CS401 BigO analysis

关于BigO搜索算法分析的概述：

我们使用同样的测试数据(2000个随机正整数)，来针对不同搜索实现算法进行测试，并展示测试结果(针对每个搜索算法我们执行三次测试，并记录执行时间(ns)和平均执行时间)展示给用户。

测试数据如下所示：

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,

关于线性搜索O(N)(搜索1900数据)的测试结果样例：

No 1. It's 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 of : 237933ns step number: 2000

The big-O is O(N).

No 2. It's 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 of : 286666ns step number: 2000

The big-O is O(N).

关于二分搜索O(log2N)(搜索1900数据)的测试结果样例：

No 1. It's 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 of : 3933ns step number: 11

The big-O is O(log2N).

No 2. It's 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 of : 6533ns step number: 11

The big-O is O(log2N).

No 1. It's 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 of : 6533ns step number: 12

The big-O is O(log2N).

分析结论：

通过观察以上测试数据结果，我们一目了然，使用复杂度为O(log2N)的搜索算法比使用复杂度为O(N)的搜索算法效率高很多很多。

从时间上来观察，将O(N)复杂度搜索算法平均执行时间与O(log2N)复杂度搜索算法的平均时间对比，前者是后者的50倍，计算如下：

((237933 + 286666) / 2) / ((3933 + 6533) / 2) ≈ 50  
从此计算公式我们更直观的看出，两个在执行花费时间上的差距。

从执行步骤上来观察，O(N)复杂度的搜索算法执行了2000步(也就是有多少元素就需要对比多少次所以它的复杂度是O(N))，O(log2N)复杂度的搜索算法只执行了11步(也就是把2000个元素每次执行都放弃一半的数据执行11次就找到了数据所以它的时间复杂度是O(log2N))。