Capacity Planning for Human Resources in the Software Industry

by

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CAPACITY PLANNING FOR HUMAN RESOURCES IN THE SOFTWARE INDUSTRY

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Abstract: The software industry in India has witnessed tremendous growth in the past few years and is poised to become the industry of the new millennium for the country. With manpower or intellectual capital being the main driver of this industry, it is imperative that the companies take proactive measures to harness, retain, train and deploy these human resources in the most productive manner possible. Currently, the importance of human resource capacity utilization has been sidelined because of the high revenues/margins involved. With margins running high, the hidden costs of wasted manpower capacity are not apparent on the bottomlines of the companies. But as the industry structure changes, competition from other low cost third-world nations intensifies and growth stabilizes, it will be essential for Indian companies to treat the manpower utilization problem with top priority and streamline their existing manpower planning procedures to remain competitive and maintain their profitability. This paper attempts to build a comprehensive framework for resporce planning for software firm. The proposed framework is then used to develop a quantitative model which can be used as a a decision support system to aid recruitment and training in a software company.

Key words: capacity Planning, Human Resorce planning, Software Industry

BACKGROUND

The software industry in India has witnessed tremendous growth in the past few years and is poised to become the industry of the new millennium for the country. Although the performance of the major software companies in India has been excellent, there are significant initiatives to be taken by these companies if they are to exploit the full potential of this boom.

With manpower or intellectual capital being the main driver of this industry, it is imperative that the companies take proactive measures to harness, retain, train and deploy these human resources in the most productive manner possible. Currently, the importance of human resource capacity utilization has been sidelined because of the high revenues/margins involved. With margins running high, the hidden costs of wasted manpower capacity are not apparent on the bottomlines of the companies. But as the industry structure changes, competition from other low cost third-world nations intensifies and growth stabilizes, it will be essential for Indian companies to treat the manpower utilization problem with top priority and streamline their existing manpower planning procedures to remain competitive and maintain their profitability.

OBJECTIVE

The objectives of the study are:

- To analyse the various factors and issues which affect capacity planning of human resources in the software industry.
- To develop a descriptive framework that incorporates these factors.
- To develop a quantitative model which can be used as a framweork for a decision support system to aid recruitment and training in a software company.

It must be noted that although the aim has been to develop a model that optimises the human resource planning in an Indian software company, this model is applicable to any company (irrespective of location, areas of operation) where the key issues and factors affecting the human resource – based activities are the same.

ISSUES IN THE SOFTWARE INDUSTRY

The Indian software industry is currently in a situation where most companies have more projects than they can handle i.e. they do not have the necessary human resources to satisfy the potential demand for their services. At the same time, in most companies it is observed that the capacity utilization of the manpower is not satisfactorily high i.e. there is significant bench-time for a resource (refer Appendix – I). This paradox has persisted because of lopsided manpower planning, hiring and staffing practices. Seen in the framework of the newsboy problem, the cost of overstocking of human resources is not high enough compared to the cost of understocking (lost projects & revenues), which leads to the phenomenon of companies recruiting people for a project much before they have contracted that project. This is further compounded by the severe attrition problem that plagues the Indian software industry – it is not possible to predict the attrition levels and at the same time there is a shortage of high-skilled professionals in the competitive labour market, so this causes a problem with the both the efficiency (high bench-time) as well as the effectiveness (low acceptance to offer ratios) of recruitment and staffing activties.

Moreover if the software industry is to be successful in the longer term, it is imperative that companies move up the IT value chain from activities such as maintenance, offshore development and sub-contracting to systems integration, process improvement and strategic IT consulting. In order to accomplish this, they need access to a manpower base, which is skilled not only in technology but also has thorough knowledge of business and management processes and practices. This manpower base is still underdeveloped in India and unless there are initiatives taken by all the major players, including the Government, the industry will fail to exploit the growth potential.

Within the HR planning function, there is the issue of classifying resources in order to enable efficient project staffing. Due to the explosion of technologies in the information space, it has become increasingly difficult for companies to translate project requirements into manpower requirements and consequently skill

requirements and at the same time organize complementary skills into sets, which can then be treated as resource competencies. For example, in one of the big software companies, which was studied, there were more than 100 skills that were listed as the competencies of the resources – to group these skills in a manner that would enable clustering of resources is a challenging task. On the other hand neither can all resources be treated as homogenous, nor is it possible to have an efficient staffing policy with an ungrouped list of skills.

Even if it were possible to identify skill sets, it is even more difficult to identify costs of transferring a resource with a certain skill competency to another skill competency – these costs would not only include the obvious costs of training but also the ease of transition of the resource. For example, although a resource experienced in COBOL and a resource experienced in C++ can both be given adequate training to learn a new skill viz. Java, the learning curve for both these resources will be very different – it will be much easier for the C++-skilled resource to make the transition than the COBOL-resource.

This study was conceptualised with these issues in the background and the model furnished here is intended to serve as a model that can be implemented as a decision support system for a software company to plan for its human resources in a longer term rather than on a day-to-day reactionary basis. An attempt has been made to integrate these diverse planning issues into a holistic framework that does not look at the human resource planning function as a standalone activity but as part of a larger scheme of inter-dependent activities.

METHODOLOGY ADOPTED

First the existing resource planning methodologies adopted by small, medium and large-size software companies were studied in detail (refer appendix-II for the detiled case studies). From this study, it emerged that aggregate capacity planning and material requirement planning concepts were used to arrive at staffing and manpower planning decisions. It was a very approximate method, which resulted in less than 60% utilisation in the case of the very large companies. In case of the small companies, human resource planning systems and procedures were not formally in place, and the recruitment was more on an ad-hoc basis. Here, staffing as

also on a more informal basis, with project managers and technical leaders keeping track of individual resource skill sets and contacting personnel directly to staff them onto projects. As company size increases, resource pools are formally defined in terms of technology expertise/domains expertise and informal planning and staffing procedures can no longer be applied. Instead, these are replaced by formal and often lengthy processes defined by human resource departments – the objective of these departments is often to just meet the manpower requirement number and not optimise the process. Usually there is no long-term planning which results in consistent resource "overstocking" or "understocking" with rules-of-thumb often being used by project managers in the absence of conceptual and quantitiative tools, to meet contingency requirements.

For the purpose of this study, a qualitative approach using the existing techniques as the base and empirically adjusting existing data to reflect improvements in the planning process was attempted. But in order to arrive at a more rigorous approach, a quantitative model is attempted to be formulated. It would be an adaptation of a linear programming problem, which would preset the parameters and allow the decision variables to dynamically interact. The key issue here would be to identify the interactions among the data variables. For testing the model, some of the parameters were obtained from historical industry data and others were approximated.

FACTORS AFFECTING CAPACITY PLANNING

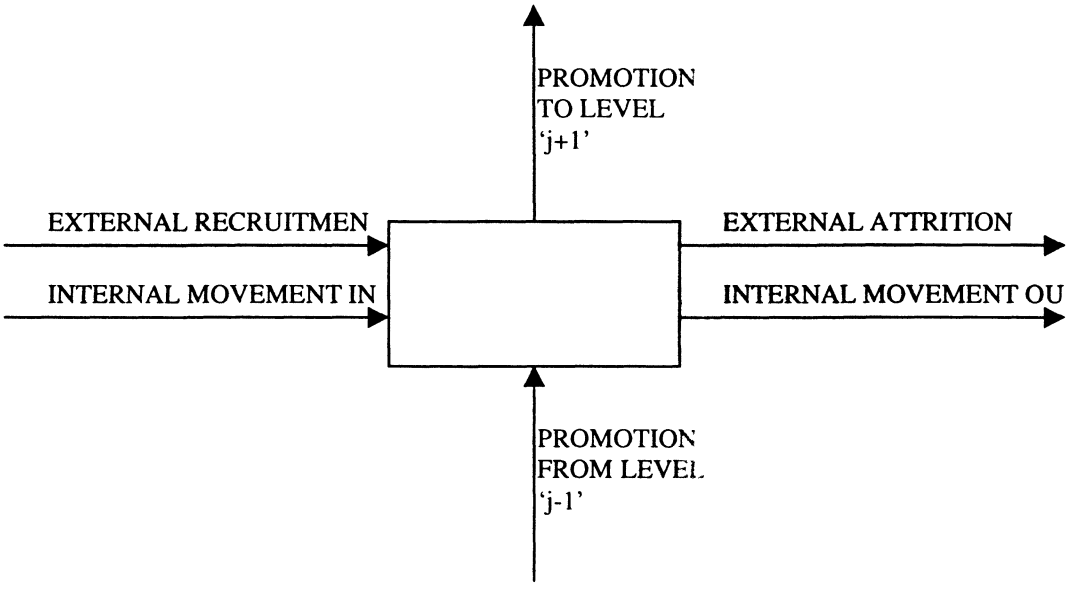
The primary factors affecting capacity planning in the software industry were identified as follows:

- Revenue growth of the software industry: A historical average of industry growth figures was used.
- Revenue growth of the company: This factor can be again decomposed into growth market segment-wise or technology-wise depending on the company.
- Marketing Efforts: This can be either in terms of cost or in terms of personnel. This would be a function of various other factors such as the degree of competition in various business segments the company is operating in, the kind of work the company is into (e.g. a products based company is likely to require higher marketing efforts than a services based company).

- Attrition/Employee Turnover Rate: This is again composed of both the industry historical average and the company average. Attrition rates may also vary by technology and organizational level and the model has been formulated such that this can be reflected.
- Supply of manpower: This is related to the availability of manpower in the IT labour market and is a factor of both the number of fresh graduates as well as the number of experienced candidates.
- Company's position in the labour market: This is a function of the company's brand reputation, salary relative to the industry, the areas of operation of the company etc. This has a direct impact on the effective supply of manpower that is available to the company.
- Training efforts: This can be again treated as a cost or in terms of number of personnel to be trained. It can be decomposed technology-wise also.
- Productivity: This factor is different for various classes of employees such as engineer, senior engineer, manager etc. It also varies amongst individuals of the same category as a reflection of their performance appraisals in the organisation.
- Technology based slippages: Depending upon the dynamism of a particular technology, productivity/schedules of projects based on that technology would vary. Fast changing technologies would also require constant training efforts.
- Free cash flows: This factor acts as a financial constraint on the growth of the company. (Although most Indian companies are more constrained by supply limitations and not cash flows, this factor has been captured)

CONCEPTUALIZATION OF THE MODEL

Based on the issues discussed and the various factors affecting the capacity planning process, a conceptual framework was established. The basis for this framework is the fundamental resource planning unit and the various organizational flows that affect the movement of this resource. The following diagram describes this resource unit and the corresponding flows:



The fundamental resource unit is defined by two parameters: a skill set 'i' and an organizational level 'j'.

A skill set 'i' is a group of skills that are related in some way that enables the organization to both translate project requirements into resource requirements in terms of skill sets as well as identify its internal resources as belonging to one or more skill sets. These skills not only include technical skills (for e.g. knowledge of a programming environment or a software engineering methodology) but also project management skills (for e.g. experience in handling a team of a large size) and client related skills (experience with a particular customer or experience in a particular geographical domain). It must be noted that there is no ready-to-use grouping of skills that can be applied across all organizations – companies will need to identify and group skills into sets depending upon their areas of business, technologies and clients.

An organizational level 'j' is similar to a level in the internal hierarchy of the company – this attempts to capture the vertical organization structure. Each organizational level in the model would typically correspond to one hierarchy level in the organization hierarchy chart.

A combination of the skill set and the organizational level defines a resource pool – an individual resource in this pool is what is referred to as the fundamental resource

unit. There are various activities within the organization that contribute to addition to or removal from a resource pool. These activities change either the skill set 'i' or the organizational level 'j' of a resource. External recruitment & attrition, internal movement in & out are activities that add or subtract from a resource pool by changing the skill set 'i' of a resource. External recruitment is addition to the resource pool from outside the organization whereas internal movement signifies a transfer of a resource to the resource pool from another resource pool, because of additional training or project experience. Similarly external attrition signifies that the resource has left the company whereas internal movement out signifies a movement to another resource pool. Promotion activities change the organization level 'j' of a resource – correspondingly promotion from an organizational level 'j-1' to 'j' signifies an addition to the resource pool and promotion from an organizational level 'j' to 'j+1' signifies a deletion from the resource pool.

DESCRIPTION OF THE MODEL

Based on the conceptual framework identified, a mathematical model describing the variables, preset parameters and constraints was formulated.

How the model works

Most of the factors have been modelled as preset variables some of which are company specific and others which are industry specific. The model works on a very fundamental optimising criterion i.e. profits. By linking revenues obtained from each project to the number of manhours it requires, and to the specific number of personnel required from various technologies and at various levels, and through this to the cost of personnel, the cost of recruitment and infrastructure, the model ultimately attempts to achieve a cost-benefit analysis of various projects. The end result variables which would be of prime importance are the specific projects which must be undertaken by the company, the number of personnel of each technology and at each level that need to be recruited for these and ultimately the projected figures for each of the cost heads i.e. recruitment, employee, infrastructure, marketing and training.

Marketing efforts in this model signify either the effort in terms of the manhours or the funds (part of the free cash flow defined earlier), which are expended by the

marketing department in getting new projects for the company. In this model, we have assumed that marketing effort is a function of the number of projects, which are finally undertaken by the company. Ideally, it would be required to model the complexity of the environment such as competition for specific projects, size of the project in terms of end-revenues and other important factors, which may vary the effort variable between projects.

A decision support system based on the model can be implemented and can facilitate an indepth analysis of the entire planning process in the company. There can be interplay for example between the supply availability and the salaries offered to a resource unit of a certain pool. These interactions can be modelled and the sensitivity of the supply to salary increases can be studied. Similarly, sensitivity of employee costs and recruitment requirements to increases in employee productivty can also be analysed. Scenarios can be built up based on different estimates of attrition at different technology and organizational levels, and based on different growth projections and the corresponding costs and recruitment schedules can be projected.

Variables/Constants

REV = t-1 year's revenues of the company (preset)

G1 = Revenue growth rate targeted => = f(company growth, industry growth, market share of company in various segments of operation) (preset)

G2 = Upper Limit on Revenue growth rate (preset)

Pit = Revenues expected in period t from project 'i' where the classification can be based on market segments, technology or internal organization structures. (preset)

Qijt = The total man-hours required in period t in technology 'j' part of project 'i' n (preset)

Tjkt = no. of people required to be recruited at level k in technology j such that they can begin work on the project in period t.

Rk = productivity factor for employee at level k

H = number of productive hours available per person in a year (preset)

SLACK = preset variable (>1) signifying contingency manpower requirement (preset)

Ejkt = number of people in the organisation expected to be at level k in technology j in period t who are free to work on projects Pi (preset)

Ajkt = retention rate of people in level k, technology j expected in period t (preset)

Yi = 1 if project 'i' is to be undertaken by the organisation

= 0 otherwise

nijkt = number of people required in project 'i' and technology j at level k in period t

Djk = minimum number of people of level k and technology j that must be existing in the company at the end of all the periods (for the bench concept)

ITjj"kt = number of people transferred from technology j to technology j" in time period t at organizational level k

Ju = max space that can be procured for the current year

Je = space units required for one employee

Jc = cost of acquiring one unit of space

ICjj" = cost of transferring one employee from technology j" to technology j (here assumption is that this cost is level independent and doesn't require significant lead time). This cost includes a notional cost of transferring + a training cost.

FCFt = free cash flow available at the end of period t

TRCt = total cost of training in period t

RECt = total cost of recruitment in period t

EMCt = total cost of employee salaries in period t

INC = total infrastructure costs (a function of the employee costs)

MKC = marketing efforts as a cost (a function of the number of projects undertaken)

SPC = total space cost

ITCt = total inter technology transfer costs in period t

M1 = preset multiple relating EMC to INC

M2 = preset multiple relating employees to project managers (ratio)

$M3_k$ = preset multiple relating to promotional policy of employeel in level k to level k+1

M4 = preset multiple relating recruitment cost to number of ppl recruited

M5 = preset multiple relating marketing costs to the number of projects undertaken

Wk = average salary of an employee at level k in the organisation (preset) for one period t

Wk" = average salary of an employee at level k in the organisation (preset) for one period t during the training period only

Cj = cost of training one person in technology j (preset)

Sjkt = number of people of level k expertise in technology j available for hire in the job market in period t (includes project managers also) for the company to choose from (preset)

Objective Function

Maximize Π: Z = Revenues - Costs

$= \sum_i \sum_t \{Y_i * P_{it}\} - [\sum_t \{TRC_t + REC_t + EMC_t + ITC_t\} + MKC + INC + SPC]$

where revenues is a sum of the revenues of the individual costs selected the model and the costs include the various cost heads explained above.

Subject To: Constraints

$\sum_j \sum_t \{Y_i * P_{it}\} >= G1 * REV$ <LOWER LIMIT ON REVENUES>

This constraint takes into account the company's requirement of a minimum growth percentage to be achieved in the coming period.

$\sum_j \sum_t \{Y_i * P_{it}\} <= G2 * REV$ <UPPER LIMIT ON REVENUES>

This constraint takes into account the company's requirement that growth percentage to cannot exceed a maximum percentage in the coming period. This is a function of the industry growth, company performance, financial resources etc.

$H * \sum_j \sum_k \sum_t \{E_{jkt} + T_{jkt}\} = SLACK * \sum_j \{Y_i * \sum_j \sum_t \{Q_{ijt}\}\}$

<MANHOUR CONSTRAINT>

This constraint takes into account that the manhour requirement at an aggregate level must be met. A compay specific SLACK may be enforced.

$H * \sum_k \{R_k * n_{ijkt}\} >= Y_i * Q_{ijt}$ for all i,j,t

<PROJ-TECH MANHOUR CONSTRAINT>

This constraint takes into account that the manhour requirement at an individual project and technology level must be met in every period. The manhour constraints are only project-specific and technology specific and not level specific although in some companies manhour requirement may be defined in terms of organizational levels or designations also. This feature can be incorporated in the model later. Here the productivity factor (assumed to increase as one moves up in the organization due to learning curve/experience effect) is used to indicate that it may be more beneficial

to the objective function to use available people at higher levels than say recruit and train people at lower levels.

$E_{jkt"} >= D_{jk}$ for all j,k and where t" is the final period

<MINIMUM EMPLOYEE i.e BENCH CONSTRAINT>

This constraint takes into account that the number of people in the organization at the end of all the periods must be greater than a certain preset number for every project, technology and organization level. This relates to the bench concept, similar to minimum stock in hand rules in traditional industrial companies. The figures for minimum number would vary from company to company.

$T_{jkt} = \sum_i \{ n_{ijkt}\} - E_{jkt}*A_{jkt} - \sum_{j"} IT_{jj"kt} + Excess_{jkt}$ for all j,k,t

<RECRUITMENT EQUATION>

This is the main recruitment equation where the number of people to be recruited for a technology and level in a time period equals the number of people required at that level and technology less the number existing in that technology and level post-attrition less the number of people at that level that can be transferred from other technologies. This constraint is defined for every technology and every organizational level per period. The variable Excess will be set if there is more manpower existing than is required at that level and at that technology in that time period.

$IT_{jj"kt} <= E_{j"kt} * A_{j"kt}$ for all j,j",k,t and where j not = j"

<INTER TECHNOLOGY TRANSFER CONSTRAINT>

This condition specifies that the upper limit for a transfer from one technology to the other is the number of people in that technology existing in the organization.

$E_{jkt+1} = E_{jkt}*A_{jkt} + T_{jkt} + E_{jk-1t} * M3_{k-1} - E_{jkt}* M3_k + \sum_{j"} (ITjj"kt - ITj"jkt)$ for all j,k,t, j" (j" not equal to j)

<RESOURCE FLOW EQUATION>

This constraint calculates the number of employees in the organization at the beginning of period t+1 at every technology and organizational level as:

Number of employees of the same level existing in the previous period after attrition in the previous period +

Number of employees of the same level recruited afresh in the previous period +

Number of employees in the previous level promoted to the present level in the previous period –
Number of employees in the same level promoted to the next higher level in the previous period +
Number of employees transferred from other technologies to this technology –
Number of employees transferred from this technology to other technologies.

T_{jkt} <= S_{jkt} for all j,k,t <SUPPLY CONSTRAINT>

This enforces the labour market condition as an upper limit for the number of people to be recruited by the company. The variable Sjkt is technology and level specific and takes into account the company's bargaining power in the labour market at various tech-levels which is a factor of the company's pay scales vis-à-vis the industry, the competition for recruitment, the brand equity of the company, the quality of projects etc. (Note: it is not the total number of people at a tech-level available in the market but the number of people available to the company after taking into account the above mentioned factors)

$J_u >= \sum_j \sum_k [T_{jkt} - E_{jkt}*(1-A_{jkt})] * J_e$ for all t <SPACE CONSTRAINT>

This constraint attempts to model the real world situation where it may not be possible to expand beyond a certain number in the short-term due to space constraints. Hence a space availability upper limt is related to the number of employees that can be recruited.

$TRC_t = \sum_j \{C_j * \sum_k \{T_{jkt+z1}\}\}$ <TRAINING COST EQUATION>

This defines the formula for the training cost – basically a product of the cost of training per person in a technology and the number of people to be recruited at that technology. Currently it is assumed that cost of training for a technology is same across organizational levels, which is not the case in reality. This of course can be incorporated by adding level specific training cost constants in the model. Here z1 is the lead time for training (assumed to be constant across technologies).

$EMC_t = \sum_k \{W_k * [\sum_j \{ T_{jkt} + E_{jkt}*A_{jkt} \}] + \sum_k \{W_{k''} * \sum_j \{T_{jkt+z1} \}\}$
<EMPLOYEE COST EQUATION>

This equation defines the employee cost as a product of salary per employee at an organization level and the number of people existing and to be recruited at that level (across technologies), summed across all organizational levels. It takes into consideration that a different salary may be paid to new recruits under the training period.

$\mathbf{REC_t = M4 * \sum_j \sum_k \{T_{jk,t+z1+ z2}\}}$ <RECRUITMENT COST EQUATION>

This relates the recruitment cost in period t as a multiple of the total people to be recruited by the organization to begin work in period t + z2 where z2 is the lead time in periods for recruitment. Ideally, there would be a fixed component to this cost, but it has been ignored for modelling purposes.

$\mathbf{ITC_t = IC_{jj'} * \sum_k \{IT_{jj'kt}\}}$ <INTER TECNOLOGY TRANSFER COST EQUATION>

This calculates the inter technology training cost based on the preset costs (notional + training) of shifting personnel between technologies.

$\mathbf{INC = M1 * \sum_t EMC_t}$ <INFRASRUCTURE COST EQUATION>

This equation relates the infrastructure costs (does not include new office space) such as computers, printers, electricity, other office equipment to the employee cost. The infrastructure cost is actually largely a fixed cost, but the variable defined here represents the variable part, which is dependent on the total employees in the organization. Hence it is a reasonable assumption that this cost would be a fraction of the employee cost (salaries) of the organization.

$\mathbf{MKC = M5 * \sum_j \{Y_i\}}$ <MKTG COST EQUATION>

This equation relates the marketing effort to the number of projects to be undertaken by the organization. This is a simplistic assumption, which can be modelled in a detailed way for a specific organization.

$\mathbf{SPC = J_c * J_e * \sum_j \sum_k \{E_{jk0} + \sum_t [T_{jkt} - E_{jkt}*(1-A_{jkt})]}$ <SPACE COST>

This defines the total space cost as a function of the number of employees including the space to be acquired for employees who are to be recruited for the coming period. In reality the existing space in the organization may have been accounted for

in the past periods, but here a notional opportunity cost is assumed even for the existing space.

$TRC_t + REC_t + EMC_t + ITC_t <= FCF_{t-1}$ <FREE CASH FLOW CONSTRAINT>

This constraint specifies that the sum of all the period specific costs specified in the model must be less than the free cash flow available to the company in that period. Ideally, cash flows would differ within the period as project phases are completed and part-payments are received but for the model, a fixed figure has been assumed which would be available at the start of the period.

$\sum_t (TRC_t + REC_t + EMC_t + ITC_t) + INC + MKC + SPC <= \sum_t FCF_t$ (0 to t –1)

This constraint specifies that the sum of all the costs for the entire year specified in the model must be less than the free cash flow available to the company for the entire year.

$FCF_t = FCF_{t-1} + \sum_i Y_i P_{it} - (TRC_t + REC_t + EMC_t + ITC_t)$

This calculates free cash flow available to the company at the end of period t, which is the income in the period t less the expenses in the period t.

$\sum_j Ejkt >= \sum_i \{Yi\}$ where k is the level of the project manager and for every period t in consideration

<PROJECT MANAGER MINIMUM NUMBER CONSTRAINT>

This takes into account the requirement that there must be one manager for every project to be undertaken by the company in any period of consideration.

$\sum_j E_{jk"t} >= \sum_j \sum_k [T_{jkt} + E_{jkt} * A_{jkt}] / M2$ for all j and for (k = 1 to k"-1) and k" is the level of the project manager, for all periods t

<PROJECT MANAGER MINIMUM NUMBER CONSTRAINT>

This takes into account the fact that there should be a certain proportion of project managers compared to the number of employees under the project manager level. Usually this condition is imposed for large projects where there may be multiple project managers.

Similarly we can have minimum number constraints for employees at various levels.

Variable description and data sources

VARIABLE/CONST #	DESCRIPTION	DATA SOURCE(S)
REV	Revenues of past year of the company	Company records
G1,G2	Minimum and maximum expected growth rates	Company's prosepects – perceptions about ability to manage future growth
Pit	Project revenues in a time period	Marketing/Project groups projections
Qijt	Manhours required for a specific technology part of a specific project in a time period	Project Group projection
Tjkt	Number of people to be recruited by the company for specific technology at a specific orgn level in a specific period	To be calculated by the model
Ejkt	Number of people currently available and skilled in a particular technology at a particular organisational level.	Human Resource Group/Individual SBU's
H	Number of productive hours available per person (at the lowest productivity level) per year	Human Resources Group
SLACK	Required extra staffing to ensure meeting of	Project/ Technology/ Marketing group

	contingencies	
Ajkt	Attrition rate at a specific organisational level in a specific technology for a time period t	Human Resources/ Technology groups
Nijkt	Number of people required on a specific project in a specific tehnology at a specific level	Technology/Project/Marketing Grpups or Client inputs
Cj	Cost of training in technology j.	Human Resource/ Training department/ Technology Group.
Yi	Binary variable which when taking the value of one implies the project should be accepted else should be rejected	To be calculated by the model
TRCt	Total cost of training calculated from recruitment figures and training costs for specific technologies	HR/ Training / Technology groups
RECt	Flat cost that will determine the cost of recruitment depending upon the levels of recruitmentl	Cost figures to be gathered from the Human Resources Group.
EMCt	Costs associated with having an employee on rolls (Salary , perks etc)	Human Resources group
INC	Costs associated with	Considered multiple of

	providing necessary infrastructure to the employees	employee costs
Npm	No of project managers on a project	To be calculated by the model
Sjkt	number of people of level k expertise in technology j available for hire in the job market for the company to choose from	Human Resources Group/ Marketing Group
M1	Multiple relating EMC to INC	Human Resources Group
M2	Multiple relating employees to project managers (ratio)	Human Resources Group
M3	Multiple relating to promotional policy to project managers	Human Resources Group
M4	Multiple relating recruitment cost to number of ppl recruited	Human Resources Group
M5	Multiple relating marketing costs to the number of projects undertaken	Human Resources Group
Je,Jc	Multiples relating to space units and space cost	Administrative department
ICjj"	Cost of transferring personnel from technology j" to	Human Resources Group

	technology j	

FUTURE EXTENSIONS TO THE MODEL

1. **Strategic Issues:** In many companies certain projects may be taken up by the company although they may not be financially attractive due to various strategic reasons such as:
    - Entry into a new market/segment – the company may use the project as a way of entering a market where it does not have a presence and get a toehold in this market/segment.
    - Important client – the project may involve a client who is very important for the company. Although the project per se may not be attractive, the company will be forced to undertake it in order to maintain a long-term relationship with that client.
    - Experience in a new technology – the company may want to position itself on some new technology or it may be developing products internally based on some technology in which it has no prior experience. Hence such projects will play an important role in acquainting the engineers to this new technology.

2. **Positioning for the High-End of the Value Chain:** Currently, the Indian software industry operates at the lower end of the IT value chain where projects consist of low-margin activities such as implementation, maintenance or Y2K transition. The higher-end which involves business consulting, system analysis, design and integration require knowledge of different & more complex skills/technologies. This would entail certain costs for the company in the initial stages of exploring this value segment and revenues in the short run may not justify their expenses. But strategically this might be the only sensible thing to do given the need for rapid growth in revenues and profitability. So a cost-benefit analysis would not suffice for such cases and the model should accommodate the additional constraint that such projects should be taken up even though they have no positive impact on the bottomline.

3. **Resource classification:** Another important issue is to identify how a resource would be defined. At lower levels of the organizational hierarchy it would be sufficient if the resource is defined in terms of the technologies in which the person is skilled at. But at higher levels of the hierarchy certain other attributes like inter-personal skills, experience in a particular geographical area and skill at handling clients become very important. These should be incorporated into the resource classification schema.

4. **New product development:** In the long run companes need to utilise the accumulated knowledge from project related activities to drive their efforts in product development. Such a migration is very beneficial from the point of view of enhancing revenues without being constrained overly by the supply of manpower. So, at any point of time it would be preferable if certain percentage of resources could be allocated activities related to new product development. A constraint which specifies certain minimum effort into product development projects can easily be modelled.

5. **Stochastic nature of the business:** There is always an element of probability being associated with acquiring projects and also the revenues accruing from them. Incorporating this stochastic detail would make the planning process more reliable. Currently the model assumes a deterministic approach for resource planning.

EXTENDING THE MODEL TO FORMULATE GOVERNMENT POLICY

The Indian software industry is poised on the edge of a major boom. The Government on its part has made it clear that it would support the sector and provide it with the infrastructure and institutional support needed to convert India into an IT powerhouse. Institutional support has been in the form of offering fiscal incentives such as tax exemptions, zero customs duty, 100% FDI licences and infrastructure support has focussed on providing facilities like setting up Software Technology Parks in various cities across the country.

The Importance of Human Resource Planning

But, one parameter on which serious policy planning has been neglected has been the area of the sophisticated Human Resources needed to support growth in this sector. A study commissioned by NASSCOM (National Assocaition of Software and Service Companies) has said that IT has got the potential to revenues of $87 bn by the year 2008, which in turn would mean 2.2 mn people being employed in this sector. This is a huge number compared to the number of IT professional who are currently employed.

So far there has been no roadmap which details out how the required number of skilled workers would be trained or what are the specific policy decisions the Government should take to successfully find the numbers. Several scenarios are possible. The figure of 2.2 million would be reduced substantially if Indian software companies migrate to the value added software services segment whch is the high revenue generating segment in a big way. But so far there have been no signals from the Indian software industry that it is prepare to abandon the traditional service areas in favour of the high return services that are attendant with high levels of skill as well as risk. The requirements in terms of academic training and skilling in the traditional programming and maintenance model is different from the requirements needed to migrate to the high end IT consulting or software products segment, where usually the levels of expertise on both technical and managerial dimensions is high. So apart from the companies' willingness to migrate to the high value segment, the educational policy of the Government should ensure that there is a continuos stream of such highly qualified skilled resources. This factor is very important given the unceasing migration of Indian IT professionals to greener

pastures in the West. The Government should then start investing in such institutions which provide the requisite training so that India can bridge the gap in technical and managerial capabilities needed to compete effectively in these segments.

In addition to this there are other sectors in the IT space like remote call processing where the skill levels required are lower than those required in the current operating space of the Indian software companies. The training needs required to compete in this sector are entirely different and the Government has to plan for them differently. A lot also depends on what is the ultimate aim of the Government. If maximising revenues is the main concern then, a shift to the high value segment looks the best bet though it has its own risks. But if the Government aims to increase employment then the potential in the low value remote call centre processing segment would be high. Of course the ideal scenario would for the Government to able to positively influence all the areas in the IT space, but that would be asking for too much.

To achieve all that has been stated above will not be easy for the Government because of several problems which constrain its freedom of action. The first and foremost is the ability of the Government to channel funds into the IT sector at a time when it is already hard pressed to find money for other more basic social and economic priorities. Also there is a natural limit to the growth in the number of academic and training institutions which limits the supply of available manpower. There are infrastructural bottlenecks, which the Government has to tackle effectively if India is to retain, its brand equity in the IT sector. This would mean an additional cost burden on the Government. An institutional framework in terms of the proper legal structures and policies governing business practices should be put in place.

In terms of a mathematical model, the various goals that the Government sets for itself can be seen as the Objective Functions that have to be achieved optimally subject to the constraints which limit the effectiveness of the Governments actions.

Conceptually, from an Operations Research problem point of view we have listed down the alternatives that could serve as Objective Functions and also the various constraints under which these Functions are optimised. In conjunction with the mathematics that we have detailed in our earlier model the current framework can

serve as a policy guideline to the Government. In addition to giving set answers for the decision variables, the model can also serve as a simulation tool to conduct critical tests like sensitivity analysis, which improve the effectiveness of the decision making process.

What should be the objective of the model

The objective of the model could be looked at from a goal-programming perspective as achievement of the following goals for which priorities have to be first defined:

- Maximise total revenues from the software industry.
- Maximise labour employment in the high technology sector.
- Maximise revenues from software exports.
- Maximise revenue per person in the IT industry. (Migrating to the higher end of the value chain).
- Maximise the number of software companies in India.
- Maximise MNC investments in India.
- Maximise India's market share in the global IT marketspace.
- At a very broad level maximise the GDP.

Achieving each of these goals/objectives separately would mean a different strategy to be adopted by the government/Indian companies. Instead these would have to be prioritised and a mix-and-match of growth strategies would need to be adopted to achieve an optimal result.

What are the constraints/factors/levers to be taken into account

- Availability of Government funds to channel into the IT sector.
- Growth of training institutes in the country. This imposes a labour supply constraint for the technical manpower.
- Availability of managerial talent – This is important if the IT industry needs to move towards managing large projects and moving towards the higher end of the value chain.
- Demand side constraint- depends on India's brand equity, competition, relative labour cost advantage and other macroeconomic factors. Another factor is the size of the various market segments (products, IT services, IT enabled services etc).
- Geographical market segments – which countries to target.

- Development of complementary industries particularly infrastructure bases like telecommunications and hardware industry.
- Factors associated with political risk like attitudes towards MNC investment.
- Growth of a sophisticated domestic market.
- Tax incentives, import duties, investment sops, reaptriation policies, risk coverage, cyberlaws etc.
- ESOP policies and ESOP taxation issues.
- Access to venture capital.
- External growth - Faciltation of mergers and acquisitions at a global level.

REFERENCES

1) Operations Research, Hamdy A. Taha, 1989
2) Findings of NASSCOM-McKinsey Study, Indian IT Strategies 1999

Appendix-I

Company	Year	Quarter	Human Resources		% Employee Utilization	
			No of emps added	Total No of Emps	Including Trainees	Excluding Trainees
Infosys	1999-2000	Q3	218	4,996		
	1999-2000	Q4(Yearly)	393	5,389	76.60%	81.50%
	2000-2001	Q1	1,056	6,445	74.90%	85.60%
	2000-2001	Q2(Half Year)	1,480	7,925		80.50%
	2000-2001	Q3	985	8,910		77.60%

Source : Company website
www.infy.com

Appendix -II

This appendix describes the human resource planning process at 4 software companies of different sizes studied for the purpose of the study.

Case Study-I

CAPACITY PLANNING AT A LARGE INDIAN SOFTWARE FIRM(1)

This company is part of a large Indian business group. It is one of the largest and oldest software companies in the country and has been a pioneer in the software services segment.

Organization Structure

The organization structure is divided into verticals and horizontals. The verticals are domains like manufacturing, retail etc. whereas the horizontals refer to technology groups like Enterprise Resource Planning or E-Commerce.

Aggregate Planning

The Annual planning process deals with resource requirements that can be worked out by taking into account different factors that are generic to the software industry as well as factors that are specific to the company.

First the current strength of resources in the various divisions of the company is gathered and analysis of utilization rates are gleaned from it. The current year's financial performance serves as a useful benchmark and starting point for the planning process. Inputs are then solicited from the project managers and technical leaders on the field who have a close interaction with their clients. This gives reasonably clear information as to how much business is forthcoming from these clients and consequently what would be the resource requirements that have to be fulfilled to meet the business.

Marketing teams supply information about the kind of expansion that is expected to take place in their respective geographical spheres. Also information about the market like market size, number of competitors, strength of the competition, prospective customers and problems of establishing a presence in new markets are provided by these marketing personnel.

The technology teams analyse emerging technologies and market trends in these technology areas and identify competency requirements – both which are already existing within the company as well as those that need to be built up. Following this, the investments needed to build up competencies and the strategies to establish the company's presence in new technology markets are decided upon.
Superimposed on all these would be the Corporate Policy of the top management - using the inputs from the various sources cited above, projections are made for the different areas and planning is done accordingly.

Resource Acquisition

Like most large Indian software companies, this company follows a variant of the traditional MRP technique where the forecasting output serves as an input for the resource planning and acquisition activity. Depending upon the annual targets set for each division within the company and the number of billable employees existing within the company, plans for frest recruitment are drawn up.

Recruitment is carried out at various levels - freshers are usually recruited from campuses and are made to undergo an induction program. Experienced people (with 2-3 years of work experience) undergo a written skill-based test followed by interviews. For individuals with more than three years of work experience, the selection is done via multiple rounds of interviews.

Recruitment takes into account both the required growth and the expected attrition rates from the various groups. Annual plans usually address the broader issues pertaining to recruitment - strategies to improve the image of the company, advertisements, campuses to be covered, on-time recruitment, pipeline management etc. In order to have on-time recruitment, measures are being taken to have the recruitment staggered rather than having it at one go. Apart from this the company also maintains a database that contains the skill profile of each employee and his/her project allocation history details. There is a central allocation team that assigns a person with the matching skills to the required project groups. A central resource pool of free resources is maintained at the corporate level to cater to dynamic resource requirements.

The tendency to hoard free resources in the past gave rise to serious mismatches in supply and demand within the company. For example, when a group needed a person with particular skills and that resource was available with some other group, he would not be released because of the group head's desire to hoard him for an emergency. This problem has now to a certain extent been solved with the deployment of the central resource pool database where all the allocation and skill details of a resource are stored with constraints that a resource cannot be held idle for more than a particular period of time.

Office space, computers and other physical resources are planned for well in advance of the human resource requirements.

Case Study- II

CAPACITY PLANNING AT A LARGE INDIAN SOFTWARE FIRM (2)

Background, Structure and Organization

This company is one of India's most reputed corporate organizations which has shown spectacular performance at the stock markets. It has now grown in size to be one of the largest companies in India in the software sector and aims to keep growing at the current pace for some time. The company also has subsidiaries in the United States of America. The firm is basically a software services firm with a minimal interest in the off the shelf software products market. It also plans to enter into the higher end of the IT consulting value chain.

The company comprises of various Business Units and Support Services.. For the purposes of planning the Business Units are further grouped on the basis of standard service offerings like development and maintenance and specialized service offerings like Internet consulting and Engineering Services.

The basis for this classification is that the planning process for the standard service offerings can be based on past data whereas planning process for the specialized services depends on the market situation.

Planning and Project Staffing

There are two approaches to planning at the company.

1) Top Down
2) Bottom up

But top down planning is given primacy for the calculation of performance measurement data. Basically in the top down approach, the planning process has its base in the sales projections. There is a five Year rolling plan which is generated based on certain targeted rates of growth.

The sales and revenue figures are allocated to the various business units and the targets are broken down further to a quarterly level. After that a process very similar to MRP in the manufacturing context takes over.

An important parameter in the whole planning process is the revenue productivity, which is the revenue per billable employee. This figure is a weighted average of the off shore and on site rates for employees of a particular business unit. For units with generalized offering this data is based on past information. But usually the rates for new clients are higher than those for existing customers. For the units with

specialized offering the billing rates are fixed by talking to personnel on the field as well as soliciting advice from experts.

Once the targets are broken down to a quarterly level and the billing rates are worked out the number of billable employees required to achieve the targets is then worked out. Then the number of employees already existing on the rolls is compared with the number of employees required as per the revenue targets . At this stage the number of new employees required with suitable skill sets is notified to the HR department and this becomes the basis for recruitment.

Recruitment

The HR department usually works with a lead time of 1 year for the recruitment process. This happens as past experience indicates that it is very difficult to acquire resources at short time intervals, and also because of the fact that the quality of people coming in through campus recruitment is much better. There is a training period which ranges from 0-3 months depending upon the experience of the resource. This also adds to the lead time. While planning for recruitment, attrition data from the past is also taken into account and the recruitment figures are suitably adjusted. Also the number of people made offers is planned based on the hit rates from the past ie., the number of people who have actually joined after being made an offer.

Depending upon the skill sets asked for, the training calendar is drawn up by the training staff. Effort is taken to ensure that the training imparted in the class room corresponds to the skill sets required by the individual business units who request for resources.

Infrastructure Planning

The corporate planning process throws up the physical space and the infrastructure that needs to be provided. Taking this as the benchmark figure the Facilities department starts acquiring the requisite infrastructure. The Facilities department operates with a lead time of 15 months as expanding or acquiring a new facility takes that much time. Generally there is a degree of interaction between the Training and the Facilities department for planning the training space required.

Case Study - III

CAPACITY PLANNING AT A MEDIUM SIZE INDIAN SOFTWARE FIRM

Company Background

This is a medium-size company that has been a pioneer in the high-technology/communication area and has been extremely successful in these segments, catering to a wide range of top telecom and semiconductor companies in the U.S.

Organization Structure

The company is organized into 4 various divisions viz. Service, Technology, Mobile Software, Internet Access.

1. The Services division is more customer-centric and the work involves integrating with network equipment manufacturers to migrate equipment to broadband and wireless. The clients are usually large semiconductor companies. This division accounts for almost 50% of the revenues.

2. The Technology division is research-centric and is focused on developing advanced communication technologies such as ADSL-based and modem-based technologies and licensing these technologies to other companies. This division accounts for about 20% of the company's revenues. Here, the cost of salaries as a percentage of total cost is very high in the initial period when the technology is under development. Later, when the technology is stable and customer acquisition begins, the marketing costs increase as a proportion of the total cost. It takes about 3 years to develop a sustainable technology which involves developing market awareness, and training the staff. A successful technology breakthrough results in another 3 years of customer development to attain market leadership and finally royalties.

3. The Mobile Software division works on developing components for the mobile and multimedia market and accounts for about 30% of the company's revenues.

4. The Internet Access division is a newly created group within the company and focuses on creating communication/network products for the Internet market such as Wireless Access Protocol (WAP) gateways to integrate with portals and messaging gateways.

Resource Structure and Project Staffing

The following insights were gained into the resource structure and staffing policies of the company:

- The company vertically organizes its resources in a BAND. The Band ranges from level 1 (the CEO) to level 5. Band Level 5 is usually the entry level and is assigned to software/design engineers. Band Level 4 is for the technical and project leaders who have management capabilities and team building skills. The resources in this level must have the ability to create and lead a team, identify requirements, delegate responsibilities and split requirements into modules. Band Level 3 is for the commercial managers, where knowledge of business development, customer acquisition and knowledge of contractual procedures is essential. These managers must have a perspective of various technologies and must be able to orchestrate solutions depending on varying customer requirements. Band 2 is for the long-term visionaries – they handle the strategic thinking and chart the future course of the company.
- In addition there is a horizontal function-wise organization of the resources, classified by the type of work viz. tester, developer, architect. These positions are across bands and do not signify any kind of hierarchy within the company. Architects are usually "Individual Contributors".
- Within a division, there is further classification of managers depending on the job-profile. For example, the Services division has Domain Owners who generate and operate resources within the division and Account Owners who run customer accounts. On the other hand, the Mobile Software Division is organized on traditional functional lines such as quality, standards, customer management etc. The technology division has relationship managers who are again account based but more involved with single/group of customer than the Account owners of service division.
- The company operates a Worldwide Sales team which is responsible for identifying successful products and pushing them further into the market. Each

division however has its own marketing team – these resources typically have a detailed knowledge of the relevant technology in order to assess customer requirements and evaluate the feasibility and cost of the company's technologies/products in meeting these requirements and at the same time a flair for marketing.

- There is no significant lateral movement between divisions. Inter-technology transfers at the lower organizational levels happen only a person is interested in moving to a different technology – the initiative is never from the company's side.
- There are some specialist skills required for the company as a whole such as knowledge of telecom protocols, standards, DSP algorithms etc. due to which the recruitment policies of the company are quite strict.
- At the manager level, transfers are actually value-adding for the company as there is a close relationship between the various domains in which the company operates. Hence knowledge of a parallel-related domain often helps in developing a deeper insight into prediction and assessment of technology-based markets.
- Knowledge base of working with particular customers is built by employees (non-technical knowledge) as customer contacts and relationships are developed. This acts as a barrier between transfer of employees between technologies/groups as the knowledge cannot be transferred.
- Business plans are submitted by unit heads. These have resource requirements and budgets which are met on a short-term (quarterly) basis. The support staff match the indents with the available/free personnel pool and then take initiatives (internal and external) to meet the requirements.
- Infrastructure planning is done in the company in parallel with the people planning.
- Projects are reviewed on weekly, monthly and quarterly basis. In the weekly and monthly meetings, exceptional manpower requirements and issues are discussed and steps are taken to meet the contingencies. In the quarterly reviews, the issues raised are of a broader scope - problems of the strategic nature pertaining to the business as a whole and succession planning are discussed.
- The free pool of resources is not part of any information system and the HR has to find out whether a resource of a particular type is free in the organization by

contacting various project leaders. The company earlier had a system of internal advertising to fill job positions in various projects, but this created a lot of problems as there was lot of lateral movement.

- Attrition is not predicted at the company, and it is treated as an exception. However, it is taken into account at the project planning level while preparing project schedules.

Resource Acquisition and Operation Policy

The company operates on the principle of minimizing the bench time of a resource, which is the time between acquisition of the resource and billing of the resource, as well as time between projects when the resource is idle. This is the offshore development centre business model. The concept of resource utilization is important from the investor's perspective. There is also a trade-off between utilization and top line growth. When utilization is very high, there is little slack in the system and hence this may lead to lost projects i.e. lost revenues. But when utilization is very low, it is similar to locked up inventory capital or idle investment. As far as the company's policy of resource acquisition is concerned, where the resource need can be predicted reasonably accurately and well in advance, it acquires the resources beforehand and keeps them on the bench. Where the resource needs are highly variable, like in cases of projects with new or fast-changing technologies, the company waits for the demand to materialized before acquisition. The Service Division in the company is one where the planning cycles are long, easy to predict and not dependent on a particular customer.

Case Study - IV

CAPACITY PLANNING AT A SMALL INDIAN SOFTWARE FIRM

Company Background

This is a 2.3 crore company operating in the hi-tech software sector. Its areas of expertise are DSP (Digital Signal Processing) and Networking. Currently its employee strength is 50 and is expected to grow to 125 by the end of this year. The company has three models of business viz. Resource Contracting, Project Contracting and Product Development. All the three models employ the same skills and technologies. There has been a conscious effort to move from Resource Contracting towards a focus on Product Development. The profitability margins for the company in the past have been in the range of 30 to 35%.

Revenue Lines

Resource Contracting involves lending of resources to clients (mainly overseas) for a price, which varies with the technology level, expertise and time period. Here, the client has to bear full responsibility for the resource over the contract period and the company is not responsible for factors like attrition, schedule slippage or resource utilization.

Project Contracting involves providing customized solutions to clients such as operating system development, real time application development etc. These are fixed price turnkey contracts where the company bears the responsibility for the resources, schedule, deliverables etc. The customer only provides the requirements in terms of the deliverables required.

Product development is a recent initiative by the company, which aims at targeting the market for off-the-shelf products. The requirements for such products originate from the marketing teams.

Organization Structure

The organizational hierarchy is classified on the basis of technology and experience(level). Every resource is part of a technology grouo (e.g Unix Internals, DSP – Voice etc.) and is assigned a level based on his/her experience. The five levels in the organizational hierarchy are Software Engineer, Senior Software Engineer, Technical Lead, Project Lead and Project Manager. Project Managers are not

expected to be experts in the technology of the projects which they are managing but need to have a broad idea of the domains. Project Leads manage different project modules whereas Technical Leads handle different technology modules in a project. If need be, project leads or technical leads may actually take on the duties of engineers in order to ensure that the projects are completed on schedule.

Risk Management

Currently for services, there is not much of a risk on the demand side. On the other hand, availability of skilled people in the hi-tech areas is a constraint for the company. The company does not have adequate resources to tap the full potential of the market. Even for products, the risk is minimized by adopting scientific methods like market research as well as insights of the experienced people in the company to project the existence of and adequate market for the product.

Project Staffing and Resource Planning

This is a relatively uncomplicated operation where the only constraint appears to be the lack of a proper supply of high-skilled technical resources. The process of capacity planning begins at the project negotiation stage with the client where the project managers identify the resource requirements for those projects which the company is likely to undertake successfully. These requirements are classified in terms of technology and required experience of the resource. These numbers are estimated by using metrics like the LOC (Lines Of Code), which ultimately get converted into a corresponding man-days figure. Here the productivity of employees at various levels is also factored in. The resource requirements in man-days are then attempted to be fulfilled by looking at existing resources (after factoring for attrition rates), who are free to work for the duration of the project life cycle. Here, the existing project staffing is examined to see which projects are currently in a mature phase so that some of the resources allocated towards these can be released to new projects. In case the existing resources are not adequate, the HR department is consulted to determine whether the required resources can be recruited within the relevant time frame. The HR department then proceeds to meet the resource requirements by various modes of recruiting, always working within a stipulated budget.

Depending upon the dynamics of the project execution, resources may need to be transferred between technology groups. Here the consent of the employee, his/her attitude towards working on/mastering new technologies is taken into consideration. Moreover, some employees of some technology groups are not interchangeable but usually once the employee consents, the time required to master the new technology and become fully operational on the project is not significant. While looking at the technology experience of a resource, details such as exposure of the resource to various development tools, utilities and methodologies relevant to the technology are also examined.

For assigning project leads and managers, factors such as previous experience in handling a project of a similar scale, acquaintance with the client etc. are also taken into consideration. Here experience in similar technology projects is not a restricting criterion although it is preferable. Similarly projects for established clients are attempted to be staffed with teams who have had experience in working with the client in the past.