Appendices:

A Variants of Course Allocation Mechanisms Some Variants of UMBS Course-Bidding Mechanism

Yale School of Management:

Uses the same mechanism as the University of Michigan Business School except that students can only bid for only five courses (and the normal course load is four courses).

Columbia Business School:

· The real-life version of UMBS course-bidding mechanism is used for two rounds.
· The first round is the "main" round whereas in Round 2 students are expected to fill the gaps in their first round schedule.
· Unsuccessful bids from Round 1 are returned to students to be used in Round 2.
· Students can only bid for under-subscribed courses in Round 2.

Haas School of Business, UC Berkeley:

Uses the same two-round version as the Columbia Business School except that students cannot bid for more than a fixed number of units.

Kellogg School of Management, Northwestern University:

· The bid endowment should be used over two quarters by first year MBA students and over three quarters by second year MBA students. Points not used in first year do not carry over to the second year.
· Each quarter there are two rounds of bidding similar to the bidding at Columbia Business School, except that
    - students can bid for at most five courses (where the normal course load is four courses),
    - students are charged for the market clearing bids, not their own bids, and
    - bids from the second rounds carry over to the next quarter unless bidding is for the last quarter of the year.
· Hence bidding for the second quarter of the first year and the third quarter of the second year is analogous to course bidding at Columbia and Haas.

Princeton University:

· Undergraduate students cluster alternate courses together and strictly rank the courses within each cluster. Students will be assigned no more than one course from each cluster.
· Students allocate their bid endowment over clusters (as opposed to individual courses). The bid for each course in a cluster is equated to the bid for the cluster. Based on these bids, course allocation is implemented via a variant of UMBS course-bidding mechanism where

- the bids of a student for courses in a cluster are ordered subsequently based on the ranking within the cluster, and
- once a bid of a student is successful for a course in a cluster, her bids for all lower ranked courses in the same cluster are dropped.

An Example of Preference-Based Course Allocation Mechanisms

Harvard Business School Course Allocation Mechanism:

· Students are strictly ordered in a single priority list with a random lottery.
· Each student submits a preference ranking of the courses.
· The assignment of the first course seat for each student is obtained with the serial dictatorship that is induced by the priority ordering of students: The first student is assigned a seat at her top choice, the next student is assigned a seat at her top choice among classes with still available seats, and so on.
· Once the assignment of the first seats are finalized (or equivalently the first cycle is completed), the assignment of second course seats are determined in a similar way using the reverse priority order, next the third course seats are determined in a similar way using the initial priority order, and so on.

B Instructions of the Laboratory Experiment

Course Bidding Exercise

For this exercise, you have been placed in groups of 9 students. Think of this as a "tiny entering second year MBA class of just 9 students". It is as if your class of 2008 was reduced drastically in size to just 9. It is now bidding time for second year courses and the object of this exercise is to bid for courses.

Each student can take **up to** 3 classes. There are 6 courses in all with varying capacities (courses 1, 2 and 3 have a capacity of 4 students each whereas courses 4, 5, and 6 can take up to 7 students each). Each student has **303** bid points to distribute across all courses that s/he bids on.

Basically, in the real world, for every course that a student successfully registers in, s/he feels a certain amount of happiness – more happiness for courses that she really wants to get into, and less happiness for less desirable courses. In this exercise, we will give you tokens to reflect how happy you feel about being able to enroll in a certain course.

You will get a certain number of tokens depending on which class you successfully get into immediately after bidding is over and course allocation is done (i.e., you will not be allowed to make any changes in classes after course allocation is done). The number of tokens we give you for a specific course reflects how much you really want that course – if course 1 gives you 100 tokens and course 2 gives you just 10 tokens, then that means you want course 1 much more than course 2. At the end of the exercise, we will see what courses you successfully registered in, we will add up your tokens and you will be paid that number in cents. In addition, one person in the subject pool for this experiment will be chosen at random and we will give him/her 20 times their total cents payoff.

Your desire for each course (in tokens) is given in the table below. So, if you get into courses 4, 5 and 6, you get 240 tokens =240 cents. If, in addition, you are the person picked in the subject pool at random, you will then also get 20X240 cents = $48.00. You can only bid in whole numbers and you need to bid at least 1 point for any course that would like to enroll in.

Note that "bid point" is what you bid with and "token" reflects your happiness at getting into a course. Table 1 below is a summary of the course capacity, and how much you like each course.

Table 1:

Course	Course Capacity	How much you like it (no. of tokens you get for successfully registering in course in first attempt)
1	4	85
2	4	2
3	4	2
4	7	80
5	7	80
6	7	80

System Y (GS Mechanism)

In this system, students not only bid for courses but also rank them according to how much they want them (preference rank). This is called the student's "preference list". If 2 or more courses are equally desirable (e.g., if 2 courses are both 3rd best for you), please give them different ranks randomly (e.g., 3rd and 4th rank) – i.e., you need to *break the tie* among them in your preference list. If a student wants to be considered for a course, she needs to bid at list 1 point for it. The sum of the bids cannot exceed 303 bid points. Otherwise, sheets will be returned for correction.

The system works as follows: After all student sheets with preference ranks and bids have been collected, the allocation is found as follows:

The computer computes the allocation as follows:

1). In the first round, each student is *tentatively* placed in her top three choices from her preference list. (or fewer if s/he has bid for less than 3 courses). Then the computer adds up course enrolment across students and calculates enrolment in each course. If a course is assigned more students than its capacity, the lowest bidding students for that course are dropped, so that each course *tentatively* holds no more students than its capacity. But, this is just the first computer allocation and is "tentative".

2) Then in the next computer allocation round, each student who was dropped from any courses in the first computer allocation round is tentatively placed in replacement courses starting from her fourth choice. Then the computer inspects the courses again. If a course is assigned more students than its capacity, then the bids of **students who were tentatively placed in it in the previous round and in this round are inspected**. The lowest bidding students tentatively placed in **this or previous rounds** for that course are dropped, so that each course tentatively holds no more students than its capacity.

3) The computer iteratively continues until no student is dropped from a course, or all options of the students are exhausted in their preference lists. The tentative assignments are realized as real assignments.

Example:

Suppose there are 4 students and 4 courses with a capacity of 2 each. Students need to take **up to 2** courses. Suppose students have 100 points to bid and they report their bids and preferences as follows:

Student 1		Student 2		Student 3		Student 4	
Course (in order of pref.)	Bid	Course (in order of pref.)	Bid	Course (in order of pref.)	Bid	Course (in order of pref.)	Bid
C1	8	C1	16	C3	2	C2	88
C2	79	C2	77	C2	89	C3	6
C3	13	C3	7	C1	4	C1	5
C4	0	C4	0	C4	3	C4	1

Computer round 1 (will consider top 2 ranks of students since students can only take 2 courses):

Stud. 1	Stud. 2	Stud. 3	Stud. 4		Course 1	Course 2	Course 3	Course 4
C1	C1	C3	C2	Computer inspects the course enrolment:	*S1-8*	~~S1-79~~	*S3-2*	
C2	C2	C2	C3		*S2-16*	~~S2-77~~	*S4-6*	
						S3 -89		
						S4 -88		

Tentative assignments are in italics, rejected bids are crossed. Since some students are dropped from courses, they are now assigned to courses from their third rank on.

Computer Round 2: S1 and S2, who were rejected by one of their courses, are tentatively assigned to their third choice course.

Stud. 1	Stud. 2	Stud. 3	Stud. 4	Computer inspects the course enrolment:	Course 1	Course 2	Course 3	Course 4
C1	C1	C3	C3		S1-8	~~S1-79~~	~~S3-2~~	
~~C2~~	~~C2~~	C2	C2		S2-16	~~S2-77~~	~~S4-6~~	
C3	C3					S3 -89	S1-13	
						S4 -88	S2-7	

S3 and S4 no longer get course 3. Instead S1 and S2 are tentatively placed in course 3.
Computer Round 3: S3 and S4, who were rejected by one of their courses, are tentatively assigned to their third choice course.

Stud. 1	Stud. 2	Stud. 3	Stud. 4	Computer inspects the course enrolment:	Course 1	Course 2	Course 3	Course 4
C1	C1	~~C3~~	~~C3~~		S1-8	~~S1-79~~	~~S3-2~~	
~~C2~~	~~C2~~	C2	C2		S2-16	~~S2-77~~	~~S4-6~~	
C3	C3	C1	C1		~~S3-4~~	S3 -89	S1-13	
					~~S4-5~~	S4 -88	S2-7	

S3 and S4 cannot get course 1 since S1 and S2 have bid a higher amount for this course. So, S3 and S4 are now to be considered for their fourth choice course.

Computer Round 4: S3 and S4 are now to be considered for their fourth choice course. The tentative allocation is finalized as:

Stud. 1	Stud. 2	Stud. 3	Stud. 4	Computer inspects the course enrolment:	Course 1	Course 2	Course 3	Course 4
C1	C1	~~C3~~	~~C3~~		S1-8	~~S1-79~~	~~S3-2~~	S3-3
~~C2~~	~~C2~~	C2	C2		S2-16	~~S2-77~~	~~S4-6~~	S4-1
C3	C3	~~C1~~	~~C1~~		~~S3-4~~	S3 -89	S1-13	
		C4	C4		~~S4-5~~	S4 -88	S2-7	

Now, please give us your ranks and bids for the courses, based on Table 1 and the bid history that's given to you. Note that the first column indicates the course # (whether its course # 1,2, 3, 4, 5 or 6), the second column is the <u>rank</u> for each course, and the third column is the bid for each course.

Course number	Your rank for this course in terms of its desirability (1 is the highest) – you must rank all courses. You can rank only one course for each rank	Your bid
1		
2		
3		
4		
5		
6		
Total		303 bid points

Please write down your UMID and email address so you can get paid:_____

System X (UMBS Mechanism)

If you want to be considered for a course, you need to bid at list 1 point for it. The sum of the bids cannot exceed 303 bid points. Otherwise, sheets will be returned for correction.

This is how course allocation is done:
After all bid sheets are collected, all bids from the 9 students are ordered from largest to the smallest. Only positive bids are taken into consideration, zero bids are dropped. Then, starting from the largest bid, each bid is processed one at a time. When it is the turn of bid b_{ic} of student i for course c, the bid is successful if:
(a) course c still has unfilled seats, and
(b) student i still has unfilled slots in her schedule.

If the bid is successful, then student i is assigned a seat at course c (i.e. the bid is honored) and the process proceeds with the next bid in the list. Otherwise student i is declined a seat at course c and the process continues with the next largest bid in the list.

When all bids are processed, a schedule is obtained for each student and a course allocation is hence obtained.

So, if each student was to bid on 4 courses (remember that you can bid your 303 points on any number of courses), then the 4 X 9 = 36 bids are organized in a list according to bid points. Then courses are assigned going down the list from highest to lowest bid points, taking requirements (a) and (b) above into consideration.

Example:

Suppose there are 4 students and 4 courses with a capacity of 2 each. Students can take up to 2 courses. Suppose students have 100 points to bid and their bids are as follows:

Student 1		Student 2		Student 3		Student 4	
Course (in order of pref.)	Bid	Course (in order of pref.)	Bid	Course (in order of pref.)	Bid	Course (in order of pref.)	Bid
C1	8	C1	16	C3	2	C2	88
C2	79	C2	77	C2	89	C3	6
C3	13	C3	7	C1	4	C1	5
C4	0	C4	0	C4	3	C4	1

All 14 positive bids are ordered in descending order:

Bid (points)	Student	Course	Assignment
89	S3	C2	C2 → S3
88	S4	C2	C2 → S4
79	S1	C2	C2 is full, bid rejected
77	S2	C2	C2 is full, bid rejected
16	S2	C1	C1 → S2
13	S1	C3	C3 → S1
8	S1	C1	C1 → S1
7	S2	C3	C3 → S2
6	S4	C3	C3 is full, bid rejected
5	S4	C1	C1 is full, bid rejected
4	S3	C1	C1 is full, bid rejected
3	S3	C4	C4 → S3
2	S3	C3	S3 already has 2 courses, bid rejected
1	S4	C4	C4 → S4

Final course assignment:

Stud. 1	Stud. 2	Stud. 3	Stud. 4		Course 1	Course 2	Course 3	Course 4
C3	C1	C2	C2		S2-16	S3-89	S1-13	S3-3
C1	C3	C4	C4		S1-8	S4-88	S2-7	S4-1

Now, please give us your bids for the courses, based on Table 1 and the bid history that's given to you:

Course number	Your bid
1	
2	
3	
4	
5	
6	
Total	303 bid points

Please write down your UMID and email address so you can get paid:_____

Little Information

By word of mouth, you have got to know that courses 1, 2 and 3 are not popular courses and are easy to get into. On the other hand, courses 4, 5 and 6 are very popular courses.

Bid History

The students' office has information available about the past market clearing prices (i.e., past bid points that were successful). According to that, in recent years student were able to enroll with 100% probability in each of the courses 1, 2 and 3 if they bid just 1 point for each of these courses. On the other hand, courses 4, 5 and 6 had the following success rate of enrollment for different bids:

bid points	success chance
1	0%
50	40%
100	75%
150	82%
200	88%
250	94%
300 or more	100%

Success chance of other bid points can easily be interpolated as follows: For example, the success chance of 160 bid points is

$$82\% + \frac{(160-150)}{(200-150)} * (88-82)\% = 83.2\%$$

There is no guarantee that this is the case for the current year.

Technical Appendix: E-mail Messages Requesting Student Preference Rankings for the Field Study

See Marketing Science Web-Page