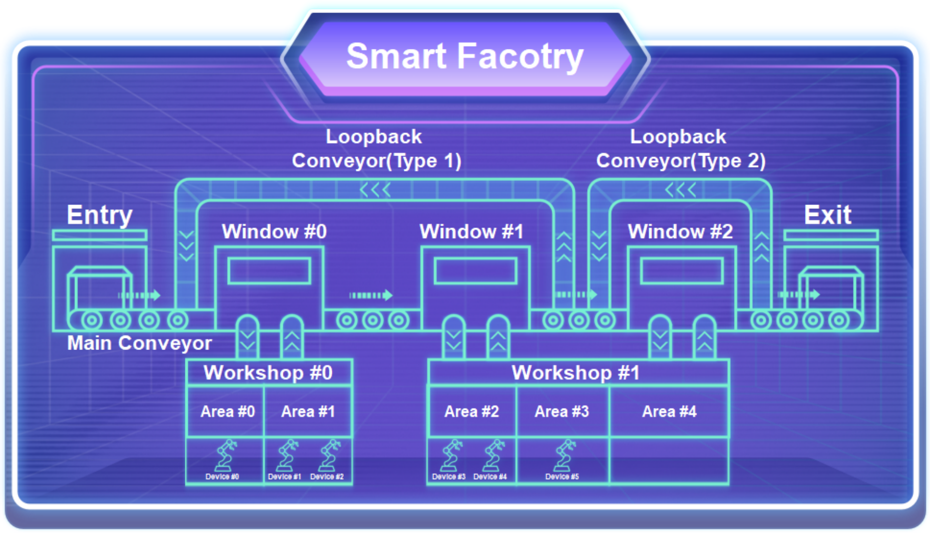
Final Supplement

(Add rules based on the preliminaries)
(The blue ones are changes)

[Context]

Now we have arrived in 2050 on a time machine. After retirement, Davis opened a smart factory that uses a set of processing devices to supports thousands of production lines. Now that the site and the devices are ready. Davis invites you to help plan the installation positions of the devices to realize an optimal installation cost and delivery speed.



[Factory Overview]

After materials are placed at a unique ingress of the smart factory, conveyor belts transport the materials to devices in sequence for processing. The finished product is sent to a unique egress.

The factory has only one main conveyor belt from left to right, with many **windows** alongside. After entering a window, the materials reach a **workshop**. One workshop can be connected to multiple windows. Each workshop is divided into several **workshop areas**, and you need to select a workshop area for each device to install. The conveyor belt controls the materials to pass through these windows in sequence. After arriving at a window, materials can either bypass the window or enter it for processing in the corresponding workshop. After processing, the materials come out of the window and go on to the next window.

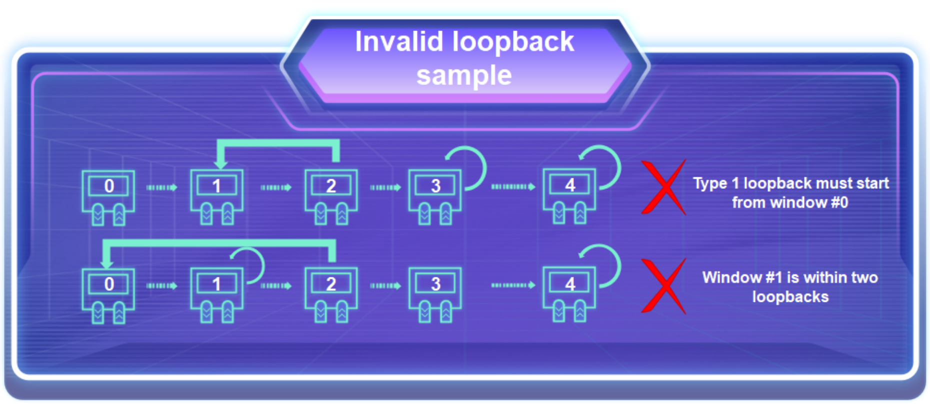
[Production Line]

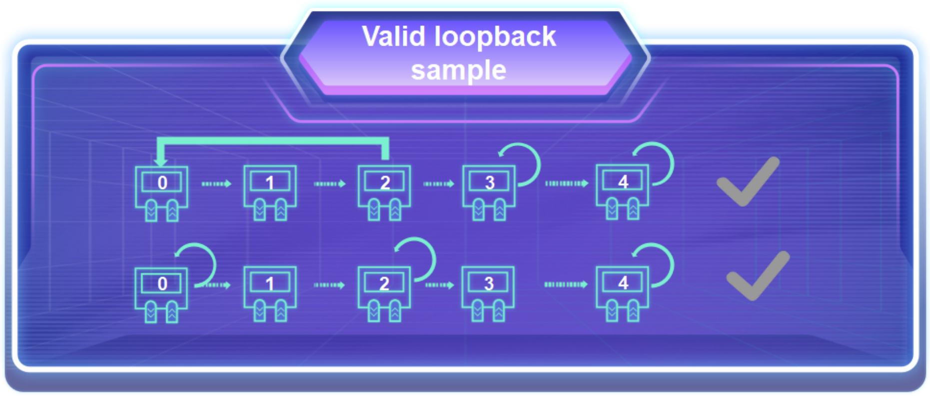
A **production line** describes the route from materials to finished products. It consists of a group of devices (at least two) in sequence. The smart factory needs to support multiple production lines.

[Loopback conveyor belt]

The main conveyor belt can only go from left to right. To support a longer production line with a limited number of windows, there are some loopback conveyor belts on the main conveyor belt. If a material needs to pass the same processing window for multiple times, the factory intelligently controls the material to enter the loopback conveyor belt. However, for efficiency consideration, the number of loopbacks is limited.

The loopback conveyor belts are preset and do not need to be planned by participants. There may be multiple loopbacks, but only two loopback modes are available. In the first mode, multiple windows are looped back, but the loopback must start from window #0. In the second mode, only one window is looped back. The first loop can be in either of the two modes, and the subsequent loops can only be in the second mode. One window can be in only one loop.





[Window Matching Schemes]

A window matching scheme is the sequence in which a material enters a group of windows. As shown in the first figure, if a maximum of one loopback is supported, the following matching schemes are available:

1. Scheme using 2 windows: 0→0, 0→1, 0→2, 1→0, 1→1, 1→2, 2→2
2. Scheme using 3 windows: 0→0→1, 0→0→2, 0→1→0, 0→1→1, 0→1→2, 1→0→1, 1→0→2, 1→1→2, 1→2→2
3. Scheme using 4 windows: 0→0→1→2, 0→0→2→2, 1→0→1→2, 1→0→2→2, 1→1→2→2
4. Scheme using 5 windows: 0→0→1→2→2, 0→1→0→1→2, 0→1→0→2→2, 0→1→1→2→2, 1→0→1→2→2
5. Scheme using 6 windows: 0→1→0→1→2→2

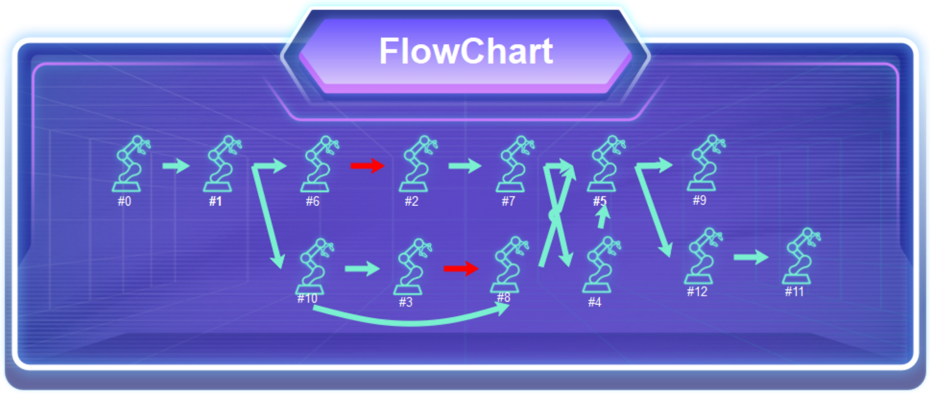
The prerequisite for the smart factory to run a production line is that there is at least one window matching scheme.

[Flowchart]

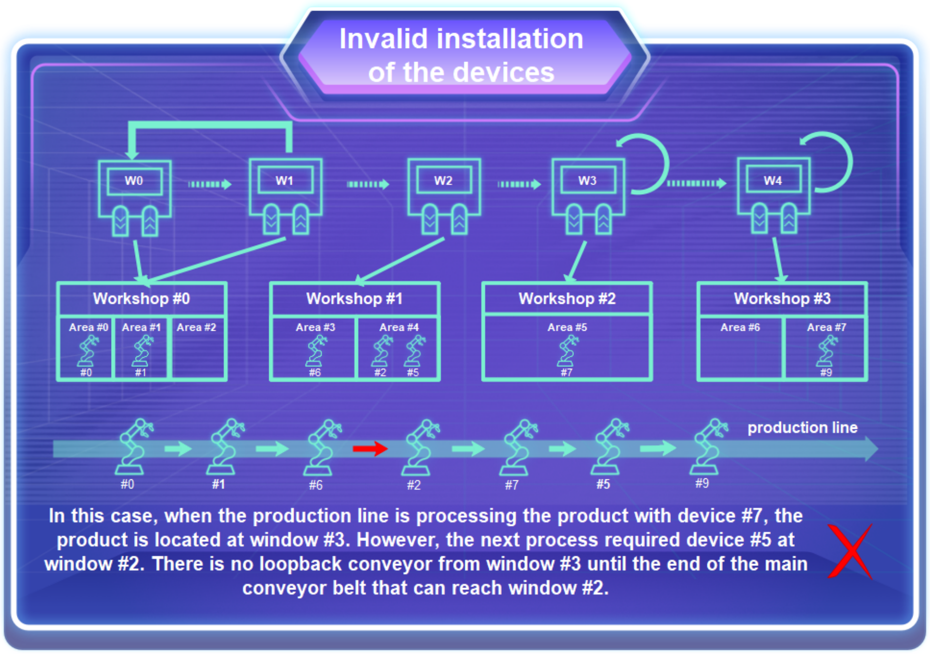
A **flowchart** describes the processing sequence requirements of all devices. It is a directed acyclic graph with no repeated edges. There are two types of edges:

1. The cyan edge (edge weight = 0) indicates the dependency relationship, in which a material must enter two different windows, and be processed by two devices each in one window in sequence.

2. The red edge (edge weight = 1) indicates the collaboration relationship, in which a material enters one window, and is then processed by two devices placed in the same workshop concurrently or in sequence.



A path with a length greater than 1 between any two devices is a production line. The smart factory must support all production lines. Each device is unique and can be installed in only one workshop area. Before the smart factory starts to work, all devices must be installed. If devices are not properly installed, the next device may be installed in workshop X which cannot be reached by a material from any subsequent windows along the production line. Therefore, you must ensure that all production lines have corresponding window matching schemes after the devices are installed.

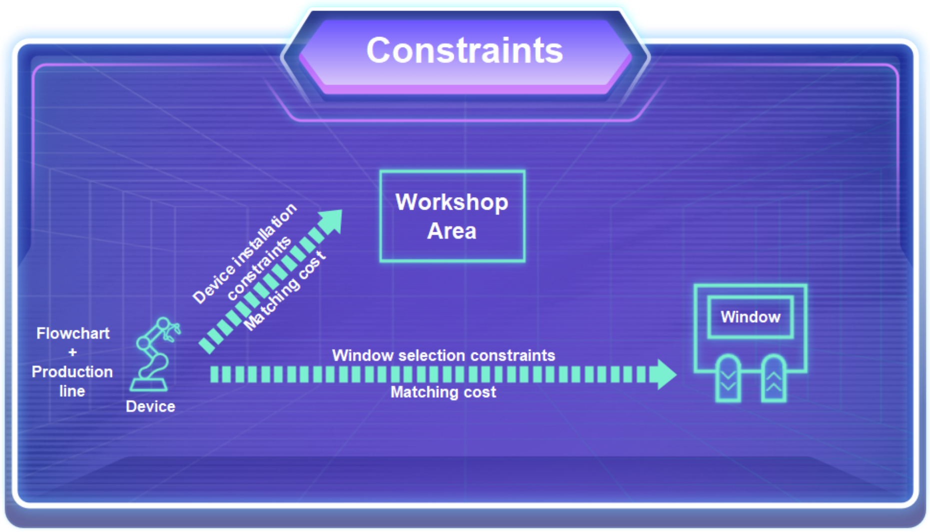


Among the many production lines, one core production line is most frequently used. To improve efficiency, a window matching scheme needs to be specially preset for the core production line before the factory starts working.

[Task Description]

Given a set of windows, a set of workshop areas, a set of devices, a flowchart between devices, and multiple core production line, you need to select a workshop area for each device in compliance with the matching constraints, so that the smart factory can process all production lines. On this basis, design a window matching scheme for each core production line to minimize the total matching cost.

(An device can select different windows on different production lines)



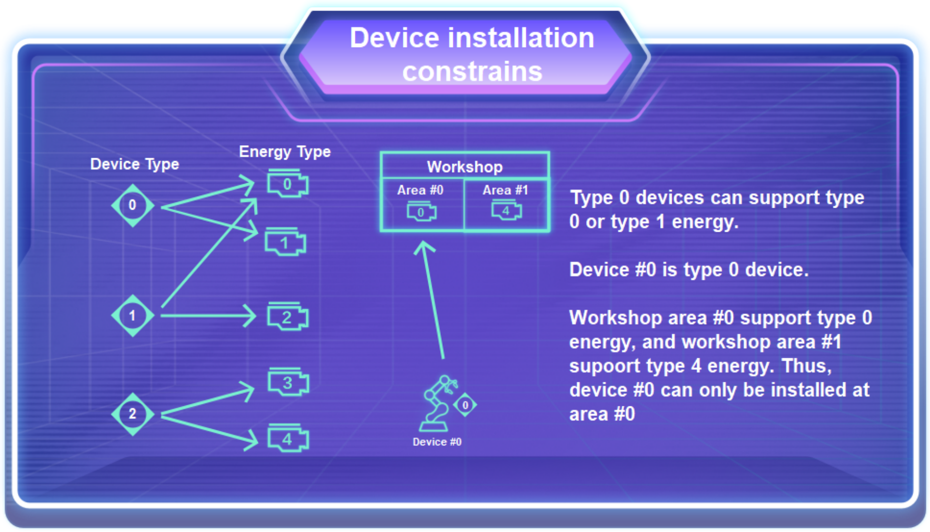
[Device Installation Constraints]

There are five energy sources, one for each workshop area. A workshop area can install an limited number of devices. Devices are divided into three different types. Each type of device can use two energy sources.

1. Device type-0: energy-0, energy-1
2. Device type-1: Energy-0, Energy-2
3. Device type-2: energy-3, energy-4

An device can be installed in a workshop area only if the area has at least one energy source applicable to the device.

Each workshop area has its own upper limit of power supply. Each device uses different energy sources with its own energy consumption. The sum of energy consumption of all devices installed in a workshop area cannot exceed the upper limit of power supply in this workshop area.



[Window Selection Constraints]

To improve the processing efficiency of the core production line, pre-processing is required for each window entry. The type of pre-processing varies with the device type. Each window can provide pre-processing for 1–2 types of devices. In this pre-set scheme, the premise that a window matches an device is that the window can provide pre-processing for the device.

[Matching Cost 1] Areas and Devices

Installing an device in a workshop area generates a certain amount of cost which varies with the device and energy type.

[Matching Cost 2] Windows and Devices

Device processing requires processing time. The processing time varies with the energy type, but is the same for different devices using the same type of energy. In all preset matching schemes, if a window is entered for multiple times, to unify the processing pace of the window, the maximum processing time is considered as the window processing time. Each time a material enters a window for processing, the time consumed is the window processing time. The total processing time is the sum of window processing time of all windows entered.

Window pre-processing generates a certain amount of pre-processing cost. The longer the window processing time, the higher the cost. Each window has a cost coefficient.

$PreProcessingCost = WindowProcessingTime * WindowCostCoefficient$

For the ith core pipeline, the predicted production times are recorded as K_i, and the number of times enter the jth window is recorded as C_{ij}.

$$MatchingCostOfEachWindow[j] =$$
$$WindowProcessingTime[j] * (\sum (K_i * C_{ij}) + WindowCostCoefficient[j])$$

(Note that these C_{ij} is calculated according to the player's scheme.)

[Scoring Mechanism]

$$TestCaseScore = \sum MatchingCostOfAreaAndDevice$$
$$+ \sum MatchingCostOfWindowAndDevice$$

Input (All Integers)

(Note that there is a number K at the beginning of the input. Now, each core production line has a number K_i. Therefore, the input is moved to the bottom.)

Description	Data Scope
Processing time of an device using five types of energy	$[1, 2000]$
Number of workshops (N)	$[1, 100]$
Number of workshop areas (R)	$[N, N * 5]$
Workshop ID of a workshop area	$[0, N - 1]$
Energy type of a workshop area.	$[0, 4]$
Upper limit of energy consumption in the workshop area.	$[1, 100]$
Maximum number of loopbacks (L)	$[1, 10]$
Number of windows in the first loopback mode	$[0, 100]$
Number of windows (W)	$[1, 100]$
Self-loopback (0: no; 1: yes)	*bool*
Subscript of a workshop connected to a window	$[0, N - 1]$
Window cost coefficient	$[1, 10000]$
Pre-processing capability array of a window for three devices(0: not supported; 1: supported)	$Bool * 3$

Description	Data Scope
Number of devices (D)	$[1, 1000]$
Device type	$[0, 3]$
Installation cost array of the five types of energy used by devices	$[1, 1billion] * 5$
Energy consumption array of the five types of energy used by devices.	$[1, 100] * 5$
Number of edges in a flowchart (E)	$[2, 1000]$
Edge type	$[0, 1]$
Subscript of the source device of an edge	$[0, D - 1]$
Subscript of the target device of an edge	$[0, D - 1]$
Number of core production lines(T)	$[2, 10]$
Estimated number of production times of the core production line (K_i)	$[1, 1million]$
Number of edges in a production line (F)	$[2, 100]$
Subscript array of production line edges	$[0, E - 1]$

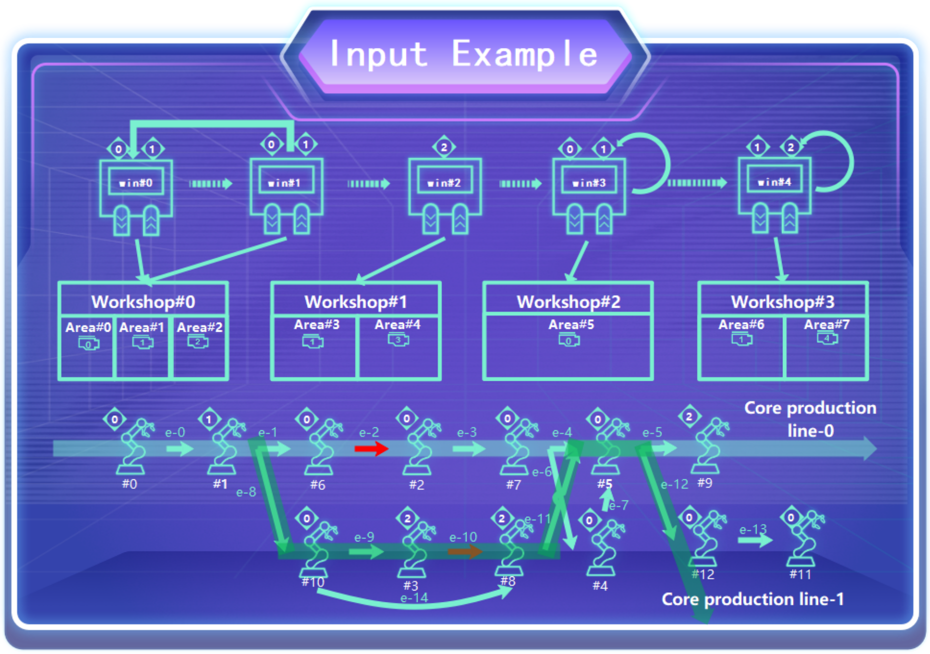
Output (All Integers)

Description	**Data Scope**
Number of devices (D)	$[1, 1000]$
Subscript array of the workshop area where an device is installed	$[0, R-1] * D$
Number of core production lines	$[2, 10]$
Number of steps in a production line (F+1)	$[3, 101]$
Subscript array of production line windows	$[0, W-1] * (F+1)$

Input example:

Description	**Data**
Processing time of an device using five types of energy	62 218 242 398 242
Number of workshops (N)	4
Number of workshop areas (R)	8
8 lines in total 3 digits in each line for one area: Digit 1: Subscript of the workshop; Digit 2: Energy type; Digit 3: Upper Limit on Energy Consumption;	0 0 10 0 1 20 0 2 30 1 1 40 1 3 50 2 0 10 3 1 20 3 4 30
Maximum number of loopbacks (L)	1
Number of windows in the first loopback mode	2
Number of windows	5
5 lines in total. 6 digits in each line for one window: Digit 1: whether self-loopback is supported; Digit 2: subscript of the connected workshop; Digit 3: window cost coefficient; Digits 4–6: pre-processing capability of a window for three types of devices;	0 0 1024 1 1 0 0 0 1480 1 1 0 0 1 1600 0 0 1 1 2 2048 1 1 0 1 3 2048 1 0 1
Number of Devices	13
13 lines in total. 11 digits in each line for one device: Digit 1: Device type; Digits 2 $\rightarrow$ 6: Installation cost of five types of energy; Digits 7 $\rightarrow$ 11: Energy consumption using 5 energy sources;	0 262144 262144 0 0 0 5 5 0 0 0 1 3014656 0 1146880 0 0 5 0 5 0 0 0 67108864 524288 0 0 0 5 5 0 0 0 2 0 0 0 851968 184680448 0 0 0 5 5 0 262144 262144 0 0 0 5 5 0 0 0 0 65536 65536 0 0 0 5 5 0 0 0 0 49152 49152 0 0 0 5 5 0 0 0 0 67108864 524288 0 0 0 5 5 0 0 0 2 0 0 0 983040 218234880 0 0 0 5 5 2 0 0 0 983040 218234880 0 0 0 5 5 0 524288 524288 0 0 0 5 5 0 0 0 0 262144 262144 0 0 0 5 5 0 0 0 0 2097152 524288 0 0 0 5 5 0 0 0

Description	**Data**
Number of edges in a flowchart	15
15 lines in total. 3 digits in each line for one edge: Digit 1: edge type; Digit 2: subscript of the previous device; Digit 3: subscript of the next device;	0 0 1 0 1 6 1 6 2 0 2 7 0 7 5 0 5 9 0 7 4 0 4 5 0 1 10 0 10 3 1 3 8 0 8 5 0 5 12 0 12 11 0 10 8
Number of core production lines(T)	2
T lines in total. $(2 + F_i)$ digits in each line for one production line: Digit 1: Estimated number of productions(K_i); Digit 2: Number of edges of the production line(F_i); Digit 3 $\rightarrow (2 + F)$: Subscript of the next device;	100000 6 0 1 2 3 4 5 90000 5 8 9 10 11 12



This is the only picture that's been altered.

Output example:

Description	Data
Number of devices	13
Subscript array of the workshop area where an device is installed	0 2 1 4 3 5 1 1 4 7 1 6 6
Number of core production lines(T)	2
T lines in total. $(2 + F_i)$ digits in each line for one production line: Number of steps in a production line$(F_i + 1)$ Subscript array of production line windows	7 0 1 0 0 1 3 4 6 0 1 2 2 3 4

Energy Consumption Constraints:

Workshop Area	0	1	2	3	4	5	6	7
Energy Limit	10	20	30	40	50	10	20	30
Installed Instruments	0	2	1,6,7,10	4	3,8	5	11,12	9
Actual Energy	5	10	20	5	10	5	10	5

Test case score:

Device	**Area**	**Window for production line 0**	**Window for production line 1**	**Processing time**	**Installation cost**
0	0	0		62	262144
1	2	1	0	242	1146880
2	1	0		218	524288
3	4		2	398	851968
4	3			218	262144
5	5	3	3	62	65536
6	1	0		218	49152
7	1	1		218	524288
8	4		2	398	983040
9	7	4		242	218234880
10	1		1	218	524288
11	6			218	262144
12	6		4	218	524288
Total					224215040

Window	**Window processing time**	**Entry times for production line 0**	**Entry times for production line 1**	**Cost coefficient**	**Preset Fee**
0	242	2	1	1024	247808
1	242	2	1	1480	358160
2	398		1	1600	636800
3	62	1	1	2048	126976
4	242	1	1	2048	495616
Total					1865360

$TotalCost = 224215040 + 1865360 + 1272 * 100000 + 1186 * 90000 = 460020400$