2582, 2720, 2972, 2326, 1957, 1958, 2327, 2328, 1959, 1960, 1961, 1962, 2329, 2331, 2332, 2333, 1963, 1964, 1965, 1966, 1967, 1968, 2335, 2334, 2336, 2337, 1969, 1970, 1971, 1972, 1973, 2339, 2338, 2340, 2341, 1975, 1976, 1595, 636, 1265, 1264, 1263, 1591, 1590, 1262, 882, 1782, 2725, 2978, 2977, 2976, 3210, 2724, 2584, 2723, 2975, 3311, 3560, 3561, 3313, 3314, 3510, 3562, 2974, 2722, 2583, 3310, 3559, 3558, 1256, 1010, 1011, 1257, 1258, 1012, 1013, 879, 1259, 1488, 626, 625, 624, 623, 248, 249, 250, 627, 247, 622, 1819, 1818, 1817, 1816, 1579, 1484, 1250, 1004, 874, 1249, 1248, 1003, 1002, 1247, 1246, 1001, 1000, 1245, 1244, 999, 998, 1243, 1242, 1241, 997, 1571, 1572, 1573, 1574, 1575, 1576, 1577, 1578, 1950, 1949, 1948, 1947, 1946, 2318, 2317, 2316, 1945, 2579, 2714, 2962, 3207, 3299, 2963,

1240, 1239, 238, 2694, 2937, 3282, 1273, 886, 887, 1025, 889, 1026, 890, 1274, 1602, 1601, 1600, 643, 644, 275, 276, 277, 645, 646, 647, 1490, 1276, 1275, 1027, 1603, 1604, 1285, 1612, 1613, 1614, 1491, 1291, 1615, 662, 663, 304, 302, 2021, 1623, 1624, 1832, 1833, 1306, 1052, 898, 1053, 1307, 1308, 1054, 1055, 1309, 899, 1056, 1310, 1312, 1057, 900, 854, 901, 1058, 1313, 1314, 1059, 681, 682, 331, 332, 334, 36, 37, 38, 39, 40, 337, 336, 335, 330, 329, 328, 327, 326, 325, 324, 323, 322, 321, 320, 318, 675, 676, 677, 678, 679, 680, 1629, 1630, 1631, 1791, 1632, 1494, 1316, 1317, 1635, 1636, 1638, 1639, 1792, 1320, 1321, 689, 690, 691, 692, 693, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 355, 356, 58, 56, 55, 54, 53, 698, 697, 696, 695, 694, 51, 50, 49, 47, 342, 52, 699, 701, 702, 357, 359, 703, 1647, 2414, 2411, 3379, 3230, 3062, 2803, 3383, 3382, 3513, 3384, 3385, 3386, 3066, 2806, 2805, 3065, 3064, 2804, 2422, 2076, 2077, 2078, 2079, 2081, 2082, 2425, 2424, 2423, 2623, 2807, 3067, 1657, 3391, 3392, 3600, 3599, 3393, 3394, 3601, 3602, 3396, 3397, 3514, 3398, 3399, 3400, 3082, 2633, 2822, 2632, 2821, 2631, 2630, 3081, 3080, 2820, 2439, 2440, 2102, 2104, 2105, 2106, 2107, 2441, 2108, 2109, 2442, 2443, 739, 740, 741, 406, 405, 75, 404, 2458, 3414, 3415, 3416, 3520, 3611, 3612, 3417, 3418, 3613, 3614, 3419, 3109, 2645, 3110, 3242, 3111, 2845, 2846, 3112, 3113, 2847, 2848, 2646, 3114, 3243, 3425, 3424, 3423, 3422, 3420, 2467, 2469, 2470, 2471, 2472, 2149, 2148, 2147, 2146, 1852, 1851, 1699, 1700, 1506, 1396, 1127, 927, 1126, 1395, 1397, 1128, 928, 929, 1129, 1398, 1507, 1703, 1856, 1855, 2151, 2152, 2150, 2473, 2474, 2475, 2648, 2850, 3116, 3244, 3115, 2849, 2647, 3426, 3616, 3615, 3617, 3618, 3427, 3619, 1857, 1701, 1854, 1853, 1698, 2145, 2144, 2143, 2142, 2466, 2463, 2462, 3647, 341, 46, 45, 43, 339, 42, 41, 685, 686, 687, 688, 1060, 1318, 1319, 1634, 1633, 1315, 903, 683, 684, 1628, 1627, 674, 317, 3355, 3584, 3583, 3585, 3586, 3356, 3357, 3358, 3359, 0]

Cost: 12685.969314505306



2. Lever2

Genetic Algorithm은 부모 세대의 값(data)를 이용해 적절히 조합하여 child 세대의 값을 추론하고, 이를 통해 평균적으로 더 개선된 값을 얻어냅니다. 주어진 기본 코드에서 초기화 부분에서는 그리디 알고리즘을 기본으로 하며, 다른 값들은 random한 순열을 만들고, 이 값을 sa를 거치며 더 향상시켜서 이용하게 됩니다.

하지만 기본적으로 부모세대의 데이터가 더 좋아진다면 이후 child세대의 값이 더 향상될 확률이 더 높다고 생각되기 때문에, 가능하다면 initialization 부분에서 더 좋은 데이터를 넘겨 줄 수 있다면 알고리즘이 더 향상될 수 있을 것이라고 판단하였습니다.

여기서 생각한 방법은 이전 과제에 사용한 greedy 알고리즘을 발전시킨 것으로, greedy 알고리즘은 조합최적화문제가 아니어서 출발점에 대한 고려를 하지 않고 문제를 풀어 결국 출발점과 도착점 사이의 고려를 하지 못하는 단점이 있다고 생각되었습니다. 때문에 최단거리가 가장 큰 지점에서 시작하여 편차를 줄일 수 있도록 구상하여 알고리즘을 작성하였는데, 기존의 경우엔 data에 따라 성능이 떨어지는 경우도 존재하였습니다. 하지만 data의 수가 많아지면 좀 더 향상되는 효과를 얻을 수 있었으며, 이를 고려해 기존의 greedy알고리즘과 향상시킨 greedy 알고리즘, 그리고 나머지는 random하게 순열을 만들어 sa를 거친 후 부모세대로 사용하면 좋을 것이라 판단하였습니다.

또한 initialization뿐만 아니라 selection에서도 random하게 선택된 n개의 data 중에서 값이 좋다고 판단되는 2개의 data를 선택하도록 구현하였는데, 여기서 random하게 선택하는 것 보다는 경우에 따라 좋은 값은 우선적으로 선별하며, local optima에 빠지지 않도록 random하게 선택되는 경우를 남기는 것도 좋을 것이라 생각했습니다.

때문에 3번중 1번은 가장 좋은 cost를 가진 2개의 값을 선택, 다른 1번은 가장 좋은 cost를 가진 1개의 값과 random, 마지막으로 2개 다 random하게 선택(n개 중 최선의 값 2개 추출)하는 방법이 좋을 것이라 생각했습니다.

3. Level3

```
# package list
import numpy as np
import sys
from sklearn.metrics.pairwise import euclidean_distances
import matplotlib.pyplot as plt
import time

# Global Variables
# GA
POOL_SIZE = 10
TOURNAMENT_SIZE = 5
MAX_ITERATION = 3000

# SA
MAX_EVALUATION = 30
SUB_ITERATIONS = 20
TEMPERATURE = 100
COOLING_RATIO = 0.5
TEMP_LIMIT = 1

np.random.seed(0)
# Plot Settings
PLOT_MODE = True # Draw Route
plt.ion()

# First City Index
FIRST_IDX = 0
```

우선 해당 과제의 제약사항에 맞추기 위해 변수 값을 조정하였다. Data1의 경우 기본 설정으로도 충분하지만, 2와 3의 경우엔 해당 변수를 변경시키지 않으면 시간이 너무 많이 소요되기 때문에, 반복횟수를 조정하였습니다.

```
def initialize_greedy_improve(coord_list, first_idx):
    cnt_cities = len(coord_list)
    # Initialize path and insert first city index to the first and last elements
    path = np.zeros(cnt_cities + 1, dtype=np.int32)

    # Euclidean distance map between cities
    path_map = euclidean_distances(coord_list, coord_list)

    cities_tovisit = np.ones((cnt_cities), dtype=np.bool_)

    path_map_copy=path_map.copy()
    longest_list = np.zeros(cnt_cities, dtype=np.int32)
    for i in range(0, cnt_cities):
        longest=np.argsort(-path_map_copy[i])
        longest_list[i]=path_map_copy[i][longest[0]]
    longest_list.sort()

    path[0], path[-1] = longest_list[0], longest_list[0]
    cities_tovisit[longest_list[0]] = False
    # Iteratively Connect nearest cities
    for i in range(1, cnt_cities):
        start_idx = path[i - 1]
        distance_from_start = path_map[start_idx, :]
        nearest_list = np.argsort(distance_from_start)
        for idx in range(len(nearest_list)):
            # check the nearest city is visited
            if cities_tovisit[nearest_list[idx]]:
                nearest_city = nearest_list[idx]
                break
        cities_tovisit[nearest_city] = False
        path[i] = nearest_city
    checker=0
    idx_cnt=0
    r_path=np.zeros(cnt_cities+1,dtype=np.int32)

    for i in range(0,cnt_cities):

        if path[i]==0:
            checker=0
        if checker==1:
            r_path[idx_cnt]=path[i]
            idx_cnt=idx_cnt+1

        if idx_cnt!=cnt_cities:
            for i in range(0,cnt_cities-idx_cnt):
                r_path[idx_cnt+i]=path[i]

    return path_map, r_path
```

initialization에서 추가한 코드로, 기존의 greedy 말고 편차를 줄일 수 있는 greedy 알고리즘을 작성하여 추가하였습니다. 4주차에 작성한 코드의 경우 출발점을 변경하였는데, 이번 과제에서는 출발점이 고정된 상태로 사용하는 것이 더 편리하다 판단하여, 마지막에 출발 지점이 0부터 다시 쓰여지도록 코드를 수정하였습니다.

```
[135] def initialization(coord_list):
    cnt_cities = len(coord_list)
    path_pool = np.zeros((POOL_SIZE, cnt_cities + 1), dtype=np.int32)
    pool_cost = np.zeros(POOL_SIZE)

    path_map, path_pool[0, :] = initialize_greedy(coord_list, FIRST_IDX)
    pool_cost[0] = path_cost(path_map, path_pool[0, :]).sum()

    print('Path {} is initialized'.format(0))

    _, path_pool[1, :] = initialize_greedy_improve(coord_list, FIRST_IDX)
    pool_cost[1] = path_cost(path_map, path_pool[1, :]).sum()
    print('Path {} is initialized'.format(1))

    for i in range(2, POOL_SIZE):
        _, path_pool[i, :] = initialize_random(coord_list, FIRST_IDX)
        path_pool[i, :], pool_cost[i] = sa(path_map, path_pool[i, :], coord_list)
        print('Path {} is initialized'.format(i))

    return path_pool, pool_cost, path_map
```

기존의 greedy 알고리즘과, 개선시킨 greedy 알고리즘, 그리고 나머지는 random하게 값을 생성하게 만들었습니다.

```
def selection(pool_cost, i, TOURNAMENT_SIZE, sel_size=2):
    # tournament selection
    if i%3==0:
        sel_idx = np.random.choice(POOL_SIZE, TOURNAMENT_SIZE, replace=False)
        sel_cost = pool_cost[sel_idx]
        best_idx = sel_idx[np.argsort(sel_cost)][::-sel_size]

    elif i%3==1:
        idx_sort=np.argsort(pool_cost)
        sel_idx=idx_sort
        sel_cost = pool_cost[sel_idx]
        best_idx = sel_idx[np.argsort(sel_cost)][::-sel_size]

    else:
        idx_sort=np.argsort(pool_cost)
        sel_idx=np.zeros(2,dtype=np.int32)
        sel_idx[0]=idx_sort[0]
        sel_idx[1]=np.random.choice(POOL_SIZE,1)
        while sel_idx[0]==sel_idx[1]:
            sel_idx[1]=np.random.choice(POOL_SIZE,1)
        best_idx=sel_idx
    return best_idx
```

selection에서 random하게 data를 선택하는 경우의 수를 한번, 그리고 가장 좋은 data와 그 다음 data를 선택하는 경우의 수, 마지막으로 가장 좋은 data와 random한 data를 선택하는 경우의 수를 차례로 선택하도록 selection 함수를 수정하였습니다.

4.Level4

Data1,2,3 모두 기존의 값들에서 미세하게 향상시킨 cost 를 확인할 수 있습니다.

Data3 의 경우 그 값이 다른 값들에 비해 더 dynamic 하게 변화한 것을 확인할 수 있었습니다.

하지만 data1 과 2 는 3 과 비교해보았을 때, 더 자주 data 가 변화하는 것을 확인할 수 있었습니다.

3 의 경우엔 향상시킨 greedy 알고리즘을 통해 초기 부모세대에서 더 훌륭한 data 를 이용한 이점을 크게 받았다고 생각되며, 1 의 경우엔 반대로 select 및 crossover 를 거치며 값이 향상되는 효과를 더 많이 볼 수 있음을 확인할 수 있습니다.

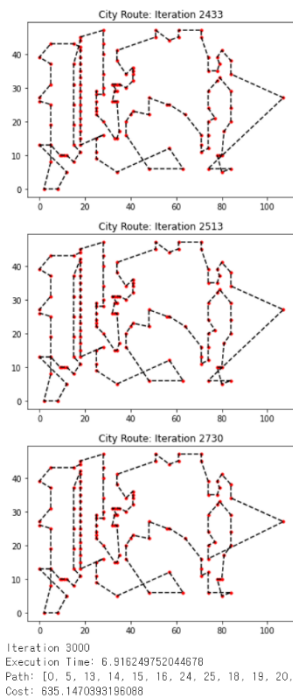
기존의 cost 값에서 대략 0.5~1% 정도의 향상을 볼 수 있었으며, cost 가 향상된 부분은 random 하게 선택하는 것 보다 좋은 값의 부모를 선택한 경우에서 그 효과를 더 자주 볼 수 있었음을 확인할 수 있다고 생각합니다.

-data1:

Execution Time: 6.916249752044678

Path: [0, 5, 13, 14, 15, 16, 24, 25, 18, 19, 20, 21, 22, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 53, 45, 44, 52, 73, 92, 97, 88, 76, 77, 80, 81, 86, 87, 91, 93, 98, 101, 100, 99, 104, 111, 129, 122, 113, 117, 120, 123, 124, 125, 126, 118, 114, 108, 107, 112, 106, 105, 130, 127, 128, 121, 116, 119, 115, 109, 110, 102, 103, 96, 95, 94, 90, 89, 72, 71, 79, 85, 84, 83, 82, 78, 75, 70, 66, 62, 69, 65, 61, 64, 68, 74, 67, 63, 54, 46, 47, 48, 49, 51, 50, 55, 56, 57, 58, 59, 60, 43, 42, 23, 10, 3, 9, 8, 2, 1, 7, 6, 11, 4, 12, 17, 0]

Cost: 635.1470393196088



-data2:

Execution Time: 15.344686031341553

Path: [0, 23, 1, 55, 54, 60, 62, 59, 67, 68, 78, 63, 77, 87, 76, 83, 16, 11, 10, 34, 9, 33, 51, 32, 8, 7, 31, 6, 30, 50, 29, 4, 28, 27, 49, 26, 2, 25, 24, 18, 57, 58, 66, 75, 69, 79, 95, 94, 93, 92, 120, 125, 122, 139, 143, 162, 150, 153, 164, 179, 180, 181, 211, 212, 222, 230, 241, 256, 255, 240, 229, 228, 221, 239, 238, 220, 219, 176, 177, 178, 210, 165, 154, 96, 129, 157, 244, 285, 301, 273, 274, 275, 276, 277, 278, 279, 326, 332, 348, 351, 352, 353, 354, 363, 364, 391, 404, 409, 422, 421, 403, 390, 394, 425, 360, 361, 362, 365, 366, 367, 368, 449, 448, 447, 704, 705, 724, 725, 739, 740, 741, 742, 707, 797, 796, 795, 794, 793, 792, 791, 754, 755, 756, 757, 758, 812, 819, 832, 833, 834, 835, 807, 821, 831, 830, 829, 828, 818, 811, 790, 752, 753, 751, 750, 749, 748, 747, 787, 788, 789, 806, 810, 817, 816, 809, 805, 786, 801, 800, 820, 824, 837, 827, 836, 849, 850, 851, 852, 853, 854, 855, 856, 886, 885, 884, 883, 882, 881, 880, 877, 898, 928, 936, 939, 943, 944, 945, 923, 909, 904, 910, 924, 946, 947, 948, 949, 950, 951, 952, 953, 964, 927, 913, 891, 890, 889, 888, 887, 857, 858, 859, 860, 861, 862, 914, 929, 954, 955, 956, 957, 958, 959, 965, 931, 916, 915, 930, 905, 932, 994, 993, 992, 991, 990, 989, 988, 987, 986, 985, 984, 983, 982, 981, 1015, 1016, 1017, 1018, 1027, 1037, 1036, 1035, 1026, 1025, 1034, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1062, 1063, 1064, 1065, 1066, 1079, 1078, 1077, 1076, 1075, 1074, 1073, 1072, 1071, 1070, 908, 922, 925, 911, 912, 926, 980, 1014, 1013, 1012, 1011, 1010, 979, 973, 1019, 1000, 1044, 1059, 1043, 1041, 1032, 1023, 1021, 1003, 970, 971, 972, 1004, 1005, 974, 975, 976, 977, 978, 1009, 1008, 1007, 1006, 1024, 1033, 1047, 1048, 1049, 1050, 1022, 1038, 1039, 1028, 1061, 1080, 1067, 1068, 1081, 1082, 1060, 1045, 1046, 1031, 1042, 1030, 1020, 1001, 1002, 967, 999, 998, 997, 996, 995, 1029, 1040, 968, 969, 1069, 822, 722, 399, 400, 384, 385, 402, 401, 418, 434, 433, 417, 416, 432, 431, 415, 414, 430, 435, 429, 413, 412, 428, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 450, 436, 420, 419, 408, 389, 357, 388, 387, 386, 356, 313, 314, 323, 315, 324, 333, 336, 337, 334, 325, 316, 312, 311, 310, 309, 299, 300, 304, 303, 302, 272, 271, 270, 298, 297, 269, 267, 262, 268, 261, 266, 265, 260, 259, 258, 257, 264, 231, 243, 242, 223, 214, 213, 182, 183, 184, 185, 186, 187, 188, 189, 215, 232, 245, 246, 233, 247, 248, 234, 218, 217, 216, 190, 191, 192, 193, 194, 195, 196, 197, 198, 205, 199, 200, 201, 202, 203, 224, 225, 235, 263, 251, 252, 253, 250, 227, 237, 236, 226, 174, 175, 208, 207, 206, 204, 173, 170, 148, 149, 144, 137, 131, 130, 136, 5, 3, 172, 249, 284, 283, 282, 308, 281, 280, 305, 306, 307, 335, 328, 318, 317, 327, 338, 339, 340, 345, 341, 329, 319, 320, 330, 346, 347, 331, 321, 322, 286, 287, 288, 289, 290, 291, 292, 343, 350, 344, 358, 359, 510, 496, 476, 461, 451, 452, 453, 462, 509, 533, 527, 532, 531, 601, 611, 610, 608, 609, 597, 596, 598, 599, 600, 561, 562, 563, 564, 565, 602, 621, 638, 649, 648, 650, 717, 723, 746, 745, 815, 848, 878, 879, 903, 907, 921, 935, 937, 938, 942, 941, 940, 920, 919, 906, 918, 934, 966, 963, 962, 961, 960, 933, 917, 899, 900, 901, 902, 876, 875, 874, 873, 872, 871, 870, 869, 868, 867, 866, 897, 896, 895, 894, 893, 892, 863, 864, 865, 839, 840, 841, 842, 843, 844, 845, 846, 847, 838, 823, 813, 825, 826, 814, 808, 802, 803, 804, 785, 744, 743, 784, 783, 782, 781, 780, 779, 778, 777, 776, 775, 774, 773, 772, 771, 770, 769, 768, 767, 766, 765, 764, 763, 762, 799, 798, 761, 760, 759, 738, 737, 736, 735, 734, 733, 732, 731, 718, 627, 595, 566, 567, 568, 569, 570, 571, 572, 634, 643, 635, 636, 628, 613, 626, 619, 618, 625, 624, 605, 579, 578, 577, 576, 575, 574, 573, 604, 603, 612, 617, 623, 632, 622, 639, 640, 641, 642, 656, 655, 654, 653, 652, 651, 684, 693, 706, 719, 726, 727, 728, 729, 730, 703, 713, 692, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 680, 679, 678, 697, 708, 698, 709, 710, 711, 700, 701, 712, 720, 721, 714, 715, 716, 702, 699, 647, 687, 686, 695, 696, 688, 689, 691, 690, 685, 694, 683, 682, 681, 646, 645, 644, 614, 629, 616, 620, 631, 637, 633, 630, 615, 594, 593, 592, 591, 590, 589, 588, 587, 586, 585, 584, 583, 582, 581, 607, 606, 580, 529, 545, 544, 543, 542, 541, 540, 539, 538, 537, 536, 535, 534, 463, 472, 517, 526, 528, 524, 511, 497, 486, 477, 464, 512, 498, 487, 478, 465, 513, 499, 488, 479, 466, 514, 500, 489, 480, 454, 467, 501, 515, 516, 502, 490, 471, 519, 504, 492, 482, 473, 520, 505, 493, 483, 474, 521, 506, 494, 484, 475, 485, 495, 507, 522, 508, 523, 530, 560, 559, 558, 557, 556, 555, 554, 553, 552, 551, 550, 549, 548, 547, 546, 525, 518, 503, 491, 481, 470, 469, 468, 455, 456, 457, 458, 459, 460, 411, 427, 426, 407, 424, 406, 423, 410, 405, 392, 369, 370, 371, 372, 373, 374, 375, 376, 377, 355, 349, 342, 379, 378, 393, 395, 396, 380,

383, 382, 381, 397, 398, 296, 295, 294, 293, 254, 209, 168, 159, 158, 141, 133, 134, 142, 135, 124, 123, 105, 104, 103, 117, 102, 86, 81, 71, 85, 80, 70, 97, 98, 99, 100, 101, 155, 166, 171, 156, 167, 140, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 84, 88, 89, 90, 91, 118, 119, 121, 126, 128, 132, 138, 145, 146, 147, 152, 151, 127, 163, 169, 161, 160, 82, 74, 73, 72, 64, 61, 65, 56, 36, 52, 35, 12, 13, 14, 38, 37, 39, 40, 15, 41, 42, 43, 53, 44, 45, 17, 46, 19, 47, 48, 20, 21, 22, 0]

Cost: 4665.170864960617



-data3:

Execution Time: 45.740594148635864

Path: [0, 209, 208, 582, 581, 580, 579, 578, 577, 206, 207, 204, 576, 575, 574, 573, 572, 571, 198, 199, 200, 202, 203, 865, 979, 1217, 1480, 1542, 1218, 980, 981, 1219, 1910, 1909, 1908, 1907, 1906, 1905, 1904, 1903, 2286, 2287, 2285, 2284, 2283, 2282, 2280, 2279, 2278, 1899, 1900, 1902, 2567, 2690, 2931, 3201, 2930, 2689, 2688, 2929, 2928, 3200, 2687, 2566, 2565, 2686, 2927, 3199, 2926, 2685, 2684, 2925, 2923, 2682, 2681, 2563, 2922, 2921, 3198, 2680, 2562, 2271, 2272, 1891, 1892, 1894, 1895, 1896, 1897, 2276, 2275, 2274, 2273, 2277, 1898, 1535, 1534, 1206, 969, 970, 858, 1207, 857, 1205, 1204, 968, 967, 1203, 1532, 1533, 1779, 1531, 1530, 1529, 1528, 1777, 1776, 1476, 1200, 965, 1201, 1202, 966, 561, 560, 178, 179, 562, 563, 180, 181, 182, 183, 184, 186, 187, 188, 189, 190, 565, 564, 852, 851, 559, 558, 557, 176, 175, 174, 173, 172, 171, 554, 553, 847, 848, 849, 850, 1475, 1527, 1774, 1887, 1886, 1773, 1772, 1885, 1884, 1771, 1525, 1472, 1197, 963, 1196, 1471, 1470, 1195, 962, 961, 1194, 1469, 1524, 1768, 1881, 1880, 1767, 1523, 1468, 1193, 960, 1191, 1466, 1465, 1190, 959, 958, 1189, 1464, 1766, 1765, 1764, 1461, 1187, 1188, 1462, 1463, 957, 838, 837, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 547, 166, 165, 164, 163, 839, 840, 841, 842, 548, 167, 168, 549, 550, 551, 552, 170, 169, 845, 846, 843, 1769, 1883, 1882, 2255, 2549, 2550, 2256, 2257, 2258, 2259, 2260, 2262, 2263, 2264, 2553, 2554, 2555, 2557, 2558, 2559, 2560, 2269, 2270, 1889, 1888, 2268, 2267, 2266, 2265, 2552, 2551, 2677, 2913, 3190, 3192, 2915, 2916, 3193, 3194, 2917, 2918, 3195, 3196, 2919, 2678, 3197, 2920, 2679, 3261, 3262, 3500, 3533, 3534, 3263, 3264, 3265, 3266, 3267, 3535, 3536, 3537, 3538, 3269, 3270, 3271,

3272, 3539, 3540, 3273, 3274, 3275, 3276, 3277, 3501, 3502, 3503, 3504, 3505, 3278, 3279, 2936, 2938, 3280, 3506, 3507, 3281, 3202, 2940, 2696, 2568, 2695, 2939, 2292, 1916, 1915, 1914, 1913, 2291, 2290, 2289, 2288, 1911, 2693, 2935, 2934, 2692, 2691, 2933, 2932, 3268, 1890, 3499, 3498, 3496, 3495, 3494, 3493, 3492, 3189, 2676, 2912, 3188, 3490, 3491, 3489, 3488, 3487, 3186, 3187, 2547, 2548, 2546, 2254, 2253, 2544, 2543, 2674, 2911, 2675, 3185, 3485, 3484, 3483, 3260, 3184, 2909, 2908, 3183, 3182, 3259, 2907, 2672, 2670, 2905, 3180, 3257, 3179, 2904, 2903, 3178, 3256, 3177, 2902, 2669, 2535, 2534, 2533, 2244, 2245, 2246, 2247, 2248, 2537, 2536, 2538, 2250, 2251, 2252, 2541, 2540, 2539, 2542, 2673, 2910, 3482, 3481, 3480, 3644, 3643, 3642, 3641, 3479, 3478, 3477, 3640, 3639, 3476, 3475, 3474, 3638, 3637, 3473, 3472, 3636, 3635, 3471, 3254, 3173, 2898, 2667, 2897, 3172, 3171, 2896, 2666, 2895, 3170, 3169, 3253, 2894, 2665, 2893, 3168, 3468, 3531, 3530, 3467, 3466, 3165, 2890, 2889, 2663, 3164, 3163, 2888, 2887, 3162, 3161, 2886, 2885, 3160, 3159, 3252, 2884, 2662, 2661, 3158, 3460, 3631, 3632, 3461, 3462, 3463, 3464, 3465, 3166, 2891, 2892, 2664, 3167, 2524, 2525, 2229, 2228, 2227, 2226, 2225, 2224, 2223, 2222, 2220, 2519, 2518, 2517, 2219, 2218, 2217, 2216, 2215, 2214, 2516, 2515, 2513, 2213, 2512, 2211, 2210, 2209, 2511, 2510, 2509, 2207, 2208, 2206, 2205, 2507, 2204, 2203, 2202, 2201, 2200, 2198, 2197, 2196, 2195, 2194, 2505, 2504, 2502, 2501, 2191, 2192, 2193, 2190, 2189, 2187, 2186, 2185, 2497, 2498, 2499, 2500, 2658, 2872, 3144, 3251, 3142, 2870, 2869, 3141, 3140, 2868, 2657, 2656, 2867, 3139, 3249, 3445, 3627, 3628, 3446, 3447, 3448, 3629, 3630, 3449, 3145, 2873, 2659, 2874, 3146, 3147, 2875, 3451, 3452, 3522, 3523, 3524, 3453, 3525, 3526, 3527, 3454, 3150, 2878, 2879, 2660, 3151, 3152, 2880, 2881, 3153, 3457, 3456, 3528, 3155, 3156, 2883, 3157, 3459, 1798, 1737, 1736, 1876, 1874, 1735, 1873, 1872, 1734, 1733, 1732, 1871, 1870, 1731, 1730, 1515, 1729, 1728, 1869, 1868, 1727, 1726, 1724, 1425, 1153, 1154, 1426, 1428, 1156, 1157, 942, 1429, 1514, 1430, 943, 797, 485, 486, 487, 488, 117, 115, 114, 113, 112, 111, 110, 481, 483, 484, 796, 795, 793, 480, 109, 479, 792, 790, 478, 107, 477, 476, 106, 474, 473, 472, 471, 470, 785, 787, 788, 789, 940, 1149, 1420, 1421, 1419, 1148, 939, 1147, 1418, 1417, 1146, 938, 1145, 1416, 1513, 1717, 1716, 1865, 1864, 1715, 1714, 1713, 1411, 1140, 1410, 1409, 1139, 1138, 1408, 1710, 1709, 1863, 1862, 1708, 1405, 1135, 935, 936, 1136, 1406, 1511, 1510, 1707, 1706, 1861, 1860, 1509, 1403, 1134, 933, 932, 1133, 1402, 1705, 1859, 1858, 1704, 1399, 1130, 1132, 1401, 1508, 931, 769, 449, 450, 451, 770, 771, 452, 453, 454, 455, 98, 100, 457, 458, 459, 774, 773, 775, 776, 461, 101, 462, 777, 778, 780, 463, 464, 103, 465, 466, 782, 781, 1141, 1412, 1413, 1142, 1143, 1414, 1512, 937, 783, 784, 469, 468, 104, 105, 1720, 1718, 1867, 1866, 2176, 2175, 2174, 2492, 2490, 2489, 2172, 2173, 2171, 2170, 2488, 2487, 2168, 2167, 2166, 2165, 2164, 2485, 2163, 2484, 2483, 2482, 2161, 2160, 2159, 2481, 2480, 2158, 2157, 2156, 2154, 2153, 2477, 2478, 2853, 3119, 3117, 2851, 3428, 3429, 3521, 3620, 3621, 3431, 3432, 3246, 3122, 2856, 2650, 2855, 3121, 3120, 3245, 2854, 2649, 2857, 3123, 3124, 3126, 2859, 2651, 3247, 3435, 3434, 3433, 3622, 3623, 3624, 3625, 3436, 3127, 2652, 3128, 3129, 2860, 3439, 3438, 3626, 3131, 2862, 2653, 2863, 3132, 3133, 2864, 2865, 2654, 3134, 3442, 3440, 3135, 2866, 3248, 3443, 3444, 3137, 2495, 2494, 2177, 2493, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2655, 3138, 1721, 1723, 1424, 1152, 1151, 1423, 798, 800, 489, 118, 119, 120, 121, 122, 123, 124, 493, 495, 803, 802, 801, 492, 491, 944, 1159, 1432, 1516, 1431, 1158, 1160, 1433, 1434, 1161, 1163, 1436, 1518, 946, 947, 1164, 1437, 1438, 1165, 948, 1519, 1439, 1166, 806, 807, 500, 501, 127, 499, 498, 497, 496, 126, 805, 804, 1520, 1738, 1739, 1740, 1440, 951, 1168, 950, 1167, 949, 808, 809, 810, 130, 131, 132, 133, 134, 135, 504, 137, 506, 507, 138, 139, 140, 141, 142, 143, 144, 145, 511, 512, 514, 515, 146, 516, 517, 518, 519, 520, 521, 522, 149, 148, 147, 150, 151, 152, 153, 525, 826, 827, 828, 829, 830, 831, 528, 158, 159, 160, 157, 156, 155, 154, 526, 825, 824, 523, 823, 822, 956, 1180, 1453, 1452, 1179, 955, 954, 1451, 1450, 1178, 1176, 1448, 1447, 1175, 1174, 1446, 1445, 1173, 1172, 953, 1444, 1443, 1171, 1169, 1441, 1521, 952, 812, 813, 814, 816, 509, 508, 510, 817, 818, 819, 820, 1749, 1748, 1747, 1746, 1745, 1743, 1742, 1879, 1878, 2520, 2521, 2522, 2523, 2230, 2231, 2233, 2234, 2235, 2526, 2527, 2528, 2236, 2238, 2239, 2240, 2241, 2530, 2529, 2531, 2532, 2242, 2243, 2668, 2900, 3175, 3255, 3174, 2899, 2901, 3176, 3470,

3469, 3634, 3633, 3648, 1750, 1454, 1181, 1182, 1455, 1753, 1754, 1755, 1756, 1757, 1758, 1759, 1522, 1457, 1184, 1183, 1456, 1752, 1760, 1761, 1762, 1763, 1459, 1186, 1460, 1458, 1185, 833, 834, 835, 836, 532, 533, 162, 531, 161, 530, 832, 1801, 1473, 1198, 1199, 1474, 1526, 964, 1775, 1537, 1478, 1212, 974, 861, 570, 196, 975, 1213, 2294, 1917, 1918, 2295, 2296, 2297, 1920, 1919, 2298, 2299, 1921, 1922, 1923, 1924, 1925, 1926, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 2307, 2308, 2309, 1936, 1938, 2955, 2954, 2708, 2707, 2953, 2952, 2706, 2575, 2574, 2951, 2949, 2704, 2572, 2703, 2948, 2947, 2702, 2701, 2571, 2946, 3204, 2945, 2700, 2699, 2944, 3203, 2943, 2698, 2570, 2942, 2941, 2697, 2569, 3283, 3542, 3541, 3284, 3543, 3544, 3285, 3286, 3545, 3546, 3288, 3289, 3290, 3291, 3292, 3293, 3294, 3295, 3508, 3547, 2306, 2305, 2304, 2303, 2302, 2301, 593, 217, 216, 215, 218, 220, 221, 222, 223, 224, 225, 226, 596, 597, 598, 228, 229, 595, 594, 503, 502, 129, 2506, 2877, 3149, 1711, 102, 934, 1404, 97, 448, 95, 446, 768, 445, 94, 767, 444, 443, 442, 93, 766, 765, 764, 763, 439, 440, 91, 437, 762, 926, 1125, 1394, 1505, 1393, 925, 1392, 1697, 1850, 1849, 1504, 1391, 1124, 923, 922, 1123, 1390, 1389, 1122, 921, 920, 1121, 1387, 1386, 1120, 919, 1119, 1385, 1384, 1118, 1117, 1383, 1382, 1116, 1115, 1381, 1380, 1114, 1113, 1379, 1689, 1691, 1692, 1693, 1694, 1695, 1696, 756, 755, 754, 753, 752, 751, 749, 415, 416, 82, 83, 417, 418, 84, 419, 420, 422, 86, 423, 424, 425, 426, 427, 87, 428, 429, 430, 431, 88, 433, 434, 435, 436, 90, 761, 760, 759, 758, 757, 81, 80, 414, 79, 78, 412, 748, 747, 745, 744, 743, 742, 408, 76, 409, 410, 411, 77, 1111, 1376, 1377, 1375, 1110, 1109, 1374, 1373, 1372, 1108, 1107, 1371, 1370, 1106, 1105, 1369, 1680, 1681, 1682, 1683, 1684, 1685, 1687, 1688, 1797, 1848, 2125, 2126, 2127, 2129, 2130, 2131, 2459, 2460, 2461, 2132, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2465, 2464, 2644, 2843, 3107, 3241, 3106, 2842, 2841, 3105, 3240, 2643, 2840, 3104, 3103, 2839, 2838, 3102, 3101, 3100, 2837, 2642, 2641, 2836, 3099, 3098, 2835, 2834, 3097, 3096, 2833, 2832, 3095, 3410, 3411, 3412, 3413, 2457, 2456, 2455, 2124, 2122, 2454, 2453, 2452, 2451, 2120, 2119, 2118, 2117, 2450, 2449, 2116, 2115, 2114, 2448, 2447, 2446, 2444, 2111, 2112, 2113, 2637, 2828, 3088, 3237, 3087, 2827, 2636, 3236, 3086, 2826, 2825, 3085, 3235, 2635, 2824, 3084, 3401, 3516, 3515, 3603, 3604, 3402, 3403, 3404, 3605, 3606, 3405, 3406, 3238, 3090, 2830, 2638, 2829, 3089, 3091, 2831, 2639, 3239, 3407, 3608, 3607, 3609, 3610, 3408, 3092, 2640, 3093, 3094, 3409, 1679, 1678, 1367, 1103, 1104, 1368, 738, 402, 74, 401, 737, 736, 399, 73, 398, 735, 734, 397, 72, 396, 732, 731, 395, 71, 70, 393, 730, 729, 1095, 1359, 1361, 1097, 1098, 1362, 1363, 1099, 1100, 1364, 1365, 1101, 1677, 1676, 1675, 1673, 1672, 1671, 1670, 1503, 1669, 1358, 917, 390, 391, 392, 389, 388, 387, 386, 385, 384, 382, 381, 725, 726, 727, 916, 1094, 1357, 1355, 1092, 1091, 1354, 1666, 1667, 1795, 1796, 2101, 2100, 2099, 2098, 2097, 2096, 2095, 2438, 2437, 2435, 2434, 2433, 2091, 2092, 2093, 2094, 2629, 2819, 3079, 3234, 3078, 2818, 2817, 3077, 3076, 2816, 2628, 2815, 3075, 3073, 2813, 2627, 2812, 3072, 3233, 3390, 3389, 3598, 3597, 3387, 3596, 3595, 3231, 3069, 2809, 2624, 2625, 2810, 3070, 3071, 2811, 2626, 3232, 2427, 2426, 2083, 2084, 2085, 2086, 2087, 2430, 2429, 2431, 2432, 2089, 2090, 1847, 1846, 1662, 1663, 1794, 1664, 1665, 1353, 1090, 1089, 1352, 1351, 1350, 1088, 915, 1502, 1349, 1087, 914, 1086, 1348, 1346, 1084, 1083, 1345, 1344, 1501, 1082, 912, 911, 1081, 1343, 1500, 1342, 1080, 1079, 1341, 1340, 1078, 1076, 910, 1338, 1498, 1651, 1840, 1841, 1652, 1653, 1654, 1655, 1842, 1843, 1844, 1845, 1658, 1659, 1660, 1661, 718, 373, 374, 375, 376, 719, 720, 721, 377, 67, 68, 69, 378, 722, 724, 380, 66, 65, 64, 63, 62, 370, 371, 717, 716, 715, 714, 369, 368, 367, 366, 60, 365, 709, 710, 711, 712, 61, 363, 708, 707, 362, 361, 360, 704, 705, 1075, 1336, 1335, 1496, 1074, 909, 908, 1072, 1333, 1495, 1332, 1071, 1070, 1331, 1330, 1069, 907, 1068, 1329, 1328, 1067, 906, 1066, 1327, 1326, 1065, 1064, 1325, 905, 1063, 1324, 1322, 1061, 1640, 1641, 1642, 1643, 1644, 1645, 1646, 1836, 1837, 1838, 1839, 1648, 1649, 1793, 1337, 1497, 2072, 2073, 2074, 2420, 2419, 2418, 2071, 2070, 2069, 2068, 2067, 2065, 2064, 2415, 2416, 2417, 2622, 2802, 3061, 3060, 2801, 2621, 2619, 2799, 3058, 3057, 2798, 3381, 3380, 3594, 3593, 3592, 3591, 3377, 3376, 3375, 3374, 3227, 3051, 2792, 2791, 3050, 3049, 2790, 3372, 3373, 3053, 2794, 2795, 3054, 3055, 2796, 2617, 3228, 3229, 3056, 2797, 2618, 2413, 2063, 2062, 2061, 2060, 2410, 2409, 2408, 2058, 2057, 2056, 2406, 2407, 2055, 2054, 2404, 2403, 2402,

2401, 2400, 2049, 2050, 2051, 2052, 2616, 2788, 3046, 3226, 3045, 2787, 2786, 3044, 3043, 2785, 2784, 3042, 3366, 3367, 3368, 3369, 3589, 3590, 3370, 3048, 2048, 2047, 2046, 2045, 2044, 2043, 2042, 2041, 2040, 2039, 2038, 2037, 2394, 2393, 2392, 2391, 2390, 2389, 2388, 2032, 2033, 2034, 2036, 2779, 3035, 3036, 3360, 3361, 3512, 3037, 2613, 2614, 2780, 3038, 3039, 2781, 2782, 3040, 3041, 2783, 2615, 2397, 2396, 2395, 2398, 3364, 3363, 3362, 3033, 3032, 2777, 2776, 3031, 3030, 2775, 2774, 2611, 3029, 3224, 3028, 2773, 2610, 2609, 2772, 3027, 3223, 3354, 3582, 3581, 3353, 3352, 3351, 3580, 3579, 3221, 3022, 2767, 2606, 2769, 3024, 3025, 2770, 2771, 3026, 3222, 2608, 2383, 2382, 2381, 2024, 2025, 2026, 2027, 2384, 2385, 2386, 2029, 2030, 2028, 1834, 1835, 1626, 1625, 1493, 1305, 1051, 897, 896, 1050, 1304, 1492, 1303, 1049, 1048, 1302, 1301, 1300, 1047, 1046, 1299, 1298, 1045, 1044, 1297, 1296, 1043, 1042, 1295, 1294, 1041, 894, 1293, 1292, 1040, 1616, 1617, 1789, 1788, 2018, 2019, 2020, 2374, 2373, 2372, 2371, 2370, 2369, 2015, 2016, 2017, 2603, 2763, 3016, 3218, 3015, 2762, 2761, 3014, 3013, 2760, 2602, 2758, 3011, 3217, 3342, 3571, 3572, 3343, 3344, 3345, 3574, 3575, 3346, 3219, 3347, 3017, 2764, 2604, 2605, 2765, 3018, 3220, 3019, 2766, 3020, 3021, 3349, 3348, 3578, 3577, 2375, 2376, 2377, 2379, 2380, 2022, 1790, 1622, 1621, 1620, 1619, 1618, 895, 666, 665, 664, 305, 306, 307, 308, 309, 310, 311, 312, 31, 32, 33, 34, 314, 315, 316, 673, 672, 671, 313, 670, 669, 668, 667, 30, 28, 27, 26, 25, 24, 301, 300, 299, 298, 297, 661, 660, 659, 658, 657, 656, 290, 291, 292, 293, 294, 296, 1039, 1290, 1289, 1038, 1037, 1288, 1287, 1036, 893, 1035, 1286, 1611, 1787, 1610, 1609, 1608, 1284, 1034, 1033, 1283, 1282, 1032, 892, 652, 653, 654, 655, 289, 288, 287, 286, 285, 284, 283, 282, 281, 280, 279, 278, 648, 649, 650, 651, 1031, 1281, 1280, 1030, 891, 1029, 1279, 1278, 1028, 1605, 1606, 1607, 1786, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2368, 2367, 2366, 2365, 2363, 2362, 2361, 2360, 2359, 2358, 2357, 1996, 1995, 1994, 1997, 2596, 2749, 3002, 3001, 2748, 2747, 3000, 3336, 3337, 3338, 3005, 2752, 2597, 2751, 3004, 3006, 2753, 2754, 3007, 3008, 2755, 2598, 2599, 2756, 3009, 3010, 2757, 2600, 3340, 3339, 2999, 2595, 2746, 2594, 2744, 2593, 2353, 2354, 2355, 3334, 3333, 3332, 3331, 3215, 3329, 2997, 2592, 2350, 1988, 1989, 1990, 1991, 1992, 2352, 1986, 1985, 1984, 1983, 1982, 2347, 2348, 2349, 2591, 2742, 2995, 2994, 2741, 2590, 2740, 2993, 2992, 2739, 2738, 2991, 2990, 2737, 2736, 2989, 2988, 2735, 2734, 2987, 3214, 2589, 2733, 2986, 2985, 2732, 2588, 3213, 2984, 2731, 2587, 2586, 2730, 2983, 3212, 2982, 2729, 2728, 2585, 2981, 3211, 2980, 2727, 2726, 2979, 3315, 3316, 3563, 3564, 3317, 3318, 3565, 3566, 3319, 3567, 3568, 3320, 3321, 3569, 3570, 3322, 3323, 3324, 3325, 3326, 3327, 3328, 2346, 2345, 2344, 2343, 2342, 1978, 1979, 1980, 1981, 1784, 1785, 1598, 1272, 1024, 1023, 885, 1271, 1270, 1022, 1020, 1269, 1596, 1597, 1831, 1830, 1829, 1828, 1783, 1594, 1593, 1266, 1017, 1018, 1267, 1268, 1489, 1019, 884, 637, 638, 639, 640, 641, 268, 269, 270, 271, 272, 273, 274, 19, 18, 17, 16, 266, 267, 265, 264, 263, 15, 262, 261, 260, 259, 635, 634, 632, 631, 258, 630, 257, 256, 255, 254, 253, 252, 251, 628, 629, 881, 1015, 1261, 1260, 1014, 1589, 1827, 1826, 1825, 1824, 1588, 1587, 1586, 1585, 1584, 1823, 1822, 1821, 1820, 1583, 1487, 1255, 1009, 878, 877, 1008, 1254, 1486, 1253, 1007, 876, 620, 621, 245, 246, 244, 243, 242, 619, 875, 1006, 1252, 1485, 1582, 1581, 1251, 1005, 618, 241, 616, 615, 614, 613, 612, 239, 240, 14, 13, 12, 11, 237, 236, 235, 10, 610, 611, 609, 608, 607, 606, 234, 9, 8, 7, 605, 604, 233, 603, 602, 600, 599, 230, 231, 232, 6, 5, 227, 219, 214, 210, 205, 201, 197, 185, 177, 556, 555, 546, 534, 529, 527, 524, 513, 505, 136, 128, 125, 494, 490, 482, 475, 467, 460, 456, 447, 441, 438, 432, 421, 413, 407, 403, 400, 394, 383, 379, 372, 364, 358, 354, 57, 48, 44, 35, 333, 338, 340, 343, 700, 706, 713, 723, 728, 733, 855, 918, 1102, 1366, 1360, 1096, 1093, 1356, 1347, 1085, 913, 1077, 1339, 1334, 1073, 1062, 904, 1323, 902, 1311, 1637, 1650, 1656, 1668, 1674, 1686, 1690, 1378, 1112, 1388, 924, 930, 1131, 1400, 1407, 1137, 1144, 1415, 1422, 1150, 1155, 941, 1427, 1435, 1517, 1162, 945, 799, 791, 786, 779, 772, 99, 96, 92, 89, 85, 750, 746, 1702, 1712, 1719, 1722, 1875, 1877, 1741, 1744, 1751, 1799, 1800, 1802, 1770, 1803, 1778, 1544, 1553, 1780, 1812, 1813, 1566, 1567, 1569, 1483, 1238, 996, 873, 995, 1237, 1236, 994, 993, 872, 1234, 1482, 1222, 982, 862, 1208, 1467, 1192, 844, 821, 815, 811, 1170, 1442, 1449, 1177, 116, 108, 2188, 2199, 2212, 2221, 2232, 2237, 2249, 2545, 2556, 2261, 1893, 1901,

1912, 2293, 2281, 2564, 2683, 2924, 3191, 2914, 2906, 3181, 3258, 2671, 3486, 3497, 3646, 3645, 3532, 3529, 3458, 3455, 3450, 3148, 2876, 2871, 3143, 3136, 3130, 2861, 2858, 3125, 3118, 2852, 2844, 3108, 3421, 3519, 3518, 3517, 3083, 2823, 2634, 2814, 3074, 3068, 2808, 2800, 3059, 3052, 2793, 2789, 3047, 3034, 3225, 2778, 2612, 2607, 2768, 3023, 3012, 3216, 2759, 2601, 2750, 3003, 2998, 2745, 2743, 2996, 3330, 3335, 3341, 3573, 3576, 3350, 3587, 3588, 3365, 3371, 3378, 3388, 3395, 2620, 2412, 2405, 2399, 2053, 2059, 2066, 2075, 2080, 2088, 2436, 2428, 2421, 2103, 2110, 2445, 2121, 2123, 2128, 2133, 2141, 2468, 2479, 2486, 2491, 2496, 2503, 2508, 2514, 2882, 3154, 3441, 3437, 3430, 2162, 2169, 2155, 2035, 2031, 2023, 2378, 2387, 2013, 1999, 1993, 1987, 1977, 1974, 2330, 2319, 2300, 2561, 3250, 3063, 2476, 3287, 3303, 3312, 3511, 2351, 2356, 2364, 1599, 1592, 1580, 1568, 1725, 1499, 856, 794, 601, 617, 880, 1016, 883, 1021, 888, 1277, 642, 633, 20, 21, 22, 23, 295, 303, 29, 319, 59, 587, 1570, 1781, 1815, 1814, 1942, 1943, 1944, 2315, 2314, 2313, 2312, 1940, 1941, 1939, 2311, 2310, 1937, 1927, 2573, 2705, 2950, 2956, 2957, 2709, 2576, 2577, 2710, 2958, 3205, 2959, 2711, 2712, 2960, 2961, 2713, 2578, 3206, 3298, 3297, 3296, 3549, 3548, 3550, 3551, 3552, 3553, 3300, 3301, 3509, 2964, 2580, 2965, 2966, 2715, 2716, 2967, 2968, 2717, 2718, 2969, 2970, 3307, 3306, 3305, 3304, 3302, 2320, 2321, 1951, 1952, 2322, 2323, 1953, 1954, 2324, 1955, 1956, 2325, 2581, 2719, 2971, 3208, 3308, 3555, 3556, 3557, 3554, 3309, 3209, 2973, 2721, 2582, 2720, 2972, 2326, 1957, 1958, 2327, 2328, 1959, 1960, 1961, 1962, 2329, 2331, 2332, 2333, 1963, 1964, 1965, 1966, 1967, 1968, 2335, 2334, 2336, 2337, 1969, 1970, 1971, 1972, 1973, 2339, 2338, 2340, 2341, 1975, 1976, 1595, 636, 1265, 1264, 1263, 1591, 1782, 882, 1262, 1590, 2725, 2978, 2977, 2976, 3210, 2724, 2584, 2723, 2975, 3311, 3560, 3561, 3313, 3314, 3510, 3562, 2974, 2722, 2583, 3310, 3559, 3558, 1256, 1010, 1011, 1257, 1258, 1012, 1013, 879, 1259, 1488, 626, 625, 624, 623, 248, 249, 250, 627, 247, 622, 1819, 1818, 1817, 1816, 1579, 1484, 1250, 1004, 874, 1249, 1248, 1003, 1002, 1247, 1246, 1001, 1000, 1245, 1244, 999, 998, 1243, 1242, 1241, 997, 1571, 1572, 1573, 1574, 1575, 1576, 1577, 1578, 1950, 1949, 1948, 1947, 1946, 2318, 2317, 2316, 1945, 2579, 2714, 2962, 3207, 3299, 2963, 1240, 1239, 238, 2694, 2937, 3282, 1273, 886, 887, 1025, 889, 1026, 890, 1274, 1602, 1601, 1600, 643, 644, 275, 276, 277, 645, 646, 647, 1490, 1276, 1275, 1027, 1603, 1604, 1285, 1612, 1613, 1614, 1491, 1291, 1615, 662, 663, 304, 302, 2021, 1623, 1624, 1832, 1833, 1306, 1052, 898, 1053, 1307, 1308, 1054, 1055, 1309, 899, 1056, 1310, 1312, 1057, 900, 854, 901, 1058, 1313, 1314, 1059, 681, 682, 331, 332, 334, 36, 37, 38, 39, 40, 337, 336, 335, 330, 329, 328, 327, 326, 325, 324, 323, 322, 321, 320, 318, 675, 676, 677, 678, 679, 680, 1629, 1630, 1631, 1791, 1632, 1494, 1316, 1317, 1635, 1636, 1638, 1639, 1792, 1320, 1321, 689, 690, 691, 692, 693, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 355, 356, 58, 56, 55, 54, 53, 698, 697, 696, 695, 694, 51, 50, 49, 47, 342, 52, 699, 701, 702, 357, 359, 703, 1647, 2414, 2411, 3379, 3230, 3062, 2803, 3383, 3382, 3513, 3384, 3385, 3386, 3066, 2806, 2805, 3065, 3064, 2804, 2422, 2076, 2077, 2078, 2079, 2081, 2082, 2425, 2424, 2423, 2623, 2807, 3067, 1657, 3391, 3392, 3600, 3599, 3393, 3394, 3601, 3602, 3396, 3397, 3514, 3398, 3399, 3400, 3082, 2633, 2822, 2632, 2821, 2631, 2630, 3081, 3080, 2820, 2439, 2440, 2102, 2104, 2105, 2106, 2107, 2441, 2108, 2109, 2442, 2443, 739, 740, 741, 406, 405, 75, 404, 2458, 3414, 3415, 3416, 3520, 3611, 3612, 3417, 3418, 3613, 3614, 3419, 3109, 2645, 3110, 3242, 3111, 2845, 2846, 3112, 3113, 2847, 2848, 2646, 3114, 3243, 3425, 3424, 3423, 3422, 3420, 2467, 2469, 2470, 2471, 2472, 2149, 2148, 2147, 2146, 1852, 1851, 1699, 1700, 1506, 1396, 1127, 927, 1126, 1395, 1397, 1128, 928, 929, 1129, 1398, 1507, 1703, 1856, 1855, 2151, 2152, 2150, 2473, 2474, 2475, 2648, 2850, 3116, 3244, 3115, 2849, 2647, 3426, 3616, 3615, 3617, 3618, 3427, 3619, 1857, 1701, 1854, 1853, 1698, 2145, 2144, 2143, 2142, 2466, 2463, 2462, 3647, 341, 46, 45, 43, 339, 42, 41, 685, 686, 687, 688, 1060, 1318, 1319, 1634, 1633, 1315, 903, 683, 684, 1628, 1627, 674, 317, 3355, 3584, 3583, 3585, 3586, 3356, 3357, 3358, 3359, 566, 567, 191, 192, 193, 194, 195, 569, 568, 859, 971, 1209, 1210, 972, 973, 860, 1211, 1477, 1536, 1804, 1805, 1806, 1807, 1538, 1539, 1540, 1214, 976, 863, 977, 1215, 1216, 978, 864, 1479, 1541, 1808, 1809, 1810, 1811, 1543, 1545, 1546, 1547, 1220, 1481, 1221, 1548, 1223, 1224, 983, 984, 1225, 1226, 1227, 985, 1228, 986, 866, 853, 987, 1229,

1230, 988, 989, 867, 1231, 1232, 868, 990, 1233, 869, 991, 870, 992, 871, 1235, 1565, 1564, 1563, 1562, 1561, 1560, 1559, 1558, 1557, 1556, 1555, 1554, 1552, 1551, 1550, 1549, 583, 584, 585, 586, 588, 589, 590, 591, 592, 213, 4, 3, 2, 1, 212, 211, 0]

Cost: 12570.756370964413

