

Centralized Admissions for Engineering Colleges in India

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We designed and implemented a new joint seat allocation process for undergraduate admissions to over 500 programs spread across 80 centrally funded technical institutes (CFTIs) in India, including the prestigious Indian Institutes of Technology (IITs). Our process is based on the well known Deferred Acceptance algorithm, but complex affirmative action seat reservations led us to make a number of algorithmic innovations, including the following.

- A carefully constructed heuristic for incorporating non-nested common quotas that span multiple programs. In general, it is NP-hard to even determine if a fair allocation exists in presence of such quotas. Our heuristic fails only rarely for small quotas, and failures can be handled by creating one additional seat. We observed no failure in practice, and only one failure in our 50 synthetically generated test cases.
- A method to utilize unfilled reserved seats with no modifications to the core software. Practitioners are reluctant to modify existing trusted software, and implementations that treat existing software as a black box can alleviate their fears. Our implementation can be viewed as a hybrid of program-proposing DA and candidate-proposing DA, making the allocation we arrive at stable, but not necessarily candidate optimal. However, we expect there to be no difference in practice, as the set of stable matchings is actually observed to be a singleton.
- A robust approach to reduce variability in the number of reserved category candidates admitted, while retaining fairness. Our algorithm was tested on past data, and verified to be superior on key relevant metrics to proposed alternative solutions. Even when it was used in practice, it performed far better than the next best alternative.

Prior to 2015, the admissions were carried out separately in IITs and later in non-IITs. The same set of candidates could be eligible to receive seats from both the systems, thus leaving one seat vacant. This was especially a problem for the IITs as their admission process used to take place first. Introduction of the combined process in 2015 resulted in a reduction in vacancies when classes began: by over 50% at the IITs (on a baseline of 587 vacancies in 9,784 seats in 2014) and by nearly 8% at the non-IIT CFTIs (on a baseline of 5,596 vacancies in about 21,285 seats in 2014).

Because the admitted candidates have options outside the system (privately funded institutes, foreign colleges etc.), and an option to reapply the following year, many candidates routinely end up not accepting the offered seat leading to vacancies, even in the combined process. Furthermore, we were not allowed, in anticipation of attrition, to speculatively admit more candidates to a program than its capacity permitted. Also, unlike in many other centralized clearinghouses, our process had to be completely transparent. This made it necessary for us to adapt some process innovations in our design that we think may prove useful in other settings. These include the following.

- Multiple rounds of seat allocations to reduce vacancies. Candidates were asked to accept their allotted seat by paying a seat acceptance fee. Those who didn't were assumed to have vacated their seats, and those seats were made available to other candidates in subsequent rounds. This is something that we retained from the old admission process, and verified that it actually resulted in a reduction in vacancies.
- An option to surrender a previously accepted seat. In 2015, candidates who accepted a seat did not have an option to surrender it even though they had made up their mind not to join. Introducing this option in 2016 allowed us to reallocate such seats in subsequent rounds, causing further reduction in vacancies. Compared to 2014, IITs had 70% fewer vacancies in 2016 and following years.
- Centralized special rounds conducted after the beginning of classes. These were useful in reducing vacancies left at the end of the seat allocation process at the non-IIT CFTIs (non-IITs), which suffer from a higher number of vacancies.

We also had some more design insights to help candidates. These include the following.

- A candidate who is allotted a seat was given the following options: "Float" (meaning to be open to upgrades in future rounds), "Slide" (be open to upgrades but only within the same institute), "Freeze" (ask to stick with the current allocation) or "Reject". These options were valued by the candidates as evidenced by the fact that after the first round in 2017, 14.2% candidates chose to Freeze their allotted program, 8.8% chose Slide and 59.6% chose Float (the proportion of Freeze and Slide increases in later rounds). The rest (17.4%) decided to exit the system by rejecting their seat.

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- Mock allocation rounds before the final deadline to fill preferences. This gave candidates an idea about what they might get given their preference list at the time of the mock round. Candidates who didn't get any seat in it could use the remaining time to fill more choices. In 2017, two mock rounds were conducted. There were 2,063 candidates who did not get a seat in the first mock round, but, upon suitably updating their preferences, were allotted a program in the actual first round. Furthermore, the mock rounds (especially the second one) were found to provide a fairly accurate guidance, in the sense that the closing ranks were close to those in the actual first round.

Our new seat allocation process went live in 2015, and based on its success, including significant and provable reduction in vacancies, it has remained in successful use since, with continuing improvements. As per our mandate, our joint process has been very successful in reducing vacancies at the IITs. Meanwhile, vacancies in the non-IITs have reduced only slightly, and concern us, though these were outside our mandate. In 2017, non-IITs had 6,510 vacancies out of 25,220 seats. Data indicates that most of these vacancies are avoidable in the sense that there are eligible candidates who want these seats.

In 2015, without the Withdraw option, quite a few vacancies were discovered only after classes began as candidates who decided to go elsewhere didn't have any way to surrender their seats. This was reduced in 2016, when candidates were allowed to withdraw until the penultimate round of seat allocation. However, most of the candidates withdraw in the last possible round, i.e., the penultimate round, and over 70% of fresh allocations in late rounds are rejected by candidates, making it difficult to fill seats vacated by withdrawing candidates. Moreover, almost all of the Withdrawals are from the non-IITs, making them the chief factor in influencing the number of vacancies in non-IITs.

While the special rounds conducted after the beginning of classes are quite successful in filling a lot of these vacancies (in 2017, the special round managed to reduce the number of vacancies to 2,680 at the non-IITs), we believe that the design of the main rounds can also be improved for maximum efficiency gains. We argue that a modification of candidate incentives can help us improve the efficiency of the main rounds. To achieve this, we advocate the following approach.

- Any candidate who is allotted a seat and then accepts should not be permitted to apply for admissions to any CFTI in future, regardless of whether or not they withdraw.** In 2017, 31.2% of all withdrawals were from candidates who intended to apply again the following year. This rule change is expected to save close to 1,400 vacancies.
- Messaging should not encourage candidates to blindly list more programs. Instead, they should be encouraged to list programs they are truly interested in, and made aware of the consequences of accepting a program they do not intend to join.** This suggestion of ours was the only one implemented in 2018, and it caused desirable changes in key metric: the average length of candidate preference list was reduced by 17%. This had the downstream effect of reducing vacancies in non-IITs by about 6%.
- Withdrawals should be stopped two rounds before the last round.** This will give us two opportunities to fill seats vacated by withdrawing candidates without too much loss of flexibility to candidates since the interval between the later rounds is 2-3 days anyway.
- Ensure that only serious candidates participate in the last two rounds, say, by using monetary incentives.** This proposal is inspired by the special rounds, which successfully use such incentives. In 2017, 59% of fresh allotments were accepted in the special round, compared to just 30% in the last main round.

We advocated to include these changes into the Business Rules for 2018, however only suggestion (ii) was partly accepted. Our other suggestions were rejected citing that the proposed penalty for backing out was "too harsh" on candidates, etc. Consequently, we predicted several thousand vacancies when classes begin in 2018 as a result of the persistent improper incentive structure, and indeed, 6,133 seats remained vacant in the non-IITs at the end of the main rounds of admission, only slightly less than in 2017. We continue to advocate for our suggested changes to be made in future years.

Additional Key Words and Phrases: stable matching, college admission, deferred acceptance, affirmative action, algorithm, implementation, market design

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