SRC Project 879
Mid-year Progress

Task 879.2: Integration of Demand Planning and Manufacturing Planning

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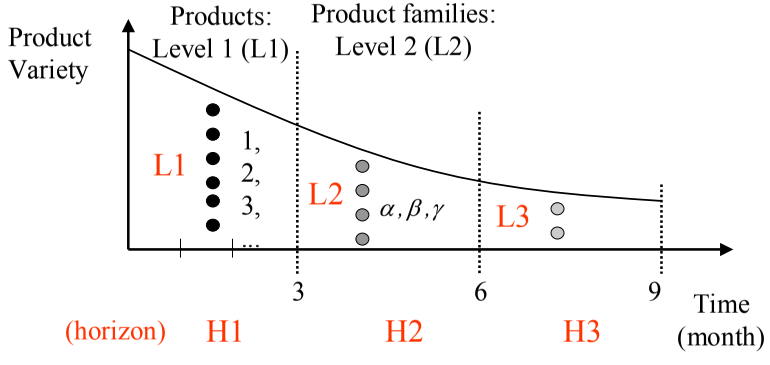
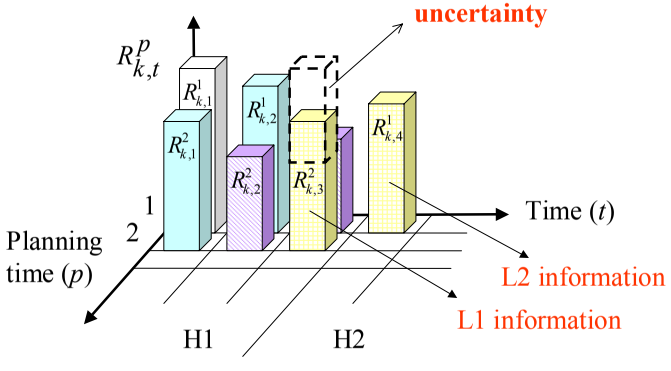
Product Grouping Hierarchy



Uncertainty in Capacity Requirements

$R^p_{k,t}$: requirements of tool set k



Research Objectives

$R_k = \Sigma_i (d_i \cdot W_{k,i})$

where

R_k is the requirements of tool k

d_i is the demand of product i

$W_{k,i}$ is the processing time

In vector form:

R = D × W

- To model the uncertainty in capacity requirements
- To improve the accuracy of capacity requirement estimate
  - **D: evolution from L2 to L1**
  - **W: similarity in processing times**

The Envelope of Capacity Requirements

demand d_α : spreaded between d_1 and d_2

$$\begin{cases} d_1 = a_1 \cdot d_\alpha \\ d_2 = a_2 \cdot d_\alpha \end{cases}$$

$0 \le a_1, a_2 \le 1$ and $a_1 + a_2 = 1$

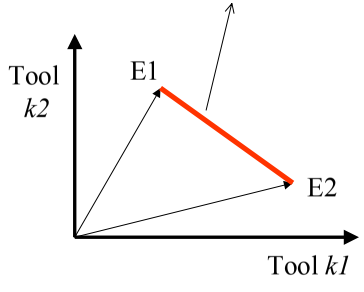
demand scenarios : (a_1, a_2)

two extreme scenarios :

$E_1 : a_1 = 1, \quad a_2 = 0$

$E_2 : a_1 = 0, \quad a_2 = 1$

The envelope of capacity requirements for all scenarios is a convex hull.



A Numerical Example

- The product group α contains two products: 7 and 8
- Total demand $d_\alpha = 20{,}000$ wpm.
- Let $d_7 + d_8 = d_\alpha$

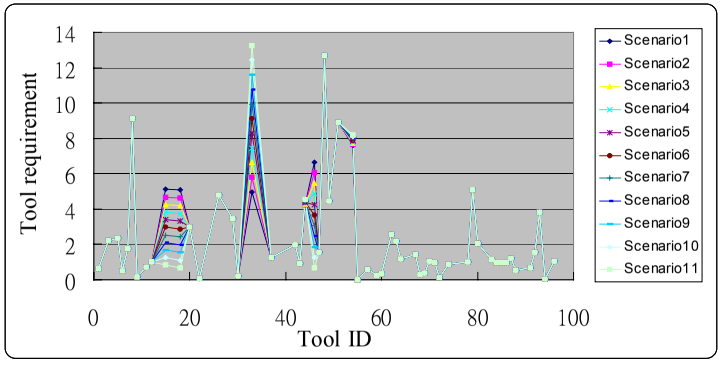
	Demand Scenario										
	1	2	3	4	5	6	7	8	9	10	11
a_7	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
a_8	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0

E1=(1.0, 0)

E2=(0, 1.0)

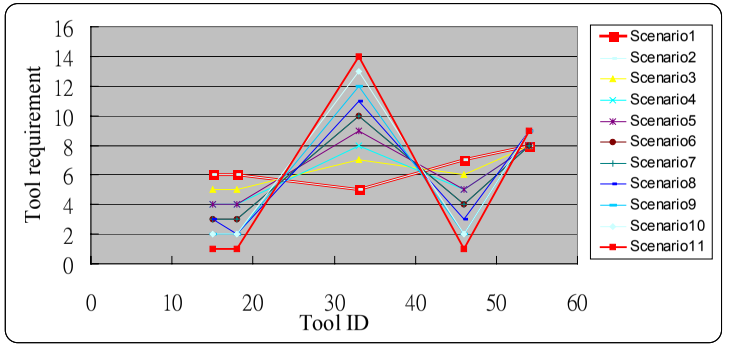
Tool Requirements of All Tool Sets

- Tools 15, 18, 33, 46, and 54 are sensitive to demand scenario.



Tool Requirements of Sensitive Tool Sets

- Scenarios 1 and 11 are the extremes, their tool requirements enclose those of all other scenarios.



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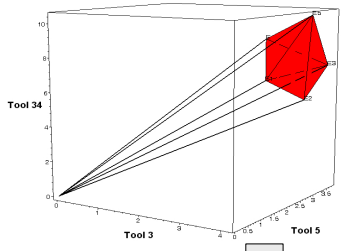
Density Function of Tool Requirements



Project

Tool *k2*

Density

Project

Density

Tool *k1*

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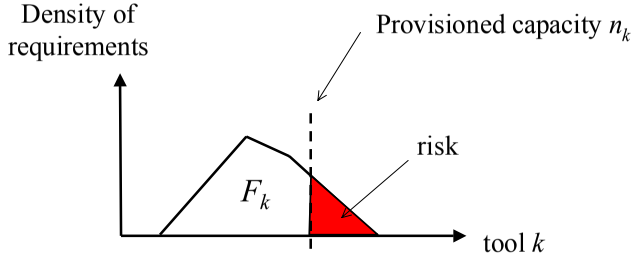
A Risk Model of Capacity Plan



$$Risk = 1 - \prod_{k \in ST} F_k(n_k)$$

where ST is the set of sensitive tools

The Problem of Product Grouping

- **Tool #6 is not a sensitive tool.**
- **Tool #7 is a sensitive tool across product families.**
- **Tool #3 is sensitive to both inter- and intra-family variation.**

Family / Tool ID	B				F	C					J	
	2	4	5	10	16	3	6	11	14	15	25	28
1	3.20	3.20	3.20	2.80	2.60	3.20	3.60	3.60	3.60	3.60	3.00	3.00
3	6.36	6.36	6.36	8.44	6.36	6.36	8.24	7.76	7.76	7.76	8.12	8.12
5	5.52	5.52	5.52	5.68	5.84	5.52	7.44	6.32	6.32	6.32	6.48	6.48
6	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
7	5.92	5.92	5.92	5.92	4.00	5.92	5.92	5.92	5.92	5.92	5.92	5.92
8	22.35	22.35	22.35	23.37	23.26	19.55	32.79	27.82	27.82	27.82	26.75	26.75
9	0.22	0.22	0.22	0.34	0.34	0.22	0.34	0.34	0.34	0.34	0.22	0.22

Product Grouping by Processing Times

tool types	products		
	α	X	β
k1	**A1**	**A1**	**B1**
k2	**A2**	**B2**	**B2**

processing time

If product X is a hybrid of products α and β in process routing, should X be classified as product group α or β?

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Notation

Product group: g

Family / Tool ID	B				C				
	2	4	5	10	3	6	11	14	15
1	3.20	3.20	3.20	2.80	3.20	3.60	3.60	3.60	3.60
3	6.36	6.36	6.36	8.44	6.36	8.24	7.76	7.76	7.76
7	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92	5.92
9	0.22	0.22	0.22	0.34	0.22	0.34	0.34	0.34	0.34

Tool: k

Product: i

Decision variable: $X_{i,g}$

Range of processing times: $R_{g,k}$

$$R_{g,k} = U_{g,k} - L_{g,k}$$

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A Formulation for Product Grouping

(Formulation Q) Min $\sum_k \sum_g R_{g,k}$

$$\begin{aligned}
X_{i,g} \cdot t_{i,k} &\le U_{g,k} && \forall i,g,k \\
X_{i,g} \cdot (t_{i,k} - H) + H &\ge L_{g,k} && \forall i,g,k \\
X_{i,g} \cdot (t_{i,k} + H) &\ge 0 && \forall i,g,k \\
U_{g,k} - L_{g,k} &= R_{g,k} && \forall g,k \\
\sum_g X_{i,g} &= 1 && \forall i
\end{aligned}$$

Work in Progress

$$R = D \times W$$

- The uncertainty in R can be attributed to uncertainties in D and variation in W.
- The uncertainty in D has two components:
  - **Total demand of a product family**
  - **The spread of demand among family members**
- The variation in W can be improved by regrouping products.