Smoothing job entrance for students and graduates

Students ⇋ Firms
→ bidirectional interaction / information exchange

The aim is to establish a matching design pattern that increase the overall welfare of all students and firms matched to each other. Both parties can send and accept/reject offers.

Firm

Biotech company 'DNA Smart Tech'

<u>Job requirements</u>

- good grades in the following fields of study ...

Fields of study	Weighting
Biotechnology	40%
Medicine	15%
Bioinformatics	15%
DNA Programming	20%
Informatics	10%

- Creativity, analytical abilities ...
- Soft Skills …
- Proximity to workplace ...

Additional Information

- company with more than 1,000 workers
- located in Cologne
- annual profit more than 50,000,000 $

Students

Andra

Study: Biochemistry

Modules	Grades
-Cell Structure	2
-Medical Foundations	1.3
-DNA Structures	2.3
-Programming	1.7
-Bioinformatics I	3
-Biotechnological Foundations	1.0
-Hormons	2.3
-Metabolism	2
- ...	

Boris

Study: Biotechnology

Modules	Grades
-DNA Programming	1.3
-Synthetical Biology	2
-Algorithms & Data Structures	3
-Object-oriented Programming	1
-Biochemical Foundations	2.3
-Protein Synthesis	1.7
- ...	

Caspar

Study: Informatics

Modules	Grades
-Object oriented Programming	2
-Java	1.7
-Web Technologies	1.3
-Algorithm & Data Structures	1.0
-ITIL	1.7
-Cluster Analysis	1.0
- ...	

In a classification table, all modules are listed in order to get an overview which module can be assigned to which field of study. Since several modules can be assigned to more than one field of study, we introduce a fragmentation with reported percentage values.
The higher the percentage value is, the more typical the course can be seen for the corresponding field of study.

Classification Table

Biotechnology		Medicine		Bioinformatics		DNA Programming		Information Systems		Informatics		...
Course	%	Course	%	Course	%	Course	%	Course	%	Course	%	...
Medical Basics	5	Cell Structure	35	Cell Structure	20	Cell Structure	5	Java	30	Java	50	
DNA Structures	25	Medical Foundations	45	DNA Structure	20	DNA Structure	35	ITIL	70	ITIL	30	
Bioinformatics I	35	Biotechnical Foundations	5	Bioinformatics I	35	Bioinformatics I	10	Cluster Analysis	25	Cluster Analysis	35	
Biotechnical Foundations	20	DNA Programming	5	DNA Programming	20	DNA Programming	45	Web Technologies	30	Network Analysis	45	
DNA Programming	30	Synthetical Biology	15	Synthetical Biology	10	Synthetical Biology	35	Object-oriented Programming	30	Web Technologies	45	
Synthetical Biology	25	Biochemical Foundation	30	Algorithms & Data Structures	15	Algorithms & Data Structures	15	Algorithm & Data Structures	20	Object-oriented Programming	40	
Biochemical Foundation	15	...		Object-oriented Programming	15	Object-oriented Programming	15	...		Algorithm & Data Structures	25	
Protein Synthesis	25			Protein Synthesis	35	Protein Synthesis	25	**Attention:** Courses from this column will be omitted in calculations.		...		
...				Programming I	10	Programming I	15					
				...		...						
Weightings of DNA Smart Tech												
40%		15%		15%		20%		0%		10%		

Explanation
The courses listed above can be assigned with xx % to the appropriate field of study, e.g. the course 'DNA Structures' can be assigned to Biotechnology with 25%, to Bioinformatics with 20%, to DNA Programming with 35% and to other fields of study (remaining 20% can be a part of Biochemistry which is not mentioned in the above table).

Determing candidates' scores for preference order

The higher the calculated score of candidates, the more preferred he will be in the job matching process. So, we have to convert our prevailing grade scheme whose values are decreasing for better grades into a new scheme:

German grades	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	5.0
Converted scores	10	9	8	7	6	5	4	3	2	1	0

Andra's preference score

Her current testimony with new scores...

Modules	Grades	Scores
-Cell Structure	2	7
-Medical Foundations	1.3	9
-DNA Structures	2.3	6
-Programming I	1.7	8
-Bioinformatics I	3	4
-Biotechnological Foundations	1.0	10
-Hormons	2.3	6
-Metabolism	2	7
- ...		

Excerpt of the Classification Table that is important for Andra and DNA Smart Tech

Biotechnology

Course	%
Medical Basics	5
DNA Structures	25
Bioinformatics I	35
Biotechnical Foundations	20
DNA Programming	30
Synthetical Biology	25
Biochemical Foundation	15
Protein Synthesis	25
...	

40%

Medicine

Course	%
Cell Structure	35
Medical Foundations	45
Biotechnical Foundations	5
DNA Programming	5
Synthetical Biology	15
Biochemical Foundation	30
...	

15%

Bioinformatics

Course	%
Cell Structure	20
DNA Structure	20
Bioinformatics I	35
DNA Programming	20
Synthetical Biology	10
Algorithms & Data Structures	15
Object-oriented Programming	15
Protein Synthesis	35
Programming I	10
...	

15%

DNA Programming

Course	%
Cell Structure	5
DNA Structure	35
Bioinformatics I	10
DNA Programming	45
Synthetical Biology	35
Algorithms & Data Structures	15
Object-oriented Programming	15
Protein Synthesis	25
Programming I	15
...	

20%

Information Systems

Course	%
Java	30
ITIL	70
Cluster Analysis	25
Web Technologies	30
Object-oriented Programming	30
Algorithm & Data Structures	20
...	

Attention: Courses from this column will be omitted in calculations.

0%

Informatics

Course	%
Java	50
ITIL	30
Cluster Analysis	35
Network Analysis	45
Web Technologies	45
Object-oriented Programming	40
Algorithm & Data Structures	25
...	

10%

...

Modules	Grades	Scores	Biotech.	Medicine	Bioinform.	DNA Progr.	Informatics	Weighted scores
Cell Structures	2	7 *		(0.35 * 0.15 +	0.20 * 0.15 +	0.05 * 0.20)		0.6475
Medical Found.	1.3	9 *		(0.45 * 0.15)				0.6075
DNA Structures	2.3	6 *	(0.25 * 0.40 +		0.20 * 0.20 +	0.35 * 0.20)		1.26
Programming I	1.7	8 *			(0.10 * 0.15 +	0.15 * 0.20)		0.36
Bioinformatics I	3	4 *	(0.35 * 0.40 +		0.35 * 0.15 +	0.10 * 0.20)		0.85
Biotechn. Found.	1.0	10 *	(0.20 * 0.40 +	0.05 * 0.15)				0.0875
Hormons	2.3	6 *						
Metabolism	2	7 *						
							total	**3.8125**

Andra's preference value for DNA Smart Tech equals 3.8125.

Boris' preference score

His current testimony with new scores...

Modules	Grades	Scores
-DNA Programming	1.3	9
-Synthetical Biology	2	7
-Algorithms & Data Structures	3	4
-Object-oriented Programming	1	10
-Biochemical Foundations	2.3	6
-Protein Synthesis	1.7	8
- ...		

Excerpt of the Classification Table that is important for Boris and DNA Smart Tech

Biotechnology	Medicine	Bioinformatics	DNA Programming	Information Systems	Informatics	...
Course / %	Course / %	Course / %	Course / %	Course / %	Course / %	...
Medical Basics 5	Cell Structure 35	Cell Structure 20	Cell Structure 5	Java 30	Java 50	
DNA Structures 25	Medical Foundations 45	DNA Structure 20	DNA Structure 35	ITIL 70	ITIL 30	
Bioinformatics I 35	Biotechnical Foundations 5	Bioinformatics I 35	Bioinformatics I 10	Cluster Analysis 25	Cluster Analysis 35	
Biotechnical Foundations 20	DNA Programming 5	DNA Programming 20	DNA Programming 45	Web Technologies 30	Network Analysis 45	
DNA Programming 30	Synthetical Biology 15	Synthetical Biology 10	Synthetical Biology 35	Object-oriented Programming 30	Web Technologies 45	
Synthetical Biology 25	Biochemical Foundation 30	Algorithms & Data Structures 15	Algorithms & Data Structures 15	Algorithm & Data Structures 20	Object-oriented Programming 40	
Biochemical Foundation 15	...	Object-oriented Programming 15	Object-oriented Programming 15	...	Algorithm & Data Structures 25	
Protein Synthesis 25		Protein Synthesis 35	Protein Synthesis 25	**Attention:** Courses from this column will be omitted in calculations.	...	
...		Programming I 10	Programming I 15			
		...	...			
40%	15%	15%	20%	0%	10%	

Modules	Grades	Scores	Biotech.	Medicine	Bioinform.	DNA Progr.	Informatics	Weighted scores
DNA Programming	1.3	9 *	(0.30 * 0.40 +	0.05 * 0.15 +	0.20 * 0.15	0.45 * 0.20)		1.9575
Synthetical Biol.	2	7 *	(0.25 * 0.40 +	0.15 * 0.15 +	0.10 * 0.15 +	0.35 * 0.20)		1.4525
Alg. & Data Str.	3	4 *			(0.15 * 0.15 +	0.15 * 0.20 +	0.25 * 0.10)	0.31
Object-or. Progr.	1	10 *			(0.15 * 0.15 +	0.15 * 0.20 +	0.40 * 0.10)	0.925
Biochem. Found.	2.3	6 *	(0.15 * 0.40 +	0.30 * 0.15)				0.63
Protein Synthesis	1.7	8 *	(0.25 * 0.40 +		0.35 * 0.15 +	0.25 * 0.20)		1.62
							total	**6.895**

Boris' preference value for DNA Smart Tech equals 6.895.

Caspar's preference score

His current testimony with new scores...

Modules	Grades	Scores
-Object oriented Programming	2	7
-Java	1.7	8
-Web Technologies	1.3	9
-Algorithm & Data Structures	1.0	10
-ITIL	1.7	8
-Cluster Analysis	1.0	10
- ...		

Excerpt of the Classification Table that is important for Caspar and DNA Smart Tech

Biotechnology	Medicine	Bioinformatics	DNA Programming	Information Systems	Informatics	...
Course / %	Course / %	Course / %	Course / %	Course / %	Course / %	...
Medical Basics 5	Cell Structure 35	Cell Structure 20	Cell Structure 5	Java 30	Java 50	
DNA Structures 25	Medical Foundations 45	DNA Structure 20	DNA Structure 35	ITIL 70	ITIL 30	
Bioinformatics I 35	Biotechnical Foundations 5	Bioinformatics I 35	Bioinformatics I 10	Cluster Analysis 25	Cluster Analysis 35	
Biotechnical Foundations 20	DNA Programming 5	DNA Programming 20	DNA Programming 45	Web Technologies 30	Network Analysis 45	
DNA Programming 30	Synthetical Biology 15	Synthetical Biology 10	Synthetical Biology 35	Object-oriented Programming 30	Web Technologies 45	
Synthetical Biology 25	Biochemical Foundation 30	Algorithms & Data Structures 15	Algorithms & Data Structures 15	Algorithm & Data Structures 20	Object-oriented Programming 40	
Biochemical Foundation 15	...	Object-oriented Programming 15	Object-oriented Programming 15	...	Algorithm & Data Structures 25	
Protein Synthesis 25		Protein Synthesis 35	Protein Synthesis 25	**Attention:** Courses from this column will be omitted in calculations.	...	
...		Programming I 10	Programming I 15			
		...	...			
40%	15%	15%	20%	0%	10%	

Modules	Grades	Scores	Biotech.	Medicine	Bioinform.	DNA Progr.	Informatics	Weighted scores
Object-or. Progr.	2	7 *					(0.40 * 0.10)	0.28
Java	1.7	8 *					(0.50 * 0.10)	0.4
Web Technologies	1.3	9 *					(0.45 * 0.10)	0.405
Alg. & Data Str.	1	10 *			(0.15 * 0.15 +	0.15 * 0.20 +	0.25 * 0.10)	0.775
ITIL	1.7	8 *					(0.30 * 0.10)	0.24
Cluster Analysis	1	10 *					(0.35 * 0.10)	0.35
							total	**2.45**

Caspar's preference value for DNA Smart Tech equals 2.45.

Preference table of DNA Smart Tech

Firm	10	9	8	7	6	5	4	3	2	1
DNA Smart Tech				B			A		C	

The preference tables are important for further algorithm procedures. [1]

Analoguously, students can set a preference table regarding general information about firms.

Student

Tim Malzbeutel

Individual requirements

- Tim has own ideas about a good job...

Criteria	Weighting
Starting salary	35%
Bonus payments possible?	5%
< 50 working hours/week	15%
Proximity to working place	15%
Company size (less is more)	20%
Annual profit of company	10%

Additional Information

- Master's degree
- studied at one of the best national universities
- lives in Hamburg
- age: 25

Firms

Labs&Chemicals

Branch: Chemistry

Parameter	Value
-Starting salary	2,600€
-Bonus payments?	yes
-Working hours	40
-Proximity to working place	500m
-Company size (employees)	150
-Annual profit	5 m. €
- ...	

MoreBiocare

Branch: Healthcare

Parameter	Value
-Starting salary	3,400€
-Bonus payments?	no
-Working hours	55
-Proximity to working place	1.2km
-Company size (employees)	200,000
-Annual profit	1.2 b. €
- ...	

Onehundred Crunches

Branch: Fitness

Parameter	Value
-Starting salary	3,600€
-Bonus payments?	yes
-Working hours	50
-Proximity to working place	3.4km
-Company size (employees)	20,000
-Annual profit	150 m. €
- ...	

Calculation Table [2]

Criteria	%	Normalization function for scores	Average values (a)
Starting salary	35	f(x) = x / a	2,700€
Bonus payments?	5	Boolean values: yes=1, no=0	
Proximity to working place	15	f(x) = a / x	5km for city (and 15km otherwise)
Working hours < 50	15	f(x) = (50 – x) / a	3 extra hours in average
Company size	20	f(x) = log(a) - log(2x)	1000 employees
Annual profit	10	f(x) = log(x) - log(a)	10 million €

Explanation

The parameter a stands for the average value of the appropriate criterion. Average values are reported by authorized institutions like 'Statistisches Bundesamt'. Here, a is chosen randomly.

Determing preferences values for firms

		Labs&Chemicals		MoreBiocare		Onehundred Crunches	
Criteria		Calculation	Result	Calculation	Result	Calculation	Result
Starting salary	0.35 *	(2,600 / 2,700)	0.3370	(3,400 / 2,700)	0.4407	(3,600 / 2,700)	0.4667
Bonus payments?	0.05 *	1	0.05	0	0	1	0.05
Proximity to work	0.15 *	(5km / 0.5km)	0.15	(5km / 1.2km)	0.625	(5km / 3.4km)	0.2206
Working hours < 50	0.15 *	((50 - 40) / 3)	0.5	((50 - 55) / 3)	-0.25	((50 – 50) / 3)	0
Company size	0.20 *	3 - log(300)	0.1046	3 - log(400k)	-0.5204	3 - log(20k)	-0.2602
Annual profit	0.10 *	log(5,000,000) - 7	-0.0301	log(1,200,000,000) - 7	0.2079	log(150,000,000) - 7	0.1176
	8 *	**total**	**1.1115**	**total**	**0.5032**	**total**	**0.5947**
		preference value	**8.892**	**preference value**	**4.0256**	**preference value**	**4.7576**

So, if we multiplicate the calculated values of these firms with factor 8 (in order to receive a better overview in preference tables), then we get the following preference table of Tim:

Student	10	9	8	7	6	5	4	3	2	1
Tim		L				O	M			

Preference tables for both students and firms can be created so that it may look like this: [3]

Students

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
A	L					M				N	O	P			
B				O			P	L				N		M	
C	P			O					L	M				N	
D	L								N	O		M			P
E			M	N					O	P			L		

Firms

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
L	A						D		B	E		C			
M	C					E				B		D	A		
N			A					D	C		B		E		
O				C						A	D	B			E
P	B					C				D				A	E

Assumption: number of students equals number of firms and every firm can only hire one student.

How can a match with different preference values be implemented and carried out?

<u>Answer:</u> Bidirectional GS algorithm with weighted preferences!

Additional remarks

1

The more courses the student has attended and the better the grades he received in these courses, the higher the preference value will be for the corresponding firm.
That means a student with bachelor's degree but good grades can keep up with another student with master's degree whose grades are on average. Both students can compared automatically and set in a preference relation to each other.

2

The calculation table with its normalization functions is important since all parameters show different values and some of them are not equally distributed, e.g. the profits of firms can increase exponentially although staff number increases on linear basis. So we have to bring all these values into a normalized range. This can be done by the help of normalization function with average values.

3

Tim is not the only student who can raise claims, there are many other students...
At the end, we have a matching algorithm within MxN matrices whereby it is assumed that the number of students, M, equals the number of firms, N.
So the algorithm works within an MxM matrix.