

Ibirwa Nyaburanga (Aesthetic Islands)

Abategura PAIO bari gutegura urugendo rwo kujya ku Kiyaga cya Kivu, kizwiho kugira ibirwa byinshi byiza. Kugira ngo babitegure neza, bakeneye kumenya umubare nyawo w'ibirwa biri muri kiyaga. Ku bw'amahirwe, baherutse kwakira ishusho ya satellite y'ikarita yi kiyaga.

Ikarita igaragazwa nk'imbonerahamwe (grid) ya $N \times M$. Imirongo (rows) y'ikarita ibarwa kuva kuri 0 kugeza kuri $N - 1$ kuva hejuru kugeza hasi, naho inkingi (columns) z'ikarita zibarwa kuva kuri 0 kugeza kuri $M - 1$ kuva ibumoso kugeza iburyo. Akazu (cell) kari mu murongo i n'inkingi j ($0 \leq i < N, 0 \leq j < M$) kagaragazwa nka (i, j) . Buri kazu kaba karimo 1 niba ari ubutaka, cyangwa 0 niba ari amazi.

Utuzu tubiri tw'ubutaka dufatwa nk'udufatanye (adjacent) niba dusangiye uruhande. Mu yandi magambo, utuzu tubiri tw'ubutaka turafatanye niba kamwe kari hejuru, hasi, ibumoso cyangwa iburyo bw'akandi. Utuzu dukoranaho gusa ku mfuruka ntituba tufatanye.

Ikirwa ni itsinda rinini rishoboka (maximal set) ry'utuzu tw'ubutaka ku buryo buri tuzu tubiri muri iryo tsinda dushobora guhuzwa n'uruhererekane rw'utuzu tw'ubutaka tufatanye. Hano, ijambo 'maximal' risobanura ko nta kandi kazu k'ubutaka gashobora kongerwa muri iryo tsinda ngo iyo miterere ikomeze kubahirizwa.

Urugero, kuri iyi karita ikurikira:

1	0	1
0	1	0
1	0	1

hari ibirwa 5, kuko gukoranaho mu mfuruka (diagonal) bidahuza utuzu tw'ubutaka.

Kuri iyi karita ikurikira:

1	1	0	1
0	1	0	1
0	0	0	0
1	1	1	0

hari ibirwa 3.

Tuzi kandi ko mu Kiyaga cya Kivu, ibirwa byose ari nyaburanga (aesthetic). Ikirwa cyitwa nyaburanga niba, ku tuzu twose tw'ubutaka tubarizwa muri icyo kirwa kandi tukaba duherereye mu murongo umwe cyangwa inkingi imwe, buri kazu kose kari hagati yatwo nako ari ubutaka. Mu

yandi magambo, mu kirwa kimwe, buri murongo na buri nkingi byihariwe n'icyo kirwa biba birimo igice kimwe gikomeje cy'utuzu tw'ubutaka.

Urugero, amakarita akurikira yashoboka ku Kiyaga cya Kivu (ni ukuvuga ko arimo ibirwa nyaburanga gusa):

0	0	1	0	0	1	1	1	1	1
0	1	1	1	0	1	0	0	0	0
1	1	1	1	1	0	1	1	1	0
0	1	1	0	0	1	0	1	0	1
0	1	0	0	0	1	1	0	1	1

Ikarita ya kabiri irimo ibirwa 4, kandi buri kimwe ni nyaburanga.

Nyamara, amakarita akurikira ntiyashoboka ku Kiyaga cya Kivu:

				1	1	1	0	1
1	1	1		1	0	1	0	1
0	1	0		1	0	1	0	0
1	1	1		1	0	1	0	1
				1	1	1	0	1

Abategura amarushanwa bafite uburenganzira bwo gukoresha mudasobwa yihariye ifite akuma kabika amakuru (memory chip) gafite bit K , zibarwa kuva kuri 0 kugeza kuri $K - 1$. Ikarita yamaze kubikwa muri ubwo bubiko. By'umwihariko, agaciro k'akazu (i, j) kabitswe muri bit $i \cdot M + j$ y'ububiko.

Abategura amarushanwa ntibashobora gusoma cyangwa guhindura ububiko mu buryo butaziguye, bityo ntibazi uko ikarita imeze. Ahubwo, binyuze mu bufasha bwawe, bashobora kwinjiza porogaramu muri mudasobwa.

Porogaramu yawe ntiyizi agaciro kabitswe mu bubiko. Izi gusa N , M na K . Inshingano yayo ni ugutanga uruherekane rudahinduka rw'ibikorwa bya bitwise operations mudasobwa izakora nyuma ku bubiko burimo ikarita.

Nyuma y'uko porogaramu yawe irangiye gukora, ibikorwa byasobanuwe bizakorwa ku makuru abitswe mu ibanga mu bubiko. Ku musozo, porogaramu yawe igomba guhitamo amwe muri bit z'ububiko zikoreshejwe (occupied memory bits). Izi bit, zisomwe kuva ku ifite agaciro gato (least significant) kugeza ku ifite agaciro kanini (most significant), zigomba kugaragaza umubare w'ibirwa mu buryo bwa binary nyuma yo gukora porogaramu yawe ku karita k'ibanga kabitswe mu bubiko.

Urasabwa gukora porogaramu isobanura ibikorwa mudasobwa igomba gukora ku bubiko.

Mu ntangiriro, bit $0, 1, \dots, N \cdot M - 1$ zirimo ikarita. Izi bit zamaze gukoreshwa kandi ntizishobora gusimbuzwa andi makuru (cannot be overwritten). Bit zindi zisigaye zose mu ntangiriro ziba zirimo

ubusa (empty).

Mudasobwa ifite amoko 6 y'amabwiriza (instructions) ashobora gukoreshwa muri porogaramu yawe gukora ibikorwa kuri bit z'ububiko. Buri bwiriza ni bitwise operation kuri bit imwe cyangwa ebyiri zinjizwa, maze igisubizo kikabikwa muri bit nshya y'ububiko.

Igihe cyose ibwiriza ritumye havuka bit nshya, mudasobwa iyibika muri bit y'ububiko yambere irimo ubusa ibonetse. Iyo bit ihita ifatwa (occupied) kandi ishobora gukoreshwa nka bit yinjizwa (input bit) mu mabwiriza azakurikira. Buri bit y'ububiko ishobora kubikwamo inshuro imwe gusa.

Amabwiriza 6 aboneka asobanuwe hano hasi. Nyuma yo kwakira buri bwiza, mudasobwa ibanza gukora bit nshya C ($0 \leq C < K$), ari yo bit ya mbere y'ububiko irimo ubusa. Kuri index ya bit X , reka $memory[X]$ igaragaze agaciro kabitswe muri bit X y'ububiko.

- $and(A, B)$: Ifata bitwise-AND ya bit zifite index A na B ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 1$ niba yaba $memory[A]$ na $memory[B]$ zombi ari 1, naho ubundi igashyiraho $memory[C] := 0$. Function igatanga C .
- $or(A, B)$: Ifata bitwise-OR ya bit zifite index A na B ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 1$ niba nibura imwe hagati ya $memory[A]$ na $memory[B]$ ari 1, naho ubundi igashyiraho $memory[C] := 0$. Function igatanga C .
- $xor(A, B)$: Ifata bitwise-XOR ya bit zifite index A na B ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 1$ niba imwe gusa hagati ya $memory[A]$ na $memory[B]$ ari 1, naho ubundi igashyiraho $memory[C] := 0$. Function igatanga C .
- $not(A)$: Ifata bitwise-NOT ya bit ifite index A ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 1 - memory[A]$. Function igatanga C .
- $nand(A, B)$: Ifata bitwise-NAND ya bit zifite index A na B ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 0$ niba yaba $memory[A]$ na $memory[B]$ zombi ari 1, naho ubundi igashyiraho $memory[C] := 1$. Function igatanga C .
- $nor(A, B)$: Ifata bitwise-NOR ya bit zifite index A na B ikayibika muri bit C y'ububiko. Mu yandi magambo, ishyiraho $memory[C] := 0$ niba nibura imwe hagati ya $memory[A]$ na $memory[B]$ ari 1, naho ubundi igashyiraho $memory[C] := 1$. Function igatanga C .

Mudasobwa izakora ibikorwa byasobanuwe mu nkurikirane yatanze na porogaramu yawe. musozo, amwe muri bit z'ububiko zakoreshejwe zahiswemo na porogaramu yawe zigomba kuba zifite binary representation of the number y'umubare w'ibirwa biri ku karita.

Uburyo bwo Kubishyira mu Bikorwa (Implementation Details)

C++/Python Interface

Ku byoherezwa mu rurimi rwa C++/Python, ugomba gukora iyi porosedire(procedure) ikurikira:

```
int32[] construct_instructions(int32 N, int32 M, int32 K)
```

- N : umubare w'imirongo(number of rows)
- M : umubare w'inkingi(number of columns)
- K : umubare wa bit mu kuma kabika amakuru(number of bits in the memory chip)
- Iyi porosedire(procedure) ihamagarwa inshuro imwe gusa kandi igomba gutegura uruhererekane rw'amabwiriza yo gukora inshingano isabwa.
- Porosedire(procedure) igomba gusubiza urutonde (array) V rurimo index z'ububiko zibitse igisubizo, kuva kuri bit ifite agaciro gato (least significant bit) kugeza ku ifite agaciro kanini (most significant bit).. Mu yandi magambo, reka l ibe uburebure bwa V . Umubare w'ibirwa ku karita ugomba kuba ungana na $2^0 \cdot memory[V[0]] + 2^1 \cdot memory[V[1]] + \dots + 2^{l-1} \cdot memory[V[l-1]]$.
- Buri index ya bit muri V igomba kugendera(refer) kuri bit yakoreshejwe (occupied bit).
- Uburebure bwa V ntibugomba kurenga 20.

Iyi porosedire(procedure) igomba guhamagara izi porosedire(procedure) zikurikira kugira ngo itegure uruhererekane rw'amabwiriza:

```
int32 append_and(int32 A, int32 B)
int32 append_or(int32 A, int32 B)
int32 append_xor(int32 A, int32 B)
int32 append_not(int32 A)
int32 append_nand(int32 A, int32 B)
int32 append_nor(int32 A, int32 B)
```

- Buri porosedire yongeraho ibwiriza rya *and, or, xor, not, nand* cyangwa *nor* muri porogaramu, mu buryo bukurikirana.
- Kuri `append_not`, A igomba kuba ari bit yakoreshejwe. Kuri buri imwe muzindi porosedire eshanu zisigaye, yaba A ndetse na B zigomba kuba bit zakoreshejwe.
- Buri porosedire(procedure) itanga index y'ububiko aho bit yakozwe izabikwa.

Ushobora kandi guhamagara porosedire ikurikira kugira ngo igufashe kugerageza (test) igisubizo cyawe:

```
void append_print(string label, int32[] A)
```

- Buri index yoherejwe muri A kuri `append_print` igomba kugendera(refer) kuri bit yakoreshejwe.
- Ihamagarwa iryo ari ryo ryose ry'iyi porosedire(procedure) rizirengagizwa mu gihe cyo gukosora (grading) igisubizo cyawe kandi ntirizabarwa nk'ibwiriza.
- Muri porogaramu ikosora y'icyitegererezo (sample grader), iyi porosedire yongeraho igikorwa cya `print(label, A)` muri porogaramu.
- Iyo porogaramu ikosora ihuye n'igikorwa cya `print(label, A)` mu gihe irimo gukora porogaramu(during the execution of a program), yandika *label* igakurikirwa n'ibirimo muri index za bit z'urutonde A ku murongo umwe mu nkurikirane imwe zigaragaramo muri A (reba igice cya "Sample Grader" ku bindi bisobanuro).

C Interface

u byoherezwa mu rurimi rwa C, shyiramo header yatanze `islands_c.h` hanyuma ukore:

```
int construct_instructions(int N, int M, int K, int answer_bits[]);
```

Porogaramu ikosora(grader) itanga `answer_bits`, urutonde rufite ubushobozi (capacity) `ISLANDS_MAX_ANSWER_BITS` (20). Andika index za V , kuva kuri bit ifite agaciro gato(least significant bit) kugeza ku ifite agaciro kanini(most significant bit), muri `answer_bits[0]`, `answer_bits[1]`, n'ibindi, kandi igatanga umubare l wa index zanditswe. Bityo, $V[i] = \text{answer_bits}[i]$ kuri $0 \leq i < l$. Igisubizo kibonetse kigomba kubahizira $0 \leq l \leq 20$. Ntukandike hejuru y'ubushobozi bwa `answer_bits` kandi ntukabohore uru rutonde (do not free) kuko rucungwa na porogaramu ikosora.

Mu rurimi rwa C, imiterere nyayo (signature) ya porosedire yo gukemura amakosa (debugging) ni:

```
void append_print(const char *label, const int A[], int length);
```

Hano, `label` igomba kwerekana urutonde rw'inyuguti rurangizwa na null (null-terminated string), kandi `length` ni umubare wa element ebyiri muri A kandi ntiugomba kuba muni ya zeru (nonnegative). A ishobora kuba `NULL` gusa iyo `length` ari 0.

Gukosora igisubizo cyawe bishobora kuvamo bumwe mu butumwa bw'amakosa bukurikira:

- `Invalid index`: index ya bit itari yo (ishobora kuba muni ya zeru) yatanze nka parameter A cyangwa B mu guhamagara kumwe kwa imwe muri porosedire cyangwa yashyizwe mu gisubizo cyakozwe na `construct_instructions(N, M, K)`.
- `Too many instructions`: nta bit z'ububiko zihagije zo kubika ibisubizo by'amabwiriza. Mu yandi magambo, wakoresheje amabwiriza arenze $K - N \cdot M$.
- `Too many bits in the answer`: `construct_instructions` hakoze bit zirenze 20 ku gisubizo.

Niba porogaramu itatanze ubutumwa bw'amakosa ubwo aribwo bwose kandi ikabara umubare nyawo w'ibirwa, porogaramu yawe izafatwa nk'Iyemewe (Accepted) kandi amanota yawe azabarwa hakurikijwe umubare w'amabwiriza akoreshejwe (reba Subtasks). Naho ubundi, izafatwa nk'Igisubizo Kitari cyo (Wrong Answer).

Ingero

Urugero rwa 1

Dufate ko $N = 1$, $M = 2$ na $K = 10^7$.

Hari amakarita ane gusa ashoboka yakwinjizwa muri porogaramu:

- Case 1: 0 0
- Case 2: 0 1
- Case 3: 1 0
- Case 4: 1 1

Dushobora kubona ko mu bibazo byose, umubare w'ibirwa ungana na 1 niba yaba akazu (0,0) cyangwa (0,1) ari akazu k'ubutaka. Kubera iyo mpamvu, igisubizo gishoboka kuri $N = 1$ na $M = 2$ ni ugutegura porogaramu ukoresheje ibwiriza rimwe rya *or*:

- `append_or(0, 1)`, rizafata bitwise-OR y'utuzu (0,0) na (0,1) tw'ikarita tubitswe muri bit 0 na 1 y'ububiko mu buryo bukurikirana, hanyuma rikayibika muri bit 2 y'ububiko.

Nyuma y'ibyo, uruhererekane rw'igisubizo rwakozwe na `construct_instructions` ni [2], kuko bit 2 y'ububiko yazaba irimo 1 niba hari ikirwa 1 neza neza ku karita, naho ubundi ikaba 0.

Urugero rwa 2

For $N = 5$, $M = 5$, $K = 10^7$ n'ikarita ikurikira:

1	1	1	1	1
1	0	0	0	0
0	1	1	1	0
1	0	1	0	1
1	1	0	1	1

Umubare w'ibirwa ni 4. Kubera iyo mpamvu, iyo porogaramu yawe idahinduka ikozwe kuri aka gaciro(values), bit zifite index zatanze na `construct_instructions` zigomba kuba zirimo 0, 0 na 1 muri iyi nkurikirane kuko binary representation ya 4 ni 100_2 .

Imipaka (Constraints)

- $1 \leq N, M \leq 32$
- $K = 10^7$

- Buri kazu k'ikarita kaba ari 0 cyangwa 1
- Ibirwa byose ni nyaburanga. Mu yandi magambo, ku tuzu tw'ubutaka twose tubarizwa mu kirwa kimwe kandi tuherereye mu murongo(row) umwe cyangwa inkingi(column) imwe, buri kazu kose kari hagati yatwo nako kaba ari ubutaka.

Igice cy'igikorwa(Subtasks)

1. (Amanota 40) Buri kirwa kigizwe n'akazu kamwe gusa k'ubutaka.
2. (Amanota 20) Kuri buri kirwa, habaho imirongo(rows) r_1, r_2 n'inkingi(columns) c_1, c_2 ku buryo icyo kirwa kigizwe neza n'utuzu twose (i, j) aho $r_1 \leq i \leq r_2$ na $c_1 \leq j \leq c_2$. Mu yandi magambo, buri kirwa gikora urukiramende(urukiramende) rwuzuye rw'utuzu tw'ubutaka.
3. (Amanota 40) Nta yandi mabwiriza ntarengwa.

Dufate ko porogaramu yawe yemejwe (Accepted), kandi igakoresha amabwiriza I . Noneho, amanota yawe P kuri icyo testcase, bitewe na numero y'icyiciro cy'ikibazo, abarwa mu buryo bukurikira:

- Subtask 1:
 - Niba $I \leq 5\,030$, $P = 40$.
 - Niba $5\,030 < I \leq 10\,760$, $P = 22 + 18 \cdot \frac{10\,760 - I}{5\,730}$.
 - Niba $10\,760 < I \leq 22\,530$, $P = 12 + 10 \cdot \frac{22\,530 - I}{11\,770}$.
 - Naho ubund, $P = 8$.
- Subtask 2:
 - Niba $I \leq 62\,000$, $P = 20$.
 - Naho ubund, $P = 8$.
- Subtask 3:
 - Niba $I \leq 9\,100$, $P = 40$.
 - Niba $9\,100 < I \leq 15\,880$, $P = 22 + 18 \cdot \frac{15\,880 - I}{6\,780}$.
 - Niba $15\,880 < I \leq 27\,650$, $P = 13 + 9 \cdot \frac{27\,650 - I}{11\,770}$.
 - Naho ubund, $P = 10$.

Sample Grader

Porogaramu ikosora(grader) isoma ibyinjizwa mu miterere ikurikir

- umurongo 1: $N\ M\ K$

Ibi bikurikirwa na test cases. buri test igizwe n'imirongo N :

- umurongo i ($0 \leq i < N$): $g[i][0]\ g[i][1]\ \dots\ g[i][M - 1]$ ((bitandukanijwe n'umwanya/space))

aho $g[i][j]$ ($0 \leq i < N, 0 \leq j < M$) dyerekana ibirimo mu kazu (i, j) k'ikarita.

Ibisobanuro by'ibibazo byose bikurikirwa n'umurongo umwe wenyine urimo -1 .

Porogaramu ikosora (grader) ibanza guhamagara `construct_instructions` ikoresheje imiterere (signature) ya `submission language`. Niba uku guhamagara kwishe rimwe mu mabwiriza asobanuwe mu kibazo, porogaramu ikosora, yandika bumwe mu butumwa bw'amakosa bugaragara ku mpera y'igice cya "Implementation Details" hanyuma igahagarara (exits).

Naho ubundi, porogaramu ikosora i processinga testcase mu nkurikirane. uri buri kibazo, ikoresha porogaramu yakozwe na `construct_instructions` kuri testcase yinjijwe

Kuri buri bwiriza rya $print(label, A)$, reka l ibe uburebure bwa A , porogaramu ikosora yandika ibirimo muri index za bit ziri muri A mu miterere ikurikira:

- $label: memory[A[0]] \ memory[A[1]] \ \dots \ memory[A[l-1]]$

Iyo amabwiriza yose amaze gukorwa, porogaramu ikosora (grader) yandika umubare wa binary wakoze n'uruhererekane rw'igisubizo V rwatanzwe na porogaramu yawe kuri buri testcase. Mu yandi magambo, kuri buri testcase, reka l ibe uburebure bwa V , porogaramu ikosora (grader) yandika $2^0 \cdot memory[V[0]] + 2^1 \cdot memory[V[1]] + \dots + 2^{l-1} \cdot memory[V[l-1]]$.

Nyuma yo executing test cases zose, porogaramu ikosora yandika `number of instructions: X` aho X ari umubare w'amabwiriza muri porogaramu yawe.