

Reserved cost

$$CR(I,J) = DT(I) * CTR(J) + DS(I) * CSR(J) + DN(I) * CNR(J) + DT(I) * CER(J)$$

- $DT(I) * CTR(J)$ = demanded CPU time * cost reserved CPU time
- $DS(I) * CSR(J)$ = demanded storage * cost reserved storage
- $DN(I) * CNR(J)$ = demanded network * cost reserved network
- $DT(I) * CER(J)$ = demanded CPU time * cost reserved power

Actual cost

$$CA(I,J) = DT(I) * CTA(J) + DS(I) * CSA(J) + DN(I) * CNA(J) + DT(I) * CEA(J)$$

- $DT(I) * CTA(J)$ = demanded CPU time * cost utilization reserved CPU time
- $DS(I) * CSA(J)$ = demanded storage * cost utilization reserved storage
- $DN(I) * CNA(J)$ = demanded network * cost utilization reserved network
- $DT(I) * CEA(J)$ = demanded CPU time * cost utilization reserved power

On-demand cost

$$CO(I,J, M) = DT(I) * CTO(J) + DS(I) * CSO(J) + DN(I) * CNO(J) + DT(I) * CEO(J) * R[M]$$

- $DT(I) * CTO(J)$ = demanded CPU time * cost on-demand CPU time
- $DS(I) * CSO(J)$ = demanded storage * cost on-demand storage
- $DN(I) * CNO(J)$ = demanded network * cost on-demand network
- $DT(I) * CEO(J) * R[M]$ = demanded CPU time * cost on-demand power * rate price increase

Objective (Z)

$$Z = E = \text{SUM}((I, J), XR(I, J) * CR(I, J)) + \text{SUM}((I, J, M, V), Pm(M) * Pv(v) * (XA(I, J, M, V) * CA(I, J) + XO(I, J, M, V) * CO(I, J, M)));$$

- $\text{SUM}((I, J), XR(I, J) * CR(I, J))$ = sum for all task/machines of reservation * reservation cost
- $Pm(M) * Pv(v)$ = probability of a price increase * demanded CPU time (normal distribution)
- $XA(I, J, M, V) * CA(I, J)$ = real usage from the reservation * actual cost
- $XO(I, J, M, V) * CO(I, J, M)$ = on-demand usage * on-demand cost

Reservation/allocation constraint

$$XA(I, J, M, V) =L= XR(I, J);$$

- $XA(I, J, M, V)$ = real usage of the reservation
- $=L=$ = lower than or equal
- $XR(I, J)$ = reservation

VM demand constraint

$$\text{SUM}(J, XA(I, J, M, V) + XO(I, J, M, V)) =G= Q(V);$$

- $XA(I, J, M, V) + XO(I, J, M, V)$ = real usage of the reservation + on-demand usage
- =G= = greater than
- $Q(V)$ = how many tasks should already be scheduled

CPU-time constraint

$$\text{SUM}(I, DT(I) * (XA(I, J, M, V) + XO(I, J, M, V))) =L= LT(J);$$

- $DT(I)$ = demanded CPU-time
- $XA(I, J, M, V) + XO(I, J, M, V)$ = usage of resources
- $LT(J)$ = offered CPU-time by machine J

Storage constraint

$$\text{SUM}(I, DS(I) * (XA(I, J, M, V) + XO(I, J, M, V))) =L= LS(J);$$

- $DS(I)$ = demanded storage
- $XA(I, J, M, V) + XO(I, J, M, V)$ = usage of resources
- $LS(J)$ = offered storage by machine J

Network constraint

$$\text{SUM}(I, DN(I) * (XA(I, J, M, V) + XO(I, J, M, V))) =L= LN(J);$$

- $DN(I)$ = demanded network
- $XA(I, J, M, V) + XO(I, J, M, V)$ = usage of resources
- $LN(J)$ = offered network by machine J