Subset Component

HackerRank

You are given an array with n 64-bit integers: $d[0], d[1], \ldots, d[n-1]$.

BIT(x, i) = (x >> i) & 1, where $B(x, i)$ is the i^{th} lower bit of x in binary form. If we regard every bit as a vertex of a graph G, there is an undirected edge between vertices i and j if there is a value k such that BIT(d[k], i) == 1 && BIT(d[k], j) == 1.

For every subset of the input array, how many connected-components are there in that graph?

A connected component in a graph is a set of nodes which are accessible to each other via a path of edges. There may be multiple connected components in a graph.

Example

$d = \{1, 2, 3, 5\}$

In the real challenge, there will be 64 nodes associated with each integer in d represented as a 64 bit binary value. For clarity, only 4 bits will be shown in the example but all 64 will be considered in the calculations.

```
Decimal  Binary Edges   Node ends
d[0] = 1   0001   0
d[1] = 2   0010   0
d[2] = 3   0011   1       0 and 1
d[3] = 5   0101   1       0 and 2
```

Consider all subsets:

```
             Edges
Subset    Count  Nodes   Connected components
{1}         0             64
{2}         0             64
{3}         1    0-1      63
{5}         1    0-2      63
{1,2}       0             64
{1,3}       1    0-1      63
{1,5}       1    0-2      63
{2,3}       1    0-1      63
{2,5}       1    0-2      63
{3,5}       2    0-1-2    62
{1,2,3}     1    0-1      63
{1,2,5}     1    0-2      63
{1,3,5}     2    0-1-2    62
{2,3,5}     2    0-1-2    62
{1,2,3,5}   2    0-1-2    62
Sum                      944
```

The values 3 and 5 have 2 bits set, so they have 1 edge each. If a subset contains only a 3 or 5, there will be one connected component with 2 nodes, and 62 components with 1 node for a total of 63.

If both 3 and 5 are in a subset, 1 component with nodes $0, 1$ and 2 is formed since node 0 is one end of each edge described. The other 61 nodes are solitary, so there are 62 connected components total.

All other values have only 1 bit set, so they have no edges. They have 64 components with 1 node each.

Function Description

Complete the *findConnectedComponents* function in the editor below.

findConnectedComponents has the following parameters:

- *int d[n]:* an array of integers

Returns

- *int:* the sum of the number of connected components for all subsets of d

Input Format

The first row contains the integer n, the size of $d[]$.
The next row has n space-separated integers, $d[i]$.

Constraints

$1 \leq n \leq 20$
$0 \leq d[i] \leq 2^{63} - 1$

Sample Input 0

```
3
2 5 9
```

Sample Output 0

```
504
```

Explanation 0

There are 8 subset of $\{2, 5, 9\}$.

{}
=> We don't have any number in this subset => no edge in the graph => Every node is a component by itself => Number of connected-components = 64.

{2}
=> The Binary Representation of 2 is 00000010. There is a bit at only one position. => So there is no edge in the graph, every node is a connected-component by itself => Number of connected-components = 64.

{5}
=> The Binary Representation of 5 is 00000101. There is a bit at the 0th and 2nd position. => So there is an edge: (0, 2) in the graph => There is one component with a pair of nodes (0,2) in the graph. Apart from that, all remaining 62 vertices are indepenent components of one node each (1,3,4,5,6...63) => Number of connected-components = 63.

{9}
=> The Binary Representation of 9 is 00001001. => There is a 1-bit at the 0th and 3rd position in this

binary representation. => edge: (0, 3) in the graph => Number of components = 63

{2, 5}
=> This will contain the edge (0, 2) in the graph which will form one component
=> Other nodes are all independent components
=> Number of connected-component = 63

{2, 9}
=> This has edge (0,3) in the graph
=> Similar to examples above, this has 63 connected components

{5, 9}
=> This has edges (0, 2) and (0, 3) in the graph
=> Similar to examples above, this has 62 connected components

{2, 5, 9}
=> This has edges(0, 2) (0, 3) in the graph. All three vertices (0,2,3) make one component => Other 61 vertices are all independent components
=> Number of connected-components = 62

$$S = 64 + 64 + 63 + 63 + 63 + 63 + 62 + 62 = 504$$