Electrical Maintenance of IIT Bombay Hostels

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The Electrical Maintenance Department (EMD) of the Indian Institute of Technology Bombay (IIT Bombay) is responsible for the electrical maintenance of all hostels on campus. At present, EMD activity is outsourced to Chintamani Electrical on an annual contract. The latter puts up its resources to operate EMD. The EMD supervisor Vijay Bhogale is concerned about the productivity of the electricians because his boss, the owner of Chintamani Electrical, has pushed him several times to improve it.

This case on electrical maintenance of IIT Bombay hostels explains the functioning of EMD along with relevant data to apply operations management techniques such as simulation and capacity analysis. The first step for using these techniques is to understand the situation by mapping its processes; hence, the initial part of the case throws light on this. The latter part of the case emphasizes relevant and precise data collection to apply the appropriate operations management technique. This case creates a stimulating environment for class discussion on key data, the underlying notion in the application of simulation and/or queuing model for a given situation.

Keywords: Simulation, maintenance, capacity analysis, probability distribution

On one hazy morning in the first week of August 2006, Vijay Bhogale, supervisor of the Electrical Maintenance Department (EMD) of the Indian Institute of Technology Bombay (IIT Bombay) hostels, was browsing through the complaint register lying on

his desk. He was not happy as several complaints were still pending. He knew that this situation would continue for the next few weeks because of the new students who had recently joined the hostel at the beginning of the academic year. He was exploring the possibility of hiring one more ad-hoc electrician to manage the situation more effectively. It was difficult for him to ask for an additional electrician from Chintamani Electrical, the firm that had the contract for the electrical maintenance of IIT Bombay hostels. Bhogale was appointed as a supervisor at EMD on behalf of Chintamani Electrical to look after the electrical maintenance activities of the hostels. He was also worried about the productivity of the electricians because the owner of Chintamani Electrical had pushed him several times to improve it. It was difficult for him to manage EMD within the given contractual amount signed between IIT Bombay and Chintamani Electrical.

Hasmukh, a doctoral student of Shailesh J. Mehta School of Management at IIT Bombay was looking for a project in which he could apply his operations management knowledge. He approached Bhogale in EMD. He listened to Bhogale's difficulties in managing the Electrical Maintenance Department. Mr Bhogale told him:

> There is a lot of competition in acquiring these kinds of contracts on reduced rates. However, we need to make sure that we don't incur losses in the long term due to the price we bid. On the other hand, we can't keep our resources idle for too long due to a lack of new contracts. I am still unsure what happens to resource productivity as arrival time of complaints by the hostels keep changing and there is uncertainty. I hope you may give me some valuable suggestions on how to manage the current situation.

Hasmukh found the problem very interesting and relevant for the application of some of the operations management techniques that he had studied. He expressed his interest in helping Bhogale. He said:

> The current situation at EMD is difficult to manage due to an increase in the number of complaints and uncertainty of their arrival times. The situation becomes more complex when demand for your resources comes from different hostels. I am quite sure that operations management techniques can analyze such a situation effectively. I need some data for doing the analysis. I hope that acquiring data [from Bhogale] should not be a problem.

Bhogale was eager to assist Hasmukh in acquiring the data that he needed. The latter immediately looked over the complaint register and started noting down the number of complaints registered at EMD during the last few months. He was happy and sure that this was what he must do before commencing any further analysis. Exhibit 1 shows the number of complaints registered at EMD in the last few months. After looking at the data summary, he smiled. He wondered which operations management model should he choose for this situation and whether any more data was needed from Bhogale.

BACKGROUND OF IIT BOMBAY

The Indian Institute of Technology Bombay (IIT Bombay)[1] was one of the premier technological institutes of India. It was set up in 1958 with the objective of facilitating higher education, research and training in various fields of science and technology. It had around 5,000 students on campus with an annual intake of 650 students in the undergraduate programmes and 1,050 students in the postgraduate and doctoral programmes. The institute campus was divided into the academic block, staff residential block and students' hostel block. The academic block comprised thirteen departments, five centres, two schools and two interdisciplinary groups. The students' hostels block had fourteen hostels that provided residential facilities to the students on campus. Each hostel was an independent entity with its own mess hall, sports and recreational facilities. The institute also had some common facilities on campus such as the central library, some banks, a hospital, a guest house, an internal bus service, school for staff children, post office, swimming pool, tennis court and a football ground.

ELECTRICAL MAINTENANCE DEPARTMENT (EMD)

The Electrical Maintenance Department (EMD) was a separate entity on the IIT Bombay campus and repaired all the electrical faults occurring in the hostels. IIT Bombay assigned such repair work to outside firms on contract through a tendering and bidding process. The contract was assigned to a firm either every year or after two years on the expiry of the previous contract. As a policy, a potential contractor

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[1] The Government of India conceptualized the idea of premier institutes, national institutes and regional institutes in its higher education policy. IIT Bombay falls into the premier category because of its funding and autonomy structure. As per policy, premier institutes are funded by the central government.

should have previously received some government contracts before he could bid for the EMD contract. In 2006, the contract was assigned to Chintamani Electrical. It was signed between IIT Bombay and Chintamani Electrical for Rs 33,000 per month. As per the contract, the firm had to deploy its resources (electricians and helpers) at EMD for the whole duration of the agreement, which was usually one year. The current organizational structure of the EMD department is shown in Exhibit 2.

There were fourteen hostels (two hostels for girls, eleven for boys and one for project staff) at the IIT Bombay campus. The locations of all the hostels are shown on the map of IIT Bombay campus in Exhibit 3. The entire process of rectifying the electrical fault is explained below.

Arrival of Complaints

Whenever an electrical fault occurred, the respective student (for fault in his/her room) or hostel in-charge/general secretary/security (for fault in other places of the hostel) registered a complaint with EMD over the telephone using the intercom. The available person at EMD then recorded the complaint in the complaint register. The relevant details of the complaint that were generally noted were the complaint number, date, time, hostel number, room number or place where the fault had occurred and the type of fault. EMD also maintained a hostel service book for each hostel. The same complaint details were then recorded in the respective hostel service book, which was with the electrician whenever he visited that hostel. A page of the complaint register and the hostel service book are shown in Exhibit 4. The noted complaints were attended to on first come first serve (FCFS) basis but if there were more than one complaints for a given hostel then they were pooled together and attended to in one visit. It was difficult to attend to complaints on FCFS, irrespective of the hostels because the electrician would then be constantly running between the different hostels. Hence, complaints were aggregated for each of the hostels.

Assignment of Electricians

As soon as the electrician on duty became available, the EMD supervisor sent him to the respective hostel to attend to all the pending complaints recorded in the hostel service book. There were four pairs of electricians and helpers who worked in four shifts (including the general shift) as shown in Table 1. A supervisor scheduled the shifts of the electricians and helpers on a rotating basis or by mutual understanding between the electricians. The available pair of electrician and helper (EMD team) was assigned to a complaint on FCFS basis. If there were more than one complaints already

pending for the same hostel then all such complaints were pooled together and assigned to the electrician visiting that hostel. Each electrician was always accompanied by a helper. The electrician carried with him the tool box required for rectifying the fault, some inventory of electrical spares and the respective hostel service book. The time required for walking to the hostel depended upon the distance of the hostel from EMD and the weather conditions (temperature or rain) of the day (see Exhibit 3). The electrician and helper returned to EMD once all the complaints were rectified and they could now go to the next hostel assigned to them.

Table 1
Working Schedule of EMD

Shift Detail	Time	People Assigned
General Shift	10 a.m. to 6 p.m.	1 electrician, 1 helper and supervisor
1st Shift	8 a.m. to 4 p.m.	1 electrician and 1 helper
2nd Shift	4 p.m. to 12 a.m.	1 electrician and 1 helper
3rd Shift	12 a.m. to 8 a.m.	1 electrician and 1 helper
Total no. of supervisors: 1, Total no. of electricians: 4, Total no. of helpers: 4.		

Source: Company documents.

Fault Detection and Rectification

After arrival at the hostel, the EMD team attended to the complaints as per FCFS rule. According to the norm, they went to where the fault had occurred and discovered the exact reason for the fault. Then they attempted to rectify it. If the need arose, the electrician would replace the faulty electric part with an available one. Generally, electricians carried an inventory of the required spares. This included switches, chokes, regulators, capacitors, starters and fuse wires. Some commonly occurring electric faults along with their causes are listed in Table 2. The time required to rectify or repair the faults generally depended upon the type or complication involved in the electrical problem and varied considerably from five minutes to an hour.

Once the fault was rectified, the electrician took the signature of the concerned person or student in the hostel service book. Furthermore, the date and time at which the complaint was attended and the electrical components replaced during rectification were also noted in the hostel service book. A representative sample of a few complaints for one hostel is shown in Exhibit 5. The electrician then attended to the remaining complaints recorded in the hostel service book for the same hostel. The process, as discussed earlier, was more or less the same for all the complaints. Once all pending complaints of that hostel were attended to, the electrician and helper

Table 2
Commonly Occurring Electrical Faults in Hostels

Electrical Faults	Possible Causes
Power failure for entire hostel	Fuse gone, etc.
Power failure of specific wing in hostel	Fuse gone, overloading, etc.
Power failure in specific student room	Fuse gone, overloading, switch wire fault, etc.
Tubelight not working	Choke, starter gone, wire fault, etc.
Fan not working	Capacitor, winding, regulator power fault, etc.
Regulator not functioning	Broken knob or wire fault
Switch not functioning/broken switches	Damage, old switches
Miscellaneous	Any electrical fault

Source: Company documents.

returned to EMD and proceeded to the next hostel assigned to them along with the respective hostel service book. The complaint attended remark was then entered into the complaint register subsequent to the inspection of the hostel service book after the electrician had reached EMD.

Outlook of Hostel Community about EMD

The most common electrical problems arising in the hostels and anywhere other than the students' rooms were reported to EMD by the General Secretary or the Warden of the hostels. The students living in the hostel became aware of EMD's existence when they encountered an electrical problem in their rooms. As soon as a certain fault occurred, they enquired at the hostel office and found out the right procedure to register a complaint with EMD. A student faced such kinds of electrical problems once or twice during his stay in the hostel. Overall, the hostel community was satisfied with the services provided by EMD as frequency of electric faults was less though they emphasized the urgency of the repairs by making frequent calls to EMD whenever the faults occurred.

Inventory Management of Spare Parts

As discussed earlier, a lot of electrical spares were used while rectifying the faults. For example, a few items that were managed as inventory spares included switches, chokes, regulators, capacitors, starters and fuse wires. Adequate inventories of spares were maintained in EMD. The inventory was replenished from time to time by IIT Bombay. Hence, the costs of replaced spares were borne by IIT Bombay instead of

by the contractor. However, IIT Bombay ensured the proper usage of electrical spares through a regular audit of the availability and consumption status.

Other Issues

IIT Bombay insisted on a 24-hour availability of electricians in EMD to attend to any emergency that may occur. This meant that EMD was operational round-the-clock as a continuous working system. Therefore, even when there were hardly any complaints from the hostels during the night, Chintamani Electrical needed to assign a team (one electrician and one helper) for the night shift. On a few occasions, the electrician reached the hostel room as per assignment and found the room locked due to non-availability of the student. In such cases, valuable time was lost because the electrician returned to EMD without doing any work.

Second Week of August 2006

On a calm and cool evening, sitting in the hostel canteen, with each extra sip of tea, Hasmukh was thinking about data collection based on his earlier conversation with Vijay Bhogale. It had been some time since he met Bhogale, the supervisor of the EMD for hostels at IIT Bombay. In his previous meeting, Bhogale had discussed his concerns about the productivity of the electricians and waiting time for complaints arriving from various hostels.

Hasmukh had an idea that precise data collection would play a key role in formulating a good improvement plan for EMD. He recollected one of his operations management classes where the professor had emphasized on precise data collection. The professor had said:

> Once you understand the given system completely, the most important task for any model is appropriate and accurate data collection. This alone would lead to the success of your modeling and subsequent analysis. If you fail at this stage, it would result in garbage in garbage out.

With a lot of enthusiasm, Hasmukh rushed to his room and started drawing a process flow diagram of the system. Further, he identified the details of data which had impacted the performance of the system. Subsequently, he prepared a list of data to be collected from Bhogale as shown in Table 3.

Table 3
List of Data Collection

No.	Data to be Collected	Details	Source of Data
1	Arrival of complaints	Arrival rate, hostel proportion, type of complaints	Complaint register
2	Walking time to hostels	Distances	Actual walking time
3	Service time	Time for different types of complaints	Respective hostel service books
4	Resource data	No. of electricians and helpers	Already collected

Source: Company documents.

Data about Complaints

Hasmukh was aware of a lot of confusing data points relating to the arrival of compliants. He guessed that all data points may not be required for analysis. Only representative data was sufficient. He plotted the month-wise data for the number of complaints registered at EMD on a graph as shown in Figure 1. He quickly realized that the July to August data points appeared to be quite different from other data points. Therefore, there were two types of data which divided the entire year into two parts—peak period and normal period. Finally, he collected fifteen days' data each of peak and normal periods listed in the complaint register. Later, the probability

Figure 1
Month-wise Complaints
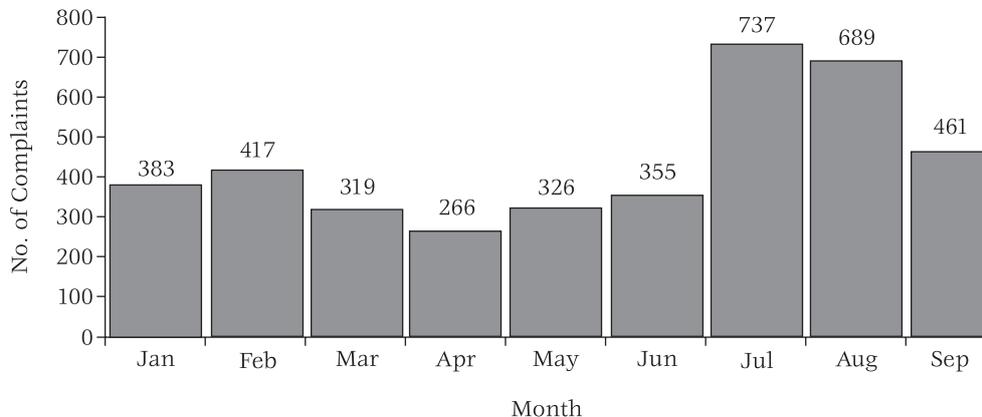
Source: Company documents.

distribution of the arrival of complaints for each period was found out using the statistical probability model.

Another observed trend in the data was that all the complaints were different in nature and distributed across the fourteen hostels. He classified the complaints into four types—hostel major, hostel minor, room major and room minor. Similarly, the hostel's complaint proportions were also found out. Tables 4A, 4B and 4C show the details of the complaint arrival distribution, proportions of four kinds of complaints and the proportion of complaints for each hostel based on data collected from the EMD complaint register.

Walking Time to Hostels

The electrician along with one helper walked to the respective hostel. The time required for walking to the hostel depended upon the distance of the hostel from

Table 4
Details Related to Arrival of Complaints

A. Arrival Distribution for Complaints

Period	Data Collected	Complaint No.	Type of Arrival Distribution (min)
Peak period (July–August)	15 days	2,934–3,488	−0.001 + 119 *BETA(1.37, 4.52)
Normal period	15 days	2,579–2,751	−0.001 + WEIB(69.7, 0.721)

B. Proportion of Four Types of Complaints (Based on 30 Days Data)

Nature of complaints	Hostel Major	Hostel Minor	Room Major	Room Minor
Priority	Priority 1	Priority 2	Priority 3	Priority 4
Percentage	7%	42%	8%	44%
Details	Power failure for entire hostel or some part of the hostel	Tube light, fan not working in hostel passage /toilet	Power failure in specific student room	Tube light, fan, switch not working in student room

C. Proportion of Complaints from Respective Hostels (Based on 30 Days Data)

H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14
10%	8%	9%	5%	5%	10%	5%	5%	10%	4%	10%	6%	6%	5%

Source: Company documents.

EMD and the weather conditions (temperature or rain) on the day. Therefore, he collected the time taken to reach each hostel from EMD by actually walking after dinner between the hostels and EMD. The walking time was found to be uniformly distributed as shown in Table 5.

Table 5
Walking Time between EMD and Hostel: Uniform Distribution (Minutes)

Hostel	H1	H2	H3	H4	H5	H6	H7
Time	10–12	9–11	8–10	7–9	6–8	3–5	2–3
Hostel	H8	H9	H10	H11	H12	H13	H14
Time	4–8	2–3	15–17	5–7	5–7	5–7	6–8

Source: Case writer's notes.

Service Time

The time required to rectify the faults generally depended on the type or complication involved in the electric fault and varied considerably from five minutes to an hour. At times, the electrician replaced the faulty electric parts from available spares. Hasmukh compiled the data of service time required for all four types of complaints from hostel number one to fourteen service book registers as shown in Exhibit 6. Later, he planned to fit appropriate probability distributions of service time for each type of complaint.

HASMUKH'S DILEMMA

Hasmukh was really happy at the end of the data collection process. At the same time, there were a number of questions crowding his mind about approaching and analyzing the EMD situation. He was bothered about how to approach and resolve peak and normal period analysis issues to find an acceptable solution. There was concern over the trade-off required concerning the performance measure for the EMD unit against the hostel units. What performance measures were required for both the units? What were the acceptable values for these performance measures? He was still wondering about what would be the most appropriate operations management technique to handle the current situation, and to what extent improvements could be made to increase the service levels and yet make them profitable.

Exhibit 1
Past Data Related to Number of Complaints noted at EMD

| Month	Start Complaint No.	End Complaint No.	Total Complaints
January	686	1,068	383
February	1,069	1,485	417
March	1,486	1,804	319
April	1,805	2,070	266
May	2,071	2,396	326
June	2,397	2,751	355
July	2,752	3,488	737
August	3,489	4,177	689
September	4,178	4,638	461

Source: EMD register.

Exhibit 2
Organization Structure of EMD (Electrical Maintenance Department)
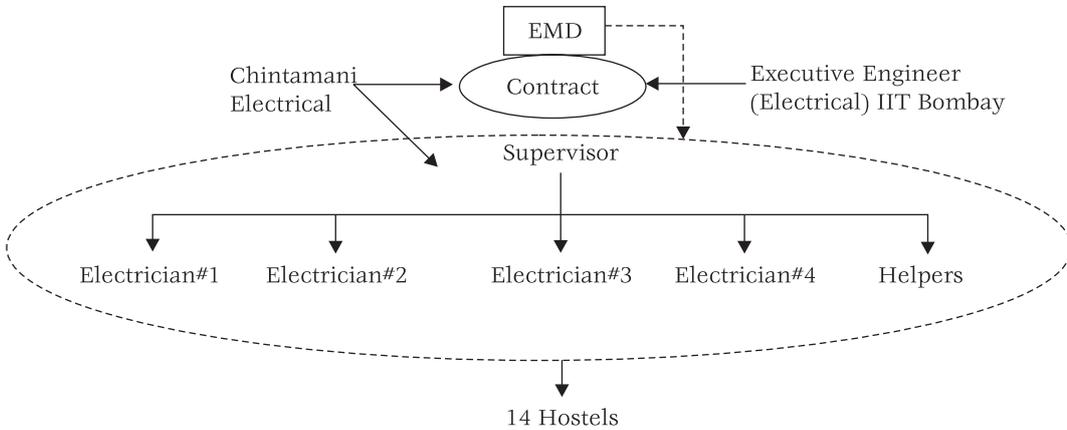
Source: Company documents.

Exhibit 3
Hostel Geographical Map of IIT Bombay
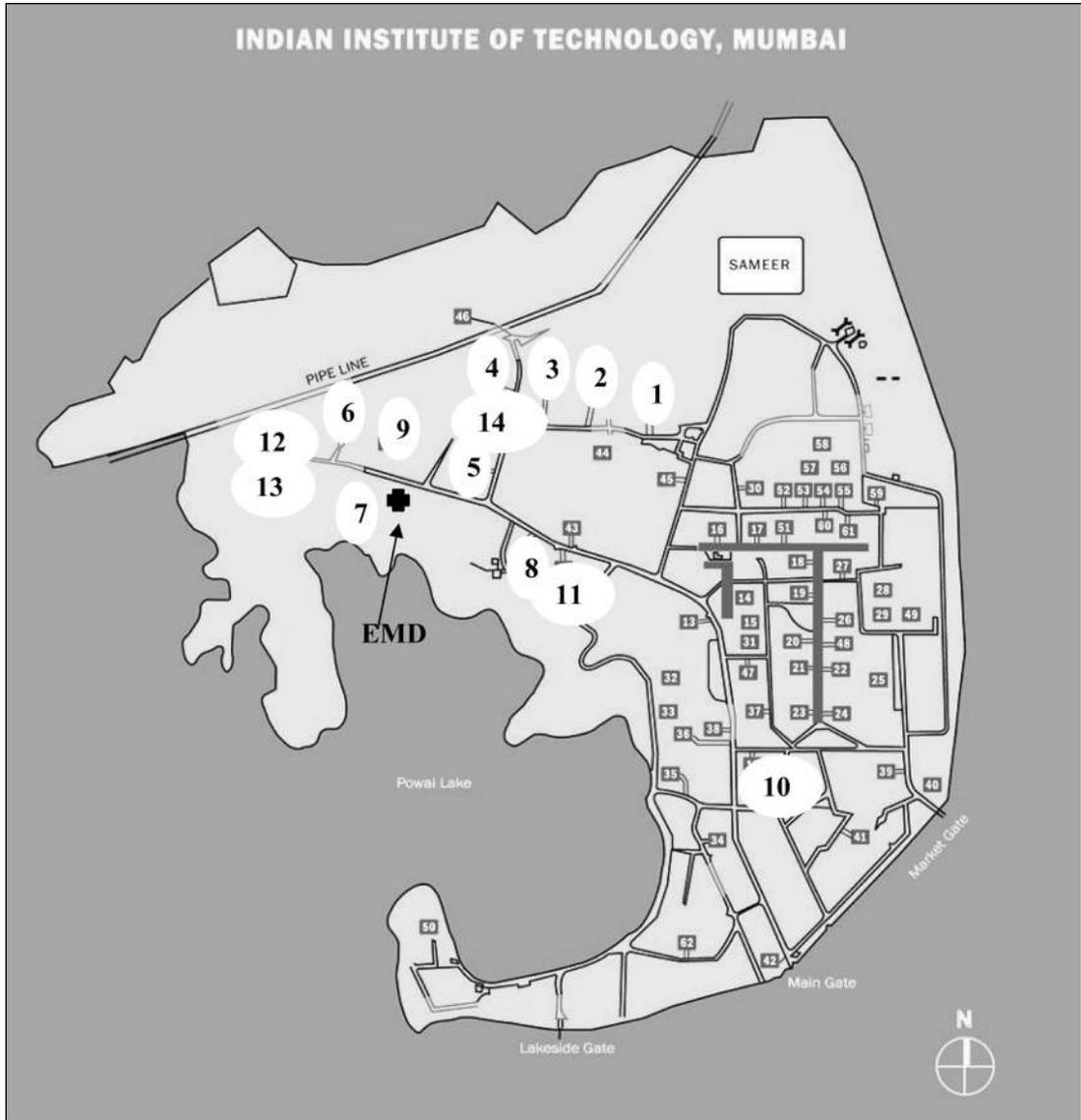
Source: IIT Bombay website (http://www.iitb.ac.in/campus/howto/iitblayout.html). Map not to scale.

Exhibit 4
Complaint Register Page (Representative Complaint)

Complaint No.	Date of Arrival	Time of Arrival	Hostel No.	Room No./Place	Nature of Complaint	Remark
.	.	.	.	.	.	.
2588	16/6/2006	15:30	03	151	Fan	
2589	16/6/2006	15:45	09	341	Fan	
2590	16/6/2006	19:30	14	West wing	Tube light	
2591	16/6/2006	22:30	03	265	Tube light	
2592	16/6/2006	22:45	12	1st floor corridor	Fan	
2593	16/6/2006	22:45	05	155	Regulator	
2594	17/6/2006	09:30	14	2nd floor toilet	Tube light	
2595	17/6/2006	10:30	03	164	Tube light	
2596	17/6/2006	10:40	02	321	Fan	
2597	17/6/2006	12:00	05	232	Switch	
2598	17/6/2006	12:10	06	171	Tube light	
2599	17/6/2006	14:00	09	246	Fan	
2600	17/6/2006	15:00	09	114	Tube light	
2601	17/6/2006	19:50	10	219	Tube light	
2602	17/6/2006	20:30	01	Mess	Tube light	
2603	17/6/2006	21:40	10	282	Fan	
.	.	.	.	.	.	.

Source: EMD register.

Exhibit 5
Hostel 9 Service Book (Finished Complaint)

No.	Complaint No.	Date of Completion	Time of Completion	Room No./Place	Signature of Concern Students/Person	Remark
.	.	.	.	.	.	.
241	2589	16/6/2006	20:45	341	Rao	
242	2599	17/6/2006	16:35	246	Sanjay	Regulator
243	2600	17/6/2006	17:05	114	Ashish Sane	
245	2621	19/6/2006	11.15	2nd floor toilet	Security	Bulb changed
246	2632	20/6/2006	09.35	229	Rajiv	
247	2639	20/6/2006	12.45	113	Anup Phatak	
248	2648	21/6/2006	08.45	Ground floor west side	Hall manager Salunke	Switch replaced
249	2656	22/6/2006	22.20	155	Avinash Narode	
250	2667	23/6/2006	10.50	Mess	Dube Ji	
.	.	.	.	.	.	.
.	.					.

Source: EMD hostel 9 service book.

Exhibit 6
Service Time for Four Types of Complaints (in Minutes)

Hostel Major complaint service time
15, 10, 70, 45, 70, 15, 45, 10

Hostel Minor complaint service time
30, 10, 15, 5, 5, 40, 30, 15, 50, 30, 15, 35, 30, 30, 20, 5, 20, 15, 15, 10, 25, 10, 10, 5, 10, 35, 20, 15, 45, 35, 20, 40, 35, 25, 15, 10, 15, 20, 20, 15

Room Major complaint service time
20, 30, 30, 30, 45, 15, 30, 30, 30, 25, 35, 35, 25, 30, 20, 35, 25, 35, 20, 40, 30, 30, 45, 15, 30, 30, 30, 20, 40, 30, 30, 45, 15, 30, 30, 30

Room Minor complaint service time
20, 10, 15, 23, 20, 18, 30, 10, 17, 5, 5, 20, 15, 30, 35, 35, 15, 30, 30, 10, 10, 10, 15, 30, 10, 20,17, 5, 25, 30, 30, 15, 15, 40, 5, 20, 30, 30, 10, 30, 22, 15, 5, 20, 10, 5, 10, 10, 30, 30, 15, 15, 12, 30, 20, 30, 15

Source: EMD hostel service books.