图片包含 文本

描述已自动生成

**20’ Fall CS 401 Project**

**Group Project**

**Student Name & CWID：**

**Wei Wu** **A20478710**

**Ye Yu A20478640**

CS401 Project Big-O Complexity Analysis

## Overview of Big-O Search Algorithm Analysis:

We use the same test data (2000 random positive integers) to test different search implementation algorithms and presented the test results (we performed three tests for each search algorithm and recorded execution time (NS) and average execution time) to the user.

The test data are as follows:

532,822,258,140,67,1597,1963,1670,802,515,1127,1156,1869,1492,1018,764,10,484,91,67,1494,772,1512,1160,1614,1825,906,1051,74,73,1236,248,83,1162,1285,100,117,1097,1853,1491,1456,1196,1148,1667,1785,277,613,264,45,1627,385,997,1765,1270,1760,1300,1940,759,139,418,638,466,597,1034,483,617,896,540,681,1094,443,1178,792,852,265,191,702,1627,301,700,227,1062,865,1440,87,195,1062,228,119,566,998,464,1166,1946,1445,301,360,1573,326,1656,1426,1559,1754,672,1629,783,1187,1468,386,1050,502,1612,447,345,1487,778,1839,1565,543,652,360,1906,160,1626,270,1445,953,422,1637,1780,1004,1197,643,1456,125,728,1124,801,1134,607,311,103,981,539,1254,1640,1391,1414,531,1514,1917,738,1085,1215,973,530,434,600,36,1609,206,264,134,1789,1170,134,1656,712,480,142,445,1115,1907,5,941,1742,1275,534,1524,744,854,510,1750,328,1066,1265,1312,430,1422,1318,938,585,505,790,1816,590,1810,844,272,177,1446,490,1382,1588,1656,200,1906,569,51,713,1731,1765,299,1212,1021,339,1138,283,1598,721,1590,724,639,283,647,1858,1798,1539,1527,679,1896,762,1178,1768,219,1822,1244,1077,1465,943,1986,563,16,1199,1608,1064,1127,1958,1194,1699,907,1391,1486,1173,504,995,1822,960,467,416,676,1690,1492,325,1631,1342,1297,1693,1250,1391,277,389,171,122,975,988,1424,871,359,1718,741,1371,1115,1388,875,830,1752,1956,130,1252,1940,1321,1823,314,1384,119,985,334,491,1941,1885,1387,874,1823,514,1936,980,1406,1783,108,1761,1559,1688,41,674,1677,1935,258,339,1443,678,1425,813,898,1131,1145,217,195,1357,301,1455,426,1539,140,1260,752,204,394,194,1659,865,332,1465,1228,1158,1503,547,1508,351,1333,1549,1428,1999,1885,1938,1872,1692,1854,954,671,1359,1488,1983,1105,1863,727,656,77,125,1676,862,1526,1762,394,1812,26,68,466,1171,439,1999,1228,123,1322,1089,346,102,1253,246,1850,1279,524,962,969,1280,1901,93,430,1689,538,1144,874,1132,1651,1437,1978,1780,1364,1733,22,646,1801,1396,490,1488,1114,990,1518,1919,343,1021,803,1980,1777,1546,29,518,1522,153,1016,1435,1338,225,1624,927,295,776,945,320,1248,1054,1967,304,1566,1744,419,1009,648,893,1371,783,1993,261,1149,1270,1568,1084,592,1701,1412,1566,742,202,658,1597,186,1693,1204,1174,1474,41,1104,914,161,1973,538,1224,1836,112,55,1824,1382,395,1183,1042,907,256,1950,1100,422,1248,1591,930,1855,219,1877,448,996,552,1952,203,1186,53,1832,214,256,1096,770,1457,1624,883,108,859,1716,886,1805,1608,1681,1999,1358,1693,1730,1644,1744,1416,996,1713,856,29,1241,1157,1966,1724,1412,103,318,62,1760,1774,1896,1741,300,1901,298,467,135,678,1704,459,372,549,501,356,1850,29,81,1908,1563,785,1871,937,559,600,450,1291,924,1731,1043,61,1060,1787,866,1714,1131,899,1670,1996,1748,365,626,1903,1127,1208,1335,20,1777,1223,1216,1690,1815,1837,1902,151,936,900,0,1421,1983,862,286,647,1250,1890,1234,1650,634,72,436,1961,479,560,433,1304,894,1484,1399,1362,1962,1341,160,1118,205,395,632,1548,665,1135,684,1926,1840,458,1297,1521,1148,1673,1742,131,380,1504,1400,1646,187,354,216,906,974,1027,890,1,1386,885,1813,1620,1888,1774,98,1932,871,267,891,1626,452,142,177,1887,71,50,218,183,533,1951,53,1504,1998,1737,267,1946,59,1683,1444,1590,1286,81,451,1664,453,1547,47,1369,1956,621,399,429,1054,475,626,1972,1560,786,56,660,1530,1034,592,515,1979,279,830,42,87,1103,1064,1685,1232,998,350,1126,1055,1508,1653,218,1925,873,1278,1028,594,1255,1143,1173,961,653,381,333,1950,1140,492,1402,197,369,182,1119,1833,475,1947,449,909,1895,1595,1387,1490,32,581,1745,1214,1570,891,1665,437,5,405,421,1399,614,1134,869,534,1681,1118,1290,257,1643,437,1773,1298,172,913,1902,1905,1066,1837,1937,547,1680,70,626,1155,765,842,985,106,361,1327,1769,1950,1299,1374,642,389,821,1482,1382,1620,681,1969,57,1496,213,1677,1649,720,321,775,141,1237,505,1354,914,1543,750,623,1840,358,183,1882,1012,186,1494,1088,1303,1935,1557,1684,1843,48,1662,1917,5,798,186,436,798,142,1377,463,1379,253,1904,1398,821,896,1385,607,1771,1756,1444,378,1771,1534,1636,1995,135,393,804,319,1716,954,639,828,694,313,799,1178,1304,1262,478,104,1288,1950,1560,1501,1918,753,1122,572,1852,112,1843,1491,1201,1232,560,1248,696,1766,1542,1695,974,406,176,1989,929,1964,537,770,1971,1254,1563,87,270,1724,1654,1332,1393,77,252,1452,1385,727,553,632,683,35,64,1908,173,315,1840,778,1604,680,1141,873,1976,1580,1835,1777,820,1097,734,974,682,156,285,1487,707,650,1868,1906,964,549,1448,1198,1324,1818,614,444,1162,1467,1413,1346,251,1940,1810,1997,657,812,1417,235,1295,1882,313,1155,769,1025,625,993,1320,554,1862,946,1267,1244,1302,856,1849,1755,519,1914,1795,1626,601,1068,1879,1054,1754,1190,1294,1824,616,1027,119,478,1985,969,1861,80,102,287,227,1010,750,560,216,1026,519,1531,246,392,951,1620,1820,717,1216,955,763,185,1058,311,485,701,1979,702,1121,1898,105,1843,555,860,32,1965,1145,1302,1847,1328,1401,1387,589,555,854,1702,1241,189,1273,1623,1231,212,1563,171,1134,932,856,1382,214,0,1408,1600,679,744,744,1513,804,1823,1757,698,1367,743,1688,1754,686,1275,509,1161,403,1241,1214,1069,41,283,1132,486,866,1633,701,1024,1997,172,921,629,1453,681,510,1836,1749,1784,1188,466,1936,1463,1035,595,269,1888,128,37,87,973,111,1394,978,1235,1346,1184,1297,498,1655,1422,1541,1847,1871,797,32,1355,643,600,1976,1132,1,994,1687,630,1733,1387,1886,1614,755,1230,1882,427,1472,10,1695,993,1264,363,705,523,137,1620,1025,612,727,1644,1108,1043,9,642,1888,561,441,782,991,759,665,197,342,1800,1529,264,1823,1337,181,1514,739,1961,1722,1836,1156,1393,713,935,1605,921,916,1205,525,1667,550,1997,144,1113,720,1705,1486,1102,653,1078,1352,1187,1046,1719,1708,1241,1490,1125,1058,1790,1365,1159,862,1942,1338,1402,1526,119,891,798,830,1361,781,1261,1647,1592,1896,1801,1910,1536,1988,608,1512,467,768,1390,563,1697,603,784,1104,837,1237,208,1909,400,528,50,1159,1157,96,202,588,1616,561,423,1678,1572,696,1968,1292,207,1874,10,571,1580,168,611,1977,596,1972,574,642,114,1869,827,1643,1538,286,1890,796,1765,406,140,1067,740,1080,735,835,1454,1026,1492,724,1473,1002,1222,195,897,1108,1112,1938,1815,1889,1747,1435,744,1746,1372,517,1856,1786,1791,1017,668,1473,1530,687,978,1749,999,465,1901,378,1127,1057,1480,1442,1624,454,1142,72,1107,1010,12,1734,484,63,1340,1095,567,999,15,1159,1659,275,398,1430,486,251,1340,315,1605,189,547,933,878,1672,154,141,132,1848,1200,1735,1094,300,425,1464,1605,82,50,1,15,1509,1889,1337,1213,589,62,1017,1861,421,1512,944,1325,985,549,487,413,1278,474,1615,1807,1179,1251,1350,646,1893,1808,921,1256,1369,413,1475,1674,1443,1356,820,54,1051,960,493,1259,1247,169,1751,1746,1659,1607,1603,1576,484,1692,844,557,1909,371,217,919,129,1303,1278,1907,1287,1650,1922,570,1332,1331,1084,1692,18,1450,198,1564,429,259,1956,936,1814,220,1070,1651,1489,309,296,816,473,771,1859,1437,756,929,892,778,1153,1460,1858,1653,1149,1962,101,163,645,1358,842,428,581,1290,1659,1684,1615,425,283,610,920,391,215,1679,1548,1784,344,604,1761,946,805,352,873,1737,1654,13,690,485,1075,238,1944,945,1562,271,729,1154,416,617,169,466,638,1464,860,728,1037,939,225,374,13,1896,894,1311,206,201,1589,307,1906,1351,806,1992,474,1,223,118,1116,1465,15,495,790,251,712,538,557,955,338,1547,1422,298,1132,1392,181,373,861,1994,1180,1482,1672,1126,1531,167,1311,1047,1982,1601,63,1842,1444,1582,89,854,1763,271,640,118,105,46,510,68,1006,128,113,1771,885,166,1107,937,577,38,135,615,1764,1137,1135,679,99,1665,379,1913,581,625,891,874,762,1385,102,473,553,1348,1251,1399,177,1743,1204,699,321,1345,323,31,1667,178,1749,90,147,1625,811,811,605,357,1655,1294,660,456,187,1471,143,1115,1213,1000,335,2,1686,840,1867,1246,1578,1731,1084,568,1651,624,900,113,1686,819,393,211,1911,662,80,338,1815,1158,1973,1381,587,1177,1702,1356,889,1207,1487,301,476,1532,721,1454,1670,1592,811,785,389,0,1626,423,590,1861,140,930,694,110,1585,956,192,21,810,1629,1520,1628,340,77,766,890,254,599,151,1285,1221,229,1629,1021,1617,1294,1214,1955,216,425,1394,1845,464,12,1069,1255,1986,917,1189,415,1146,709,1390,396,699,340,1569,644,399,1381,507,521,1308,423,1,1383,1586,1908,1906,1421,209,266,213,1046,1848,1027,1632,595,1320,1268,874,343,1143,703,681,1966,1904,1108,677,1402,695,1963,1934,315,1898,1511,40,1546,948,199,228,595,1915,1982,1819,813,57,301,1795,360,1575,954,1028,993,1157,160,1716,420,1031,1122,1790,895,1578,349,498,159,132,1081,598,1114,168,1771,617,1224,1801,522,824,958,214,1564,346,1608,1268,1757,1062,1939,1977,268,788,372,676,465,1441,1368,1867,670,492,649,1340,1538,1933,1226,1684,1156,22,640,990,1490,1105,940,436,741,152,1673,497,1696,804,1647,439,1622,1165,673,1147,598,545,585,1006,724,160,1758,1687,789,819,1823,28,790,1308,1599,1776,1801,809,1741,966,813,707,78,1683,1208,1747,889,1042,820,1299,367,273,436,1858,1013,1368,18,641,992,1770,486,203,604,1812,1668,418,1161,1602,3,1956,818,625,1158,701,555,543,152,565,998,590,1513,1322,594,312,1839,232,898,1725,1339,1157,69,407,490,170,1030,702,1860,971,1602,936,1732,1511,1282,1000,148,90,372,1687,1125,48,666,1776,472,1205,159,1893,1852,664,1745,1600,132,1294,1472,580,660,514,849,257,216,1898,1087,1558,497,1397,735,1952,1997,1600,574,1169,418,1592,1353,1196,471,1225,921,109,590,85,1113,

## Sample test results for linear search O(N)(searching 1900 data) :

**No 1. Bounded unsorted list based on array**

Execution time of 1: 350900ns step number: 2000

Execution time of 2: 198900ns step number: 2000

Execution time of 3: 164000ns step number: 2000

Execution avg time: 237933ns step number: 2000

The Big-O complexity is O(N).

**No 2. Unbounded and unsorted list based on array**

Execution time of 1: 448200ns step number: 2000

Execution time of 2: 262500ns step number: 2000

Execution time of 3: 149300ns step number: 2000

Execution avg time: 286666ns step number: 2000

The Big-O complexity is O(N).

## Sample test results for binary search O(log(2)(N))(search 1900 data) :

**No 1. Bounded sorted list based on array**

Execution time of 1: 9900ns step number: 11

Execution time of 2: 1200ns step number: 11

Execution time of 3: 700ns step number: 11

Execution avg time: 3933ns step number: 11

The Big-O complexity is O(log(2)(N)).

**No 2. Unbounded sorted list based on array**

Execution time of 1: 17200ns step number: 11

Execution time of 2: 1500ns step number: 11

Execution time of 3: 900ns step number: 11

Execution avg time: 6533ns step number: 11

The Big-O complexity is O(log(2)(N)).

**No 3. Binary search tree**

Execution time of 1: 15100ns step number: 12

Execution time of 2: 2400ns step number: 12

Execution time of 3: 2100ns step number: 12

Execution avg time: 6533ns step number: 12

The Big-O complexity is O(log(2)(N)).

## Analysis conclusion:

By looking at the test results above, we can clearly see that using the search algorithm with complexity O(log(2)(N)) is much more efficient than using the search algorithm with complexity O(N).

From the perspective of time, the average execution time of O(N) complexity search algorithm is compared with the average execution time of O(log(2)(N)) complexity search algorithm. The former is 50 times as much as the latter. The calculation is as follows:

(237933 + 286666) / 2)/(3933 + 6533) / 2) ≈ 50

From this calculation formula we can see more intuitively, the two in the execution time difference.

From the step up observation, with O (N) complexity of the search algorithm performed 2000 steps (that is, how many times how many elements you need to contrast so its complexity is O (N)), O(log(2)(N)) complexity of the search algorithm performed only 11 steps (that is, to perform every time to give up half of the 2000 elements execute 11 found the data so its time complexity is O(log(2)(N)).