patni

World-Wide Partnerships. World-Class Solutions.

Symposium on Optimization in Supply Chains

Skills Requirement Planning in a Services Supply Chain

Milind Padalkar
Patni Computer Systems Ltd

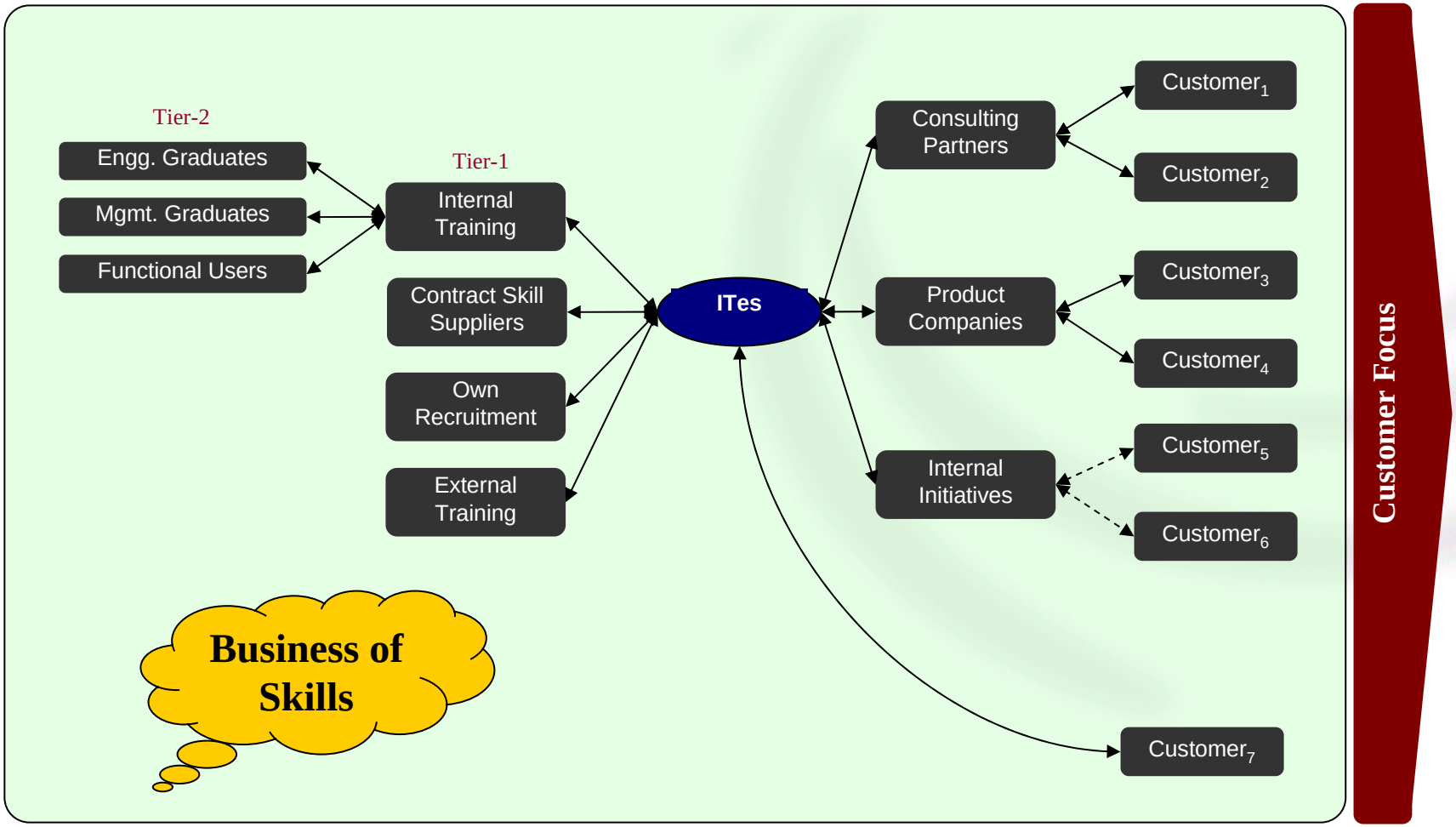
Jayendran Venkateswaran
Indian Institute of Technology Bombay

Milind Patil
Patni Computer Systems Ltd

Agenda

- ITes Supply Chain
- ITes Supply Chain Challenges
- Skills requirements planning
- MRP To SRP Model
- Results
- Conclusion
- Future Directions

ITes Supply Chain

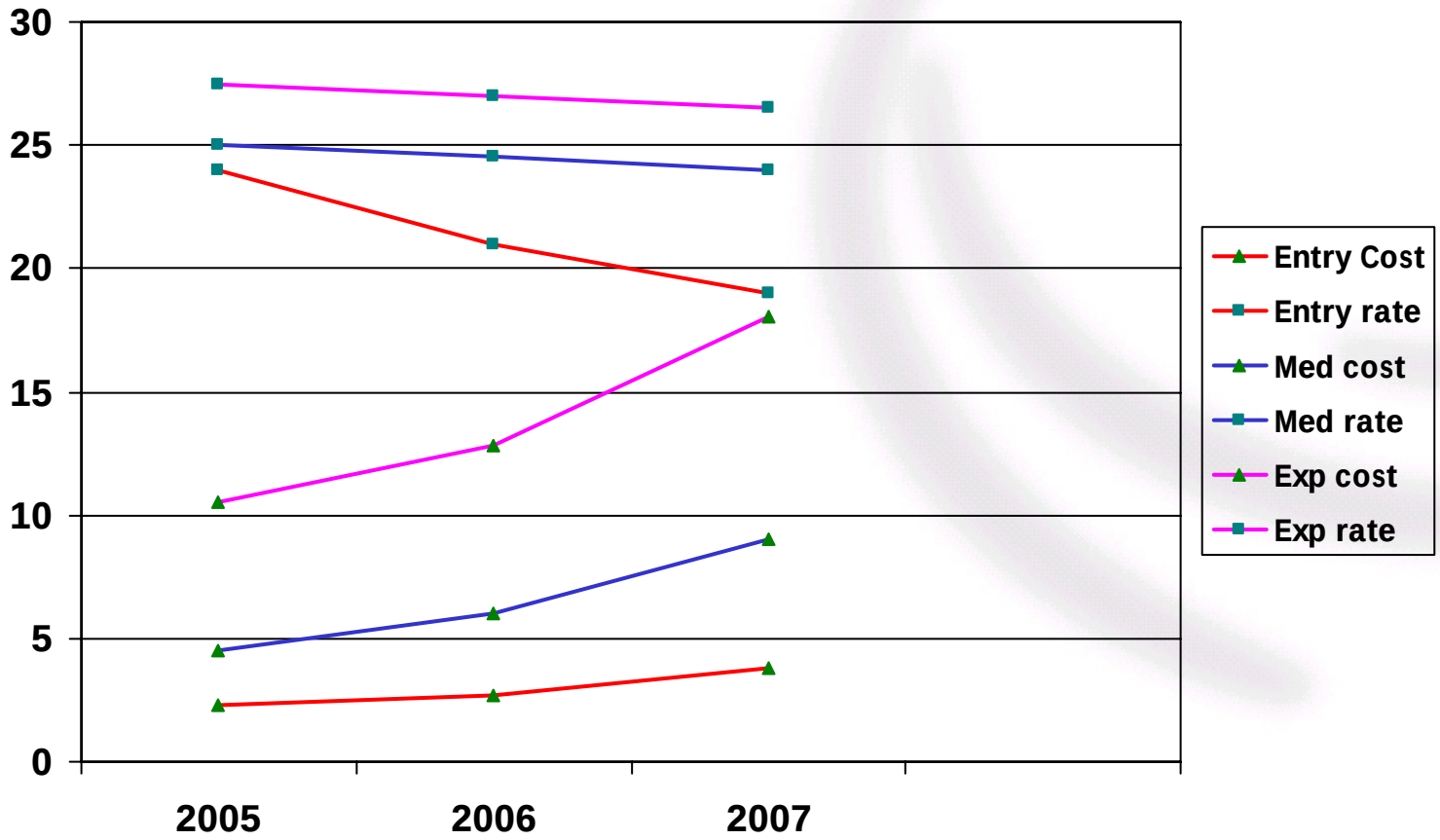


ITes Supply Chain Challenges

- Skill proliferation: Technology, Functional Knowledge, Experience, Location – Valid combinations exceed 15000.
- People have skills, but also have a mind. Personal constraints interfere.
- Business Applications require special skills – which are hard to codify.
- Skill allocation to revenue-project is important to right cost flow because:
  - Labour costs fluctuate over time depending on the demand-supply situation.
  - Skill cost is over a range and not a point cost.
  - Labour Attrition can be seen as perishable inventory. However, the perishability rates are lower when on project (allocated) then when on bench (on-hand).
  - Billing rates follow their own logic – not connected to cost-of-production. Clients do not insist on specific type of a skill or experience for many jobs.
  - ITes Industry has lived with large bench strengths in India. Rupee appreciation against US Dollar puts pressure on this.

Behaviour of Wages and Prices in ITes Supply Chain – an Example

- Wage inflation and price deflation as the market matures.
- Costs, prices for SAP Technology for the past three years (assumed at constant exchange rate of 1 US = 45 INR).



Skills requirements planning in ITes SC

- What skill mix is required in future?
- What skill mix is available today?
- What are the ways to match the skill mix?
- How much it will cost to match the skill mix?
- How much time it will take to match the skill mix?
- How profitable is this skill match?

The difficulties

- One person multiple skills
- Different skill proficiency levels
- Resistance for skill conversion in some areas
- High demand for a particular skill conversion
- Less time for response
- Cost data and Skills inventory data not readily available. Even when available, it may not be suitable for the model assumptions.

Where is the opportunity?

- Profitable to match
- Skills can be created via training. Once created, they are additive, i.e. the earlier skills remain.
- Training may be cheaper than direct sourcing.
- Training caters to internal as well as external demand.
- Investment in training may lead to lower attrition.
- Planning models used today assume static skills. Skill conversion is not considered in the model. This may lead to more expensive resources being allocated to period demands.

Proposed Model

Variables definition

Indices

$$s = 1,...,S \quad \textit{index of skills}$$

$$k, g = 1,...,K \quad \textit{index of groups}$$

$$t = 1,...,T \quad \textit{index of time period}$$

Variables definition

Parameters

G_{ks} Association of skills s with group k, 0-1 variable

1 indicates skill s is part of group k, 0 otherwise

D_{st} Number of persons required (demand) with skill s in time period t

I_{k0} Initial inventory of persons in group k

L_{kg} Lead – time in weeks required to train one person to move from group g to group k

C_{kg}^{T} Cost in Rupees required to train one person to move from group g to group k

C_{s}^{P} Penalty cost in Rupees for unit unmet demand of skill s

C_{k}^{B} Cost in Rupees for each "idle" person in group k

M Big – M

Variables definition

Decision variables

Y_{kst} Number of persons used for project from group k for skill s in period t

P_{kt} Number of persons used for project from group k in period t

A_{st} Number of persons with skill s used for project in period t

X_{kgt} Number of persons from group g starting training in period t to move to group k

I_{kt} Number of persons (inventory) in group k in period t

U_{st} Unmet demand for skill s in period t

Base model

Minimize

The total training cost PLUS penalty cost for unmet demand PLUS holding cost

$$\sum_{t=1}^{T}\sum_{k=1}^{K}\sum_{g=1}^{K} X_{kgt} C_{kg}^{T} + \sum_{t=1}^{T}\sum_{s=1}^{S} U_{st} C_{s}^{P} + \sum_{t=1}^{T}\sum_{k=1}^{K}\left[I_{kt}^{+} - P_{kt} \right] C_{k}^{B}$$

Base model

Subject to

1. *Demand for skill s is met by assigning people from various groups*

$$\sum_{k=1}^{K} G_{ks} Y_{kst} + U_{st} = D_{st} + U_{st-1} \quad \forall \; s \in S, t \in T$$

2. *Person can be allotted from group k for skill s only if that skill is part of that group*

$$Y_{kst} - M.G_{ks} \leq 0 \quad \forall \; k \in K, s \in S, t \in T$$

3. *Number of persons assigned from group k cannot exceed the inventory of the group*

$$\sum_{s=1}^{S} Y_{kst} \leq I_{kt} \quad \forall \; k \in K, t \in T$$

Base model

Subject to

4. Computing the number of persons used from group k

$$\sum_{s=1}^{S} Y_{kst} = P_{kt} \qquad \forall \; k \in K, t \in T$$

5. Computing the number of persons with skill s used in period t

$$\sum_{k=1}^{K} G_{ks} P_{kt} = A_{st} \qquad \forall \; s \in S, t \in T$$

Base model

Subject to

6. *Inventory balance* :

The inventory of persons in group k equals

the intial inventory PLUS

number of people moved to group k from all other groups MINUS

the number of people from group k who have been put on training

$$I_{kt} = I_{k0} + \sum_{g=1}^{K} \sum_{r=1}^{t-L_{kg}} X_{kgr} - \sum_{g=1}^{K} \sum_{r=1}^{t} X_{kgr} \qquad \forall \; k \in K, t \in T$$

$$I_{kt} = I_{kt}^{+} - I_{kt}^{-} \qquad \forall \; k \in K, t \in T$$

Solution methodology

- A case of 12 periods, 2 functions (i.e. 6 skills)
- Solved the above model using ILOG CPLEX 9.1 and ILOG OPL Development Studio 4.0
- System: Intel, Pentium Processor 2.80 GHz under UNIX environment

Results

- The model

SRPModel_24102007.txt

- The data

SRPData_24102007.txt

Microsoft Office
Excel Worksheet

- The output

SRPOutput_24102007.txt

Interpretation of Results and Discussion

- Model has indicated 3 people to be trained in period 1 (G1 to G2) and 2 to be trained in period 5 (G2 to G3). Current planning practices are manual; hence do not indicate training decisions. Cost saving can be linearly calculated by applying wage differences.

- Tradeoff between carrying cost, training cost and penalty cost for not meeting the demand can give interesting insights:
  - Are these cost linked to each other?
  - How are they linked?
  - Will analysis of these relationships before optimization throw some interesting results?
  - Study of cost behaviours can lead to more interesting model extensions.

Limitations

- Analysis of solution procedure: More algorithms can be tried out.
- Sensitivity analysis: Extreme cases for different demands, starting inventories and cost combinations needed.
- Stress checks: More functions and skills need to be tried out
- Cost matrix assumed to be linear; Actual cost curves will be non-linear.
- Lead-time matrix assumed to be linear; Actual lead times are non-linear depending on the skills.

Conclusion

- MRP logic can be extended to professional services capacity planning
- Needs well organized cost data.
- Needs authentic skill data
- Demand must be expressed in required skills by periods.
- Needs a well established project planning tool as a transaction system for getting the required data.

Future directions

- Model can be extended to include:
  - Demand Concerns
    - Stochastic demand
    - Demand priorities: by location, client, company priority
  - Supply Concerns
    - Training lot size
    - Attrition rates
    - Assignment constraints: visas, gender
- Pegging: Order-level visibility
- Hard Pegging: Specific skill must be allocated.

Thanks