Presentation

- Bruteforce algorithm
    - Time complexity is exponential: **O(2^N)**.
      The number of combinations is 2^N which N is the number of stocks.
    - Space complexity is linear: **O(N)**.
      Memory is allocated for each recursion needed to compute a combination.

	A	B
1	0	0
2	0	1
3	1	0
4	1	1

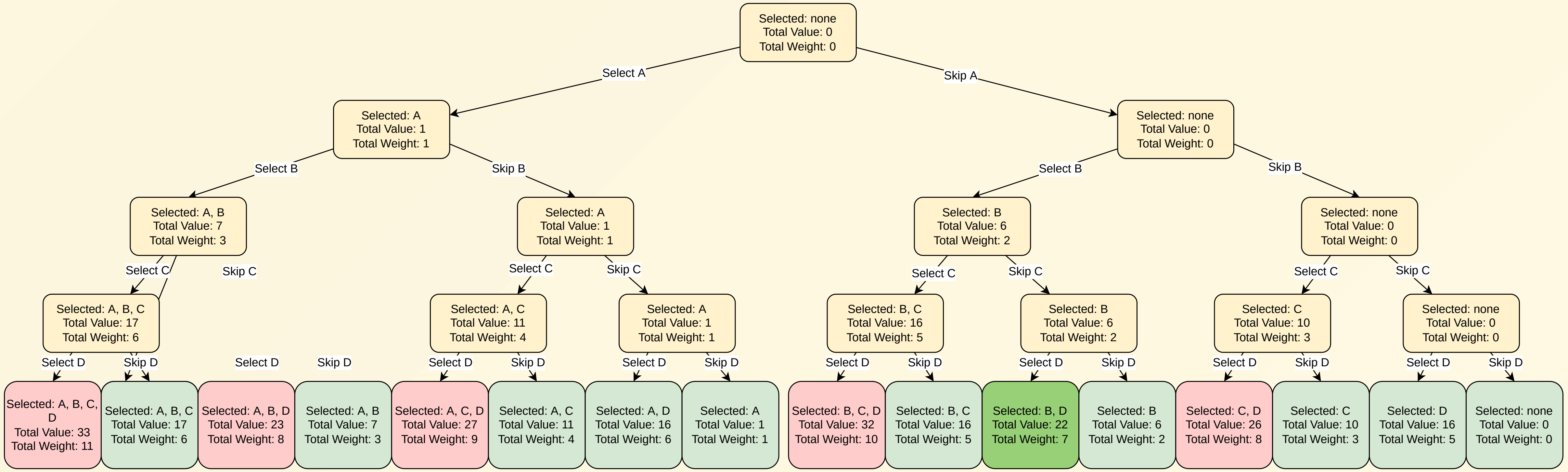
	A	B	C
1	0	0	0
2	0	0	1
3	0	1	0
4	0	1	1
5	1	0	0
6	1	0	1
7	1	1	0
8	1	1	1

N	2^N
0	1
1	2
2	4
3	8
4	16
18	262144
19	524288
20	1048576

- Bruteforce visual representation

Item:	Item A	Item B	Item C	Item D
Value:	1	6	10	16
Weight:	1	2	3	5

Capacity: 7


Selected: none Total Value: 0 Total Weight: 0
Select A
Skip A
Selected: A Total Value: 1 Total Weight: 1
Selected: none Total Value: 0 Total Weight: 0
Select B
Skip B
Select B
Skip B
Selected: A, B Total Value: 7 Total Weight: 3
Selected: A Total Value: 1 Total Weight: 1
Selected: B Total Value: 6 Total Weight: 2
Selected: none Total Value: 0 Total Weight: 0
Select C
Skip C
Select C
Skip C
Select C
Skip C
Select C
Skip C
Selected: A, B, C Total Value: 17 Total Weight: 6
Selected: A, C Total Value: 11 Total Weight: 4
Selected: A Total Value: 1 Total Weight: 1
Selected: B, C Total Value: 16 Total Weight: 5
Selected: B Total Value: 6 Total Weight: 2
Selected: C Total Value: 10 Total Weight: 3
Selected: none Total Value: 0 Total Weight: 0
Select D
Skip D
Select D
Skip D
Select D
Skip D
Select D
Skip D
Select D
Skip D
Select D
Skip D
Select D
Skip D
Select D
Skip D
Selected: A, B, C, D Total Value: 33 Total Weight: 11
Selected: A, B, C Total Value: 17 Total Weight: 6
Selected: A, B, D Total Value: 23 Total Weight: 8
Selected: A, B Total Value: 7 Total Weight: 3
Selected: A, C, D Total Value: 27 Total Weight: 9
Selected: A, C Total Value: 11 Total Weight: 4
Selected: A, D Total Value: 16 Total Weight: 6
Selected: A Total Value: 1 Total Weight: 1
Selected: B, C, D Total Value: 32 Total Weight: 10
Selected: B, C Total Value: 16 Total Weight: 5
Selected: B, D Total Value: 22 Total Weight: 7
Selected: B Total Value: 6 Total Weight: 2
Selected: C, D Total Value: 26 Total Weight: 8
Selected: C Total Value: 10 Total Weight: 3
Selected: D Total Value: 16 Total Weight: 5
Selected: none Total Value: 0 Total Weight: 0

```python
def bruteforce(value, stocks, picked=[]):
    if stocks:
        # recursively call bruteforce and start to evaluate possibilities from the last item in stocks
        # 1st possibility: skip the stock
        x, combi1 = bruteforce(value, stocks[1:], picked)

        pick = stocks[0]
        if pick[1] <= value:
            # second possibility: pick the stock
            # update new value
            y, combi2 = bruteforce(value - pick[1], stocks[1:], picked + [pick])

            # return the combination with the best profit
            if x < y:
                return y, combi2
        return x, combi1
    else:
        return sum(i[2] for i in picked), picked
```

- Optimized algorithm
  - Time complexity is: **O(m * N)**.
    The numbers of subproblems which m represents every possible value (or capacity) and N the number of items.
  - Space complexity is: **O((m+1) * (N+1))**.
    The size of the matrix containing each subproblems.

Avoid redundant events by breaking them in subproblems so don't need to calculate all the possibilities.
Start from the simpliest to the most complex event.
Each computation is incremental.

- Optimized algorithm visual representation

	Price	Profit	0	1	2	3	4	5
None			0	0	0	0	0	0
A	4	12	0	0	0	0	12	12
B	3	10	0	0	0	10	12	12
C	2	6	0	0	6	10	12	16

```python
def optimized(value, stocks):
    # Build a matrix of possible solutions
    value = trunc(value)
    m = [[0 for column in range(value + 1)] for line in range(len(stocks) + 1)]

    # Start from index 1 because no solutions in first line and first column (fill with 0's)
    # Iterate for each stock
    for ln in range(1, len(stocks) + 1):
        # Iterate for each possible value
        for col in range(1, value + 1):
            # if stock price is less or equals to actual value, pick it
            # otherwise skip it, optimized profits is same as previous stock
            if stocks[ln - 1][1] <= col:
                # compare optimized profits of actual value for previous stock with
                # (stock profit + optimized profits for previous stock of [value = actual value - stock value])
                m[ln][col] = max(stocks[ln - 1][2] + m[ln - 1][col - trunc(stocks[ln - 1][1])], m[ln - 1][col])
            else:
                m[ln][col] = m[ln - 1][col]

    v = value
    n = len(stocks)
    picked = []

    # Retrieve picked stocks from the last stock in the matrix until value is zero
    while v >= 0 and n >= 0:
        p = stocks[n - 1]
        # Optimized profit is equals to stock profit + optimized profits for previous stock of [value = actual value - stock value]
        if m[n][trunc(v)] == m[n - 1][trunc(v - p[1])] + p[2]:
            picked.append(p)
            v -= p[1]
        n -= 1
    return m[-1][-1], picked
```

- Bruteforce vs. Optimized ?

For m = 20	Bruteforce	Optimized
N	2^N	m*N
3	8	60
4	16	80
6	64	120
7	128	140
8	256	160
20	1048576	400

0. Number of stocks: 20

```
   Name      Price €   Profit €
Action-20     114.0    20.52
Action-6       80.0    20.00
Action-4       70.0    14.00
Action-5       60.0    10.20
Action-11      42.0    7.14
Action-13      38.0    8.74
Action-10      34.0    9.18
Action-8       26.0    2.86
Action-19      24.0    5.04
Action-18      10.0    1.40
Portfolio value: 498.00 €
Return profits: 99.08 €
```

1. Number of stocks: 957

```
   Name       Price €    Profit €
Share-GHIZ     28.0     11.17
Share-LSZT     34.9     13.68
Share-DBMG    37.07     14.13
Share-LPDM    39.35     15.63
Share-LOKP    41.04     16.08
Share-FYKQ    41.06     15.91
Share-JHLP    42.97     15.95
Share-TEET     43.2     16.39
Share-YRSC     47.0     18.00
Share-XKAM    47.01     17.91
Share-EKHU    47.13     16.51
Share-AOLT    48.53     17.68
Portfolio value: 497.26 €
Return profits: 204.53 €
```

```
Sienna bought:

Share-GRUT

Total cost: 498.76€
Total return: 196.61€
```

2. Number of stocks: 541

```
   Name      Price €   Profit €
Share-NDKR    33.06     13.19
Share-PSMF    33.45     13.00
Share-JGTW    35.29     13.91
Share-SFQC    36.53     14.22
Share-ENZZ    37.24     14.22
Share-YRAH    37.34     12.33
Share-OPBR     39.0     15.19
Share-VWZM    40.41     14.63
Share-DFGJ    40.44     13.22
Share-JWGF    48.69     19.44
Share-QEVK    49.77     17.11
Share-MBQU    51.46     18.41
Portfolio value: 482.68 €
Return profits: 202.12 €
```

```
Sienna bought:
Share-ECAQ 3166
Share-IXCI 2632
Share-FWBE 1830
Share-ZOFA 2532
Share-PLLK 1994
Share-YFVZ 2255
Share-ANFX 3854
Share-PATS 2770
Share-NDKR 3306
Share-ALIY 2908
Share-JWGF 4869
Share-JGTW 3529
Share-FAPS 3257
Share-VCAX 2742
Share-LFXB 1483
Share-DWSK 2949
Share-XQII 1342
Share-ROOM 1506

Total cost: 489.24€
Profit: 193.78€
```

End