RIGA TECHNICAL UNIVERSITY

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

INSTITUTE OF APPLIED COMPUTER SYSTEMS

Introduction to Operations Research
Assignment 6
Linear Programming

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➢ Task

Data input:

- User stories code names (R.01, R.02, etc.)
- Sprints names (Sprint 1, Sprint 2, etc.)
- User story profitability
- User story points
- Sprint capacity
- User story interdependencies

Decision variables:

- What user stories can we fit in each sprint, by also taking into account their interdependencies?

Objective function:

- Maximize user story profitability.

Constraints:

- The total amount of user stories' points cannot exceed the sprint capacity.
- One user story can only be associated to one sprint (one sprint can have multiple user stories).
- If a user story (US_1) depends on an user story (US_2), then US_2 should be included in a sprint before or in the same sprint as US_1.

Example:

- Sprint 3: US_2 *or* Sprint 3: US_2, US_1
- Sprint 4: US_1

- The interdependencies file is update to eliminate symmetry.
- You consider only interdependecies among user stories included in your variant.
- User stories are defined in Latvian. If you want to understand these then use Google Translate.
- LinearProgramingHomeWork_variants.xlsx contains variant number for each student.
- Sprint capacity and user story sizes are in the OperationsResearch.zip file.
- Please take the Word document corresponding to you variant number.

➢ Answer

- ## My Variants (13)

Sprinta Nr.	1	2	3	4	5	6
Kapacitāte P_i^{max}	30	20	15	15	20	20

User Story	Rentabilitāte U_j (10-100)	Story point P_j (1-10)
R.01	100	8
R.02	100	7
R.06	60	2
R.07	60	6
R.08	30	6
R.09	40	4
R.10	35	4
R.12	80	7
R.13	80	10
R.14	75	6
R.15	70	7
R.16	60	8
R.17	20	3
R.18	20	5
R.19	30	6
R.20	15	6
R.31	75	8
R.32	40	6

- ## Code in CPLEX Model File

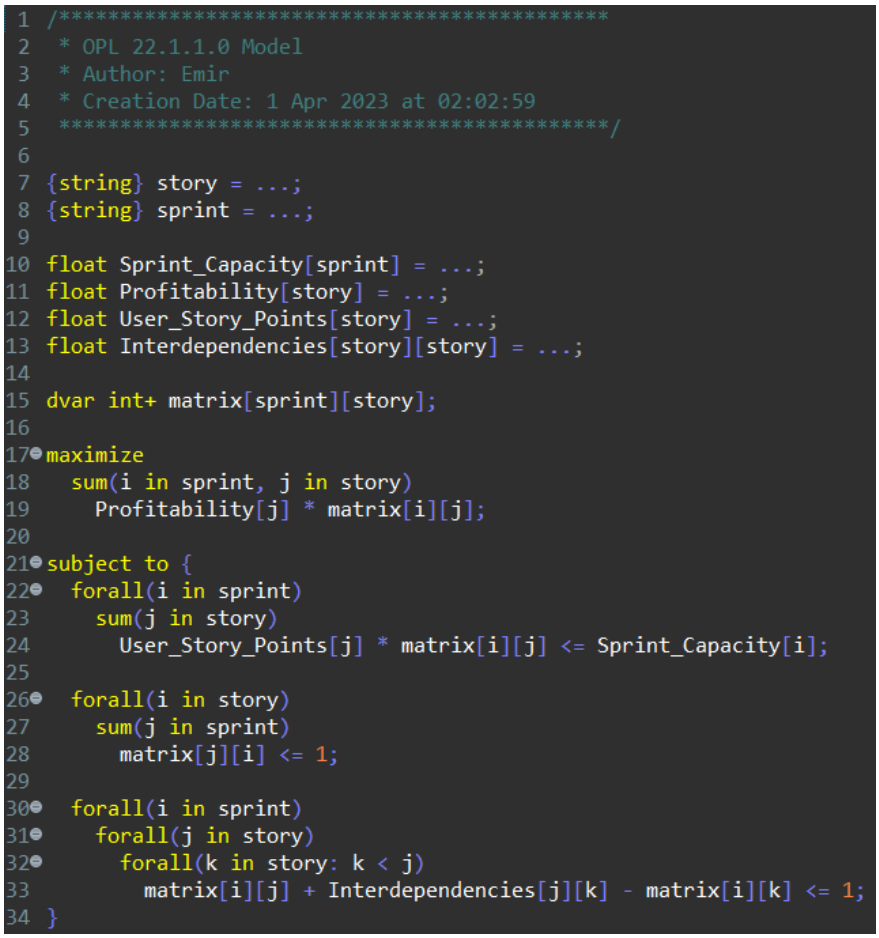
```
{string} story = ...;
{string} sprint = ...;

float Sprint_Capacity[sprint] = ...;
float Profitability[story] = ...;
float User_Story_Points[story] = ...;
float Interdependencies[story][story] = ...;

dvar int+ matrix[sprint][story];

maximize
  sum(i in sprint, j in story)
    Profitability[j] * matrix[i][j];

subject to {
  forall(i in sprint)
    sum(j in story)
      User_Story_Points[j] * matrix[i][j] <= Sprint_Capacity[i];

  forall(i in story)
    sum(j in sprint)
      matrix[j][i] <= 1;

  forall(i in sprint)
    forall(j in story)
      forall(k in story: k < j)
        matrix[i][j] + Interdependencies[j][k] - matrix[i][k] <= 1;
}
```

- **Code in CPLEX Data File**

```
SheetConnection Sheet("CourseWork_Interdependences.xlsx");
story from SheetRead(Sheet, "'Sheet1'!A2:A19");
sprint from SheetRead(Sheet, "'Sheet1'!C20:H20");
Sprint_Capacity from SheetRead(Sheet, "'Sheet1'!C21:H21");
Profitability from SheetRead(Sheet, "'Sheet1'!C22:T22");
User_Story_Points from SheetRead(Sheet, "'Sheet1'!C23:T23");
Interdependencies from SheetRead(Sheet, "'Sheet1'!C2:T19");
```

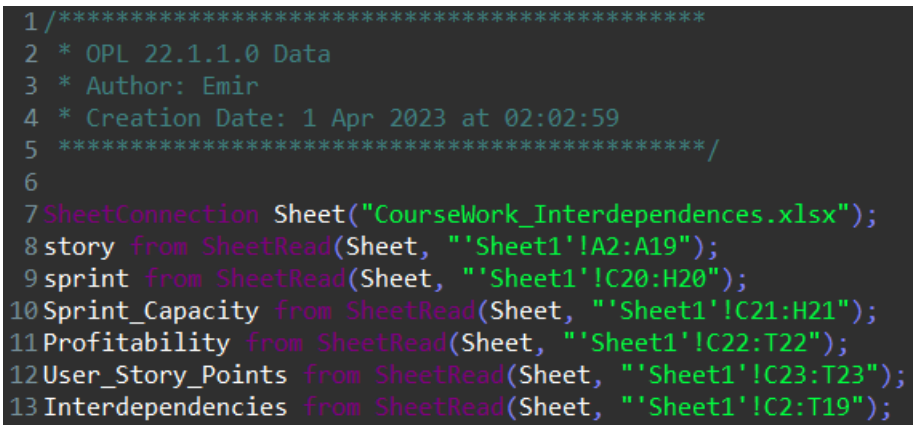
- **Screenshots**

  - **CPLEX Model**



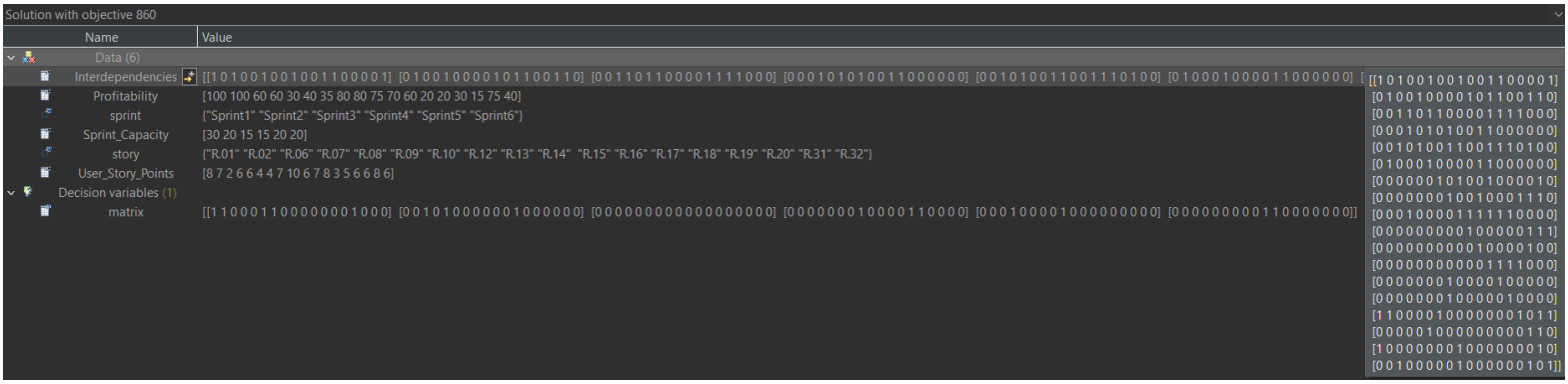
```
/*********************************************
 * OPL 22.1.1.0 Model
 * Author: Emir
 * Creation Date: 1 Apr 2023 at 02:02:59
 *********************************************/

{string} story = ...;
{string} sprint = ...;

float Sprint_Capacity[sprint] = ...;
float Profitability[story] = ...;
float User_Story_Points[story] = ...;
float Interdependencies[story][story] = ...;

dvar int+ matrix[sprint][story];

maximize
  sum(i in sprint, j in story)
    Profitability[j] * matrix[i][j];

subject to {
  forall(i in sprint)
    sum(j in story)
      User_Story_Points[j] * matrix[i][j] <= Sprint_Capacity[i];

  forall(i in story)
    sum(j in sprint)
      matrix[j][i] <= 1;

  forall(i in sprint)
    forall(j in story)
      forall(k in story: k < j)
        matrix[i][j] + Interdependencies[j][k] - matrix[i][k] <= 1;
}
```

  - **CPLEX Data**



```
/*********************************************
 * OPL 22.1.1.0 Data
 * Author: Emir
 * Creation Date: 1 Apr 2023 at 02:02:59
 *********************************************/

SheetConnection Sheet("CourseWork_Interdependences.xlsx");
story from SheetRead(Sheet, "'Sheet1'!A2:A19");
sprint from SheetRead(Sheet, "'Sheet1'!C20:H20");
Sprint_Capacity from SheetRead(Sheet, "'Sheet1'!C21:H21");
Profitability from SheetRead(Sheet, "'Sheet1'!C22:T22");
User_Story_Points from SheetRead(Sheet, "'Sheet1'!C23:T23");
Interdependencies from SheetRead(Sheet, "'Sheet1'!C2:T19");
```

- **Output**



- ## Results

  - **User Stories**

    R.01, R.02, R.06, R.07, R.08, R.09, R.10, R.12, R.13, R.14, R.15, R.16, R.17, R.18, R.19, R.20, R.31, R.32

  - **Sprints**

    Sprint1, Sprint2, Sprint3, Sprint4, Sprint5, Sprint6

  - **Matrix**

    [[1,1,0,0,0,1,1,0,0,0,0,0,0,0,1,0,0,0
    [0,0,1,0,1,0,0,0,0,0,0,1,0,0,0,0,0,0]
    [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
    [0,0,0,0,0,0,0,1,0,0,0,0,1,1,0,0,0,0]
    [0,0,0,1,0,0,0,0,1,0,0,0,0,0,0,0,0,0]
    [0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0]]

  - **Profit**

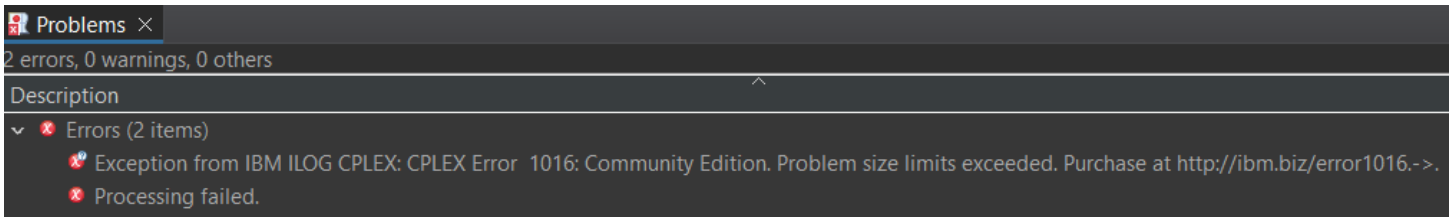
	R.01	R.02	R.06	R.07	R.08	R.09	R.10	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	R.31	R.32
Sprint1	100	100				40	35								30			
Sprint2			60		30							60						
Sprint3																		
Sprint4								80					20	20				
Sprint5				60					80									
Sprint6										75	70							

  - **Capacity**

	R.01	R.02	R.06	R.07	R.08	R.09	R.10	R.12	R.13	R.14	R.15	R.16	R.17	R.18	R.19	R.20	R.31	R.32
Sprint1	8	7				4	4								6			
Sprint2			2		6							8						
Sprint3																		
Sprint4								7					3	5				
Sprint5				6					10									
Sprint6										6	7							

- ## Annotation

  Because of the error below, I deleted one of the user stories (R33) given in the variant file and did the homework in this way. So, I just deleted one column and thus got rid of the following error.



- ## Conclusion

  In this assignment, I first combined the user stories into an Excel file based on the variant number (13) assigned to me. I have also added the "Sprint Number, Sprint Capacity, Sprint Profitability and User Story Scores" attributes to this Excel file. I created a CPLEX data file by writing the necessary codes to use the data in this Excel file. Then I wrote a code where I could use this data and created the CPLEX model file. I added the Excel file to the CPLEX project folder I created and ran the code. I got the data and decision variables that I used in the output and showed them in the assignment as well. I created the profitability and capacity tables according to the output matrix created under the name of decision variables and completed the homework.
  As a result, in this assignment, I found the most optimized way by using sample files with project management decisions, I learned where OPL is used and how to use CPLEX.