

Task 879.1: Intelligent Demand Aggregation and Forecasting

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Outline

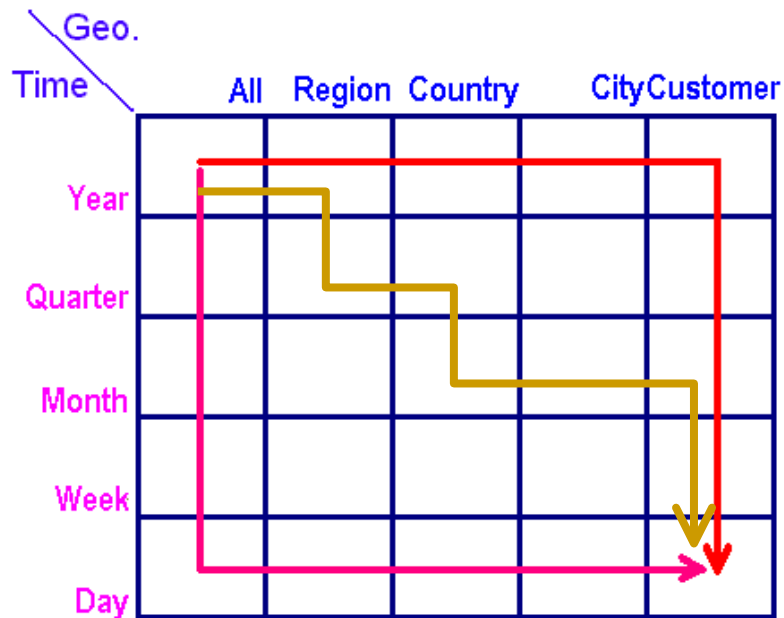
- ✓ Prior work: Demand Planning Hierarchy (DPH)
- Product Hierarchy
- DPH Extension for Product Hierarchy
- DPH Analysis System Prototype
- Feature Works

Problem Description

- Strategies for Demand Planning:
 - Top-down approach
 - Bottom-up approach
 - Middle-out approach
 - Problems:
 - What dimension should be considered to aggregate/disaggregate first?
 - What's the difference?
 - Objectives:
 - Define Demand Planning Views
 - Develop an optimal strategy for Demand Planning: Demand Planning Hierarchy (DPH)
-

Demand Planning Hierarchy (DPH)

Example:



- Two demands views: Time and Geography
- Strategy: Top-down
 - Path 1: break down along Geography View first, then along Time View
 - Path 2: break down along Time View first, then along Geography View
 - Path 3:

Demand Planning Hierarchy: Sequence of Aggregation Levels

Representation of Demand Views

- **View with Hierarchical Levels: e.g. time horizon (necessary), geography view, etc..**

Notation: $VIEW_{\text{level1} \cdot \text{level2}}$

Example: $TIME_{\text{Year} \cdot \text{Quarter} \cdot \text{Month} \cdot \text{Week}}$

$GEOGRAPHY_{\text{Continent} \cdot \text{Country} \cdot \text{City}}$

- **View with Attributes: e.g. product type**

Notation: $VIEW_{\text{attribute} \times \text{attribute}}$

Example: $PRODUCT_{\text{Generation} \times \text{Function} \times \text{Technology}}$

- **View with Mixed Attributes**

Example: $PRODUCT_{(\text{Generation} \times \text{Function} \times \text{Technology}) \cdot \text{PartNumber}}$

DPH Evaluation Metric: Actual Demand Fluctuation

- Coefficient of Variation (CV):

$$CV = \frac{\text{Std.Dev of demand } (\sigma)}{\text{Mean of demand } (\mu)} = \text{degree of fluctuation}$$

- Weighted Average CV: by demand volume

$$\frac{\mu_1}{\sum_{i=1}^n \mu_i} \cdot CV_1 + \frac{\mu_2}{\sum_{i=1}^n \mu_i} \cdot CV_2 + \dots + \frac{\mu_n}{\sum_{i=1}^n \mu_i} \cdot CV_n$$

Weighted-average CV values at all levels are averaged to represent the demand stability of a DPH

Case Study

■ Demand Views

- Product: ASIC

- Views with Hierarchical Levels:

 - Time: Quarter, Month, Week

 - Customer: Geocorp Geography (GG), Geocorp Code (GC)

- View with Mixed Attributes:

 - Product: Technology (T), Number of Metal Layers(L), Package (P); PartNum is hierarchical to the combination of T, L, P

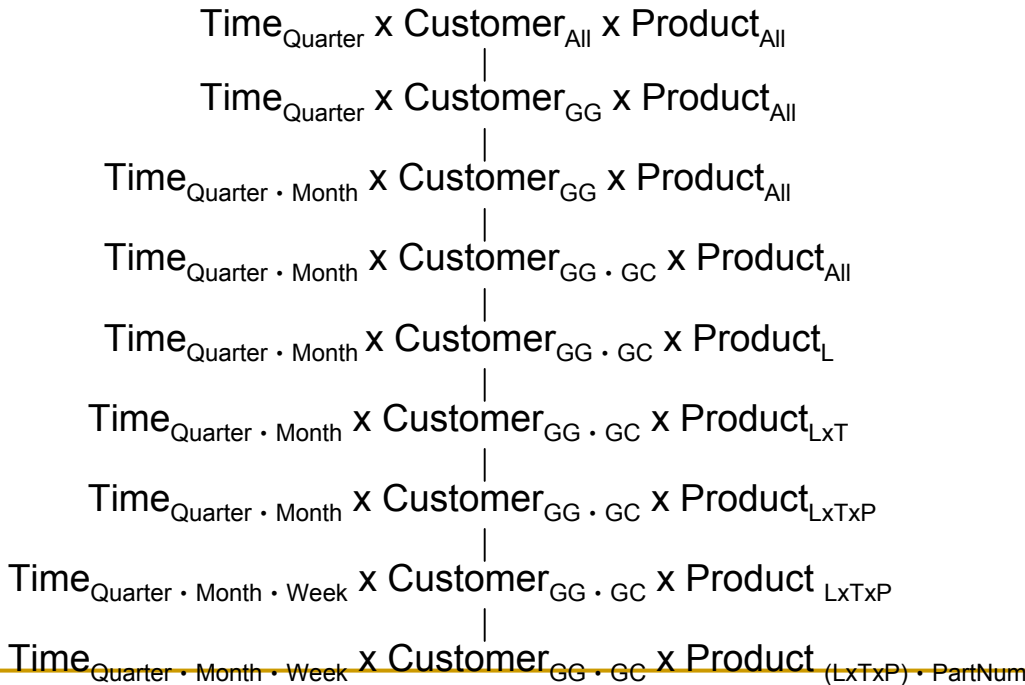
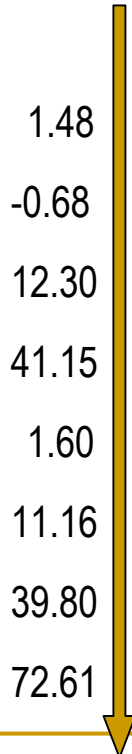
Least-Fluctuation DPH

- Dynamic programming search:

Avg. of Sum of Std. Dev: 3,295,969.3

Avg. of W. Avg. CV: 1.284784

W. Avg. CV
Inflation(%)



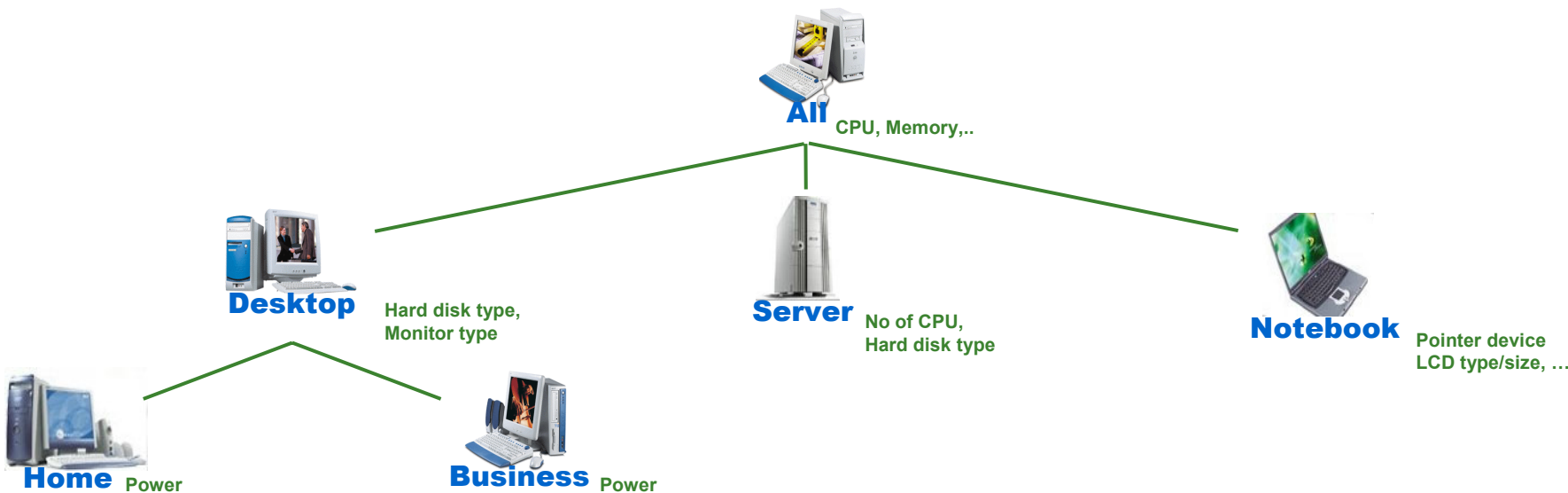
W. Avg. CV
Shrinkage(%)



W. Avg. CV	W. Avg. CV
Shrinkage(%)	Value
1.46	0.720
-0.68	0.731
10.92	0.726
29.13	0.815
1.57	1.150
10.04	1.169
28.47	1.299
42.07	1.817
	3.136

DPH Extension - Motivation

- Prior work: DPH for only one product type
- DPH for an entire product hierarchy?
 - A product hierarchy example



Outline

- Prior work: Demand Planning Hierarchy (DPH)
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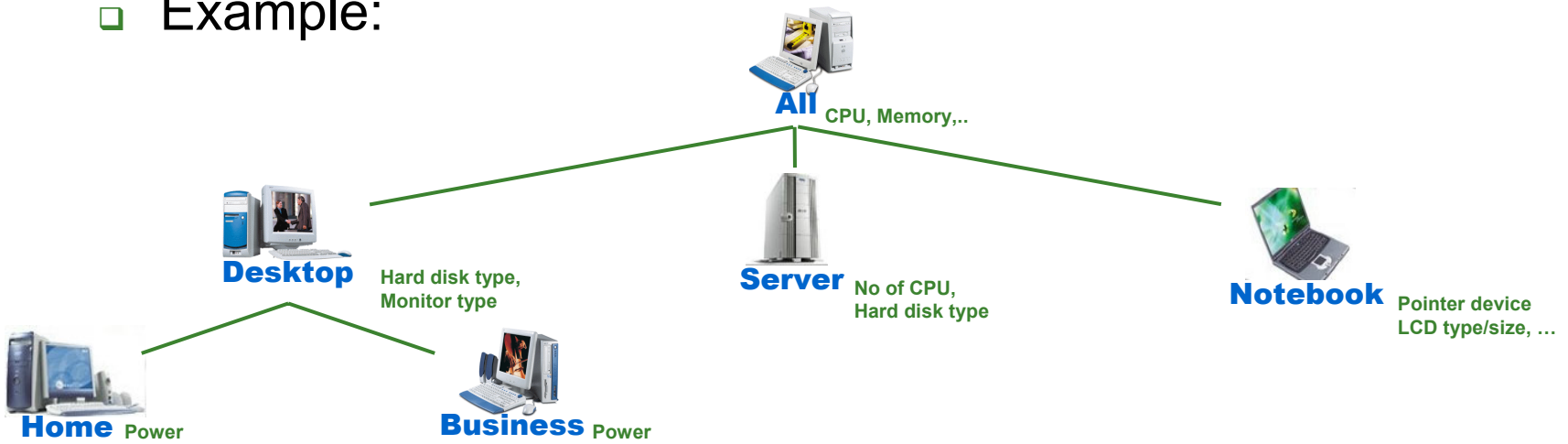
Product Hierarchy

- Product Differentiation

- Base on the substitutive and/or heterogeneous properties of different products, we can classify and arrange all products into a product hierarchy

- Product Hierarchy

- Hierarchical product differentiation
- Example:



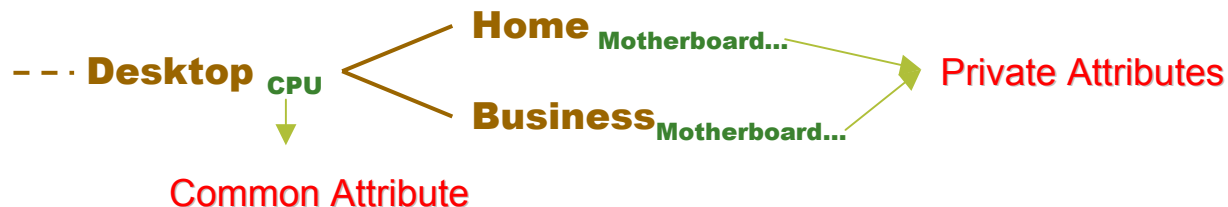
Common Attributes in Product Hierarchy

■ Common Attributes

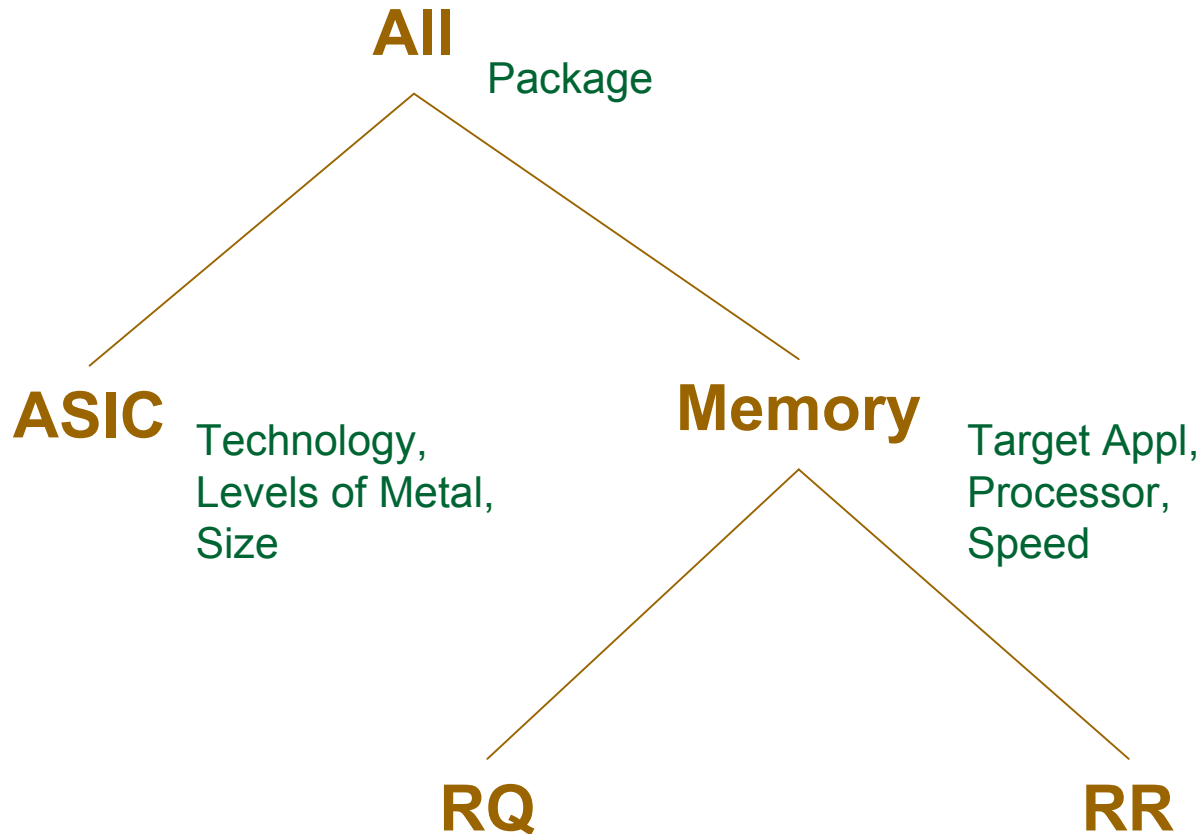
- It is possible for different nodes have the same product attributes



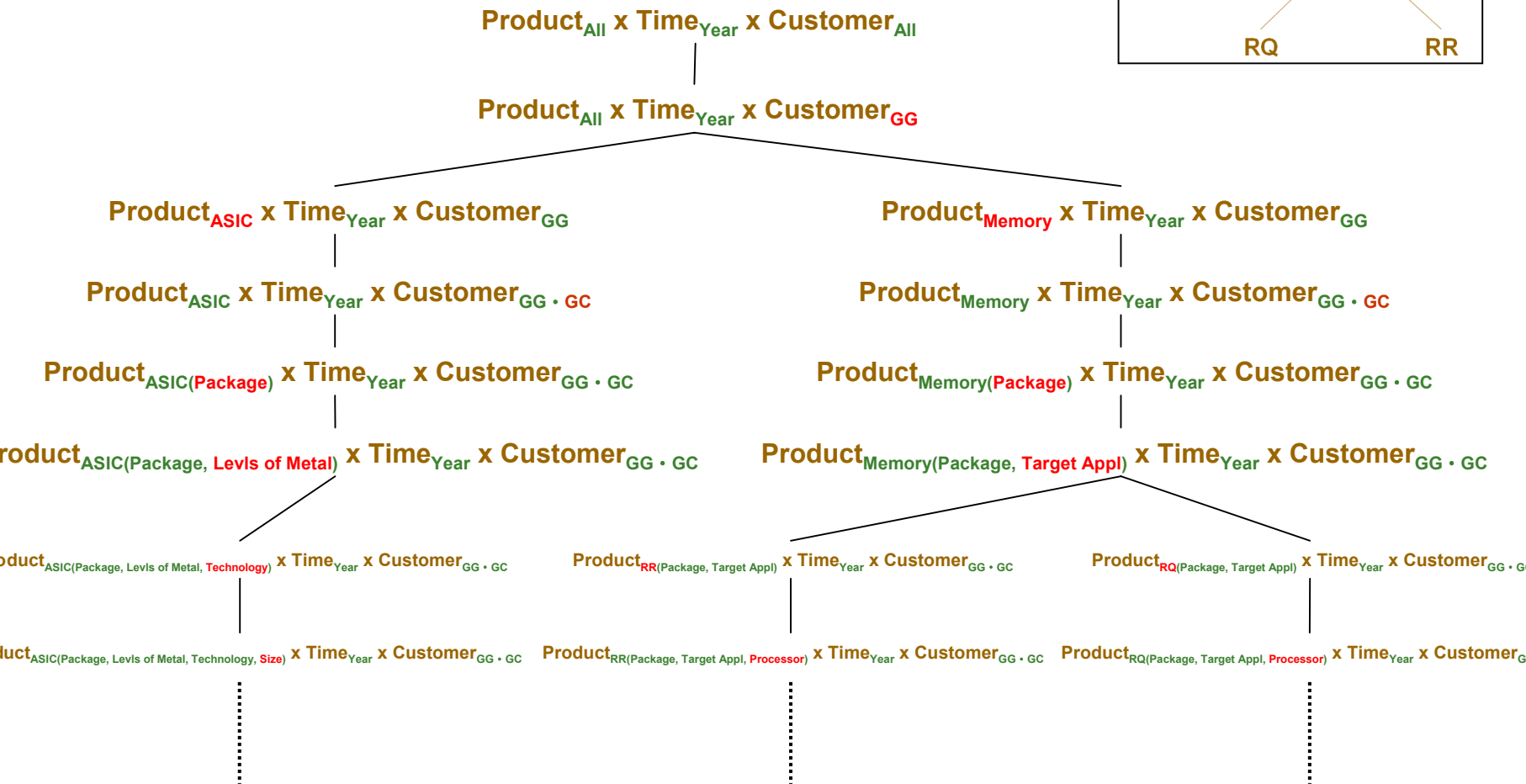
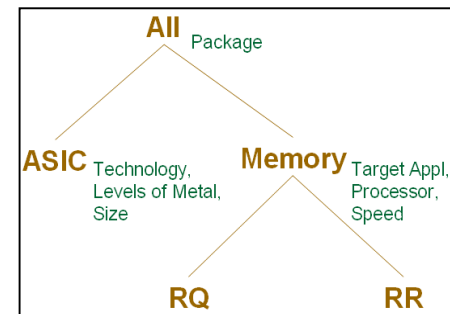
- We may like to raise some of the attribute to a higher planning level that called common attribute



A Semiconductor Example



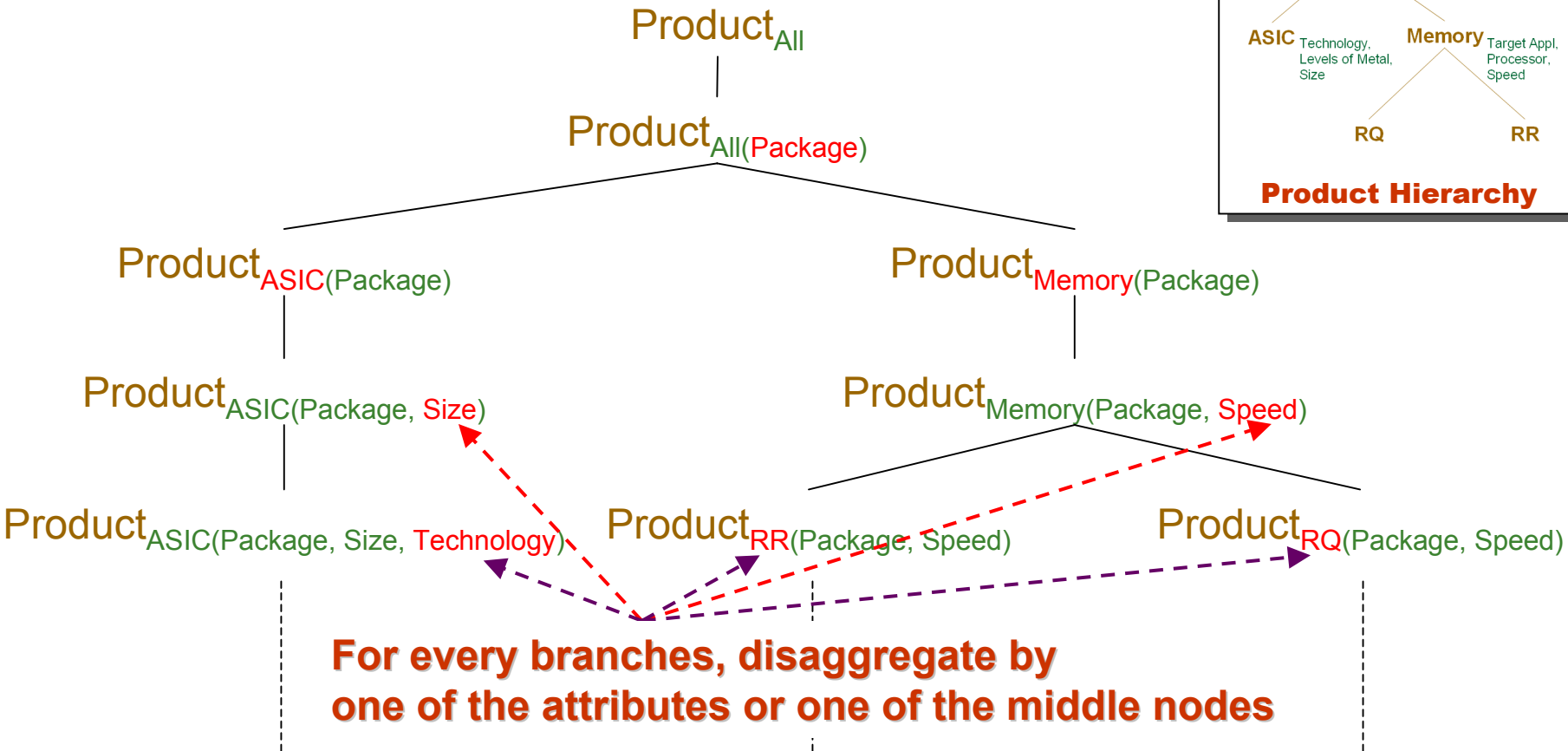
A DPH Solution



Outline

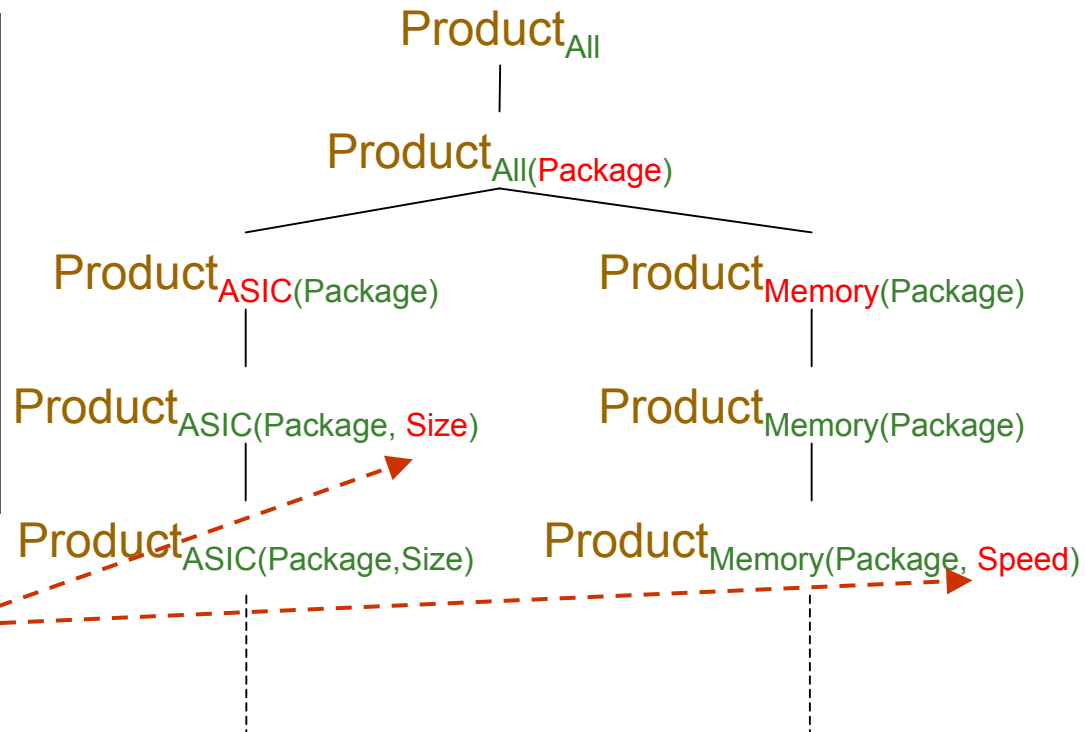
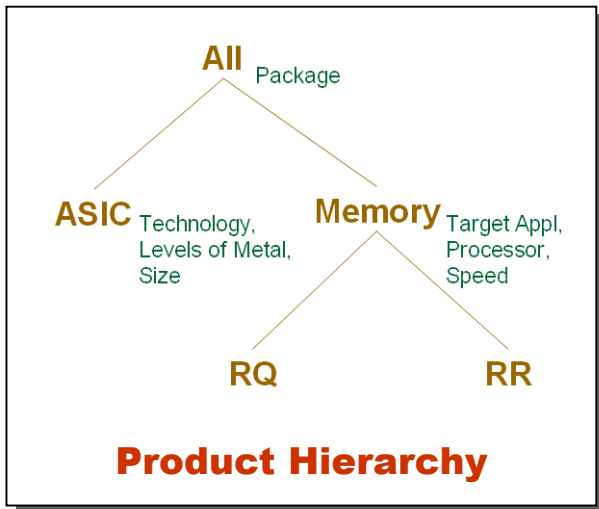
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Balanced DPH – Example



Unbalanced DPH – Example

- We focus on product dimension only

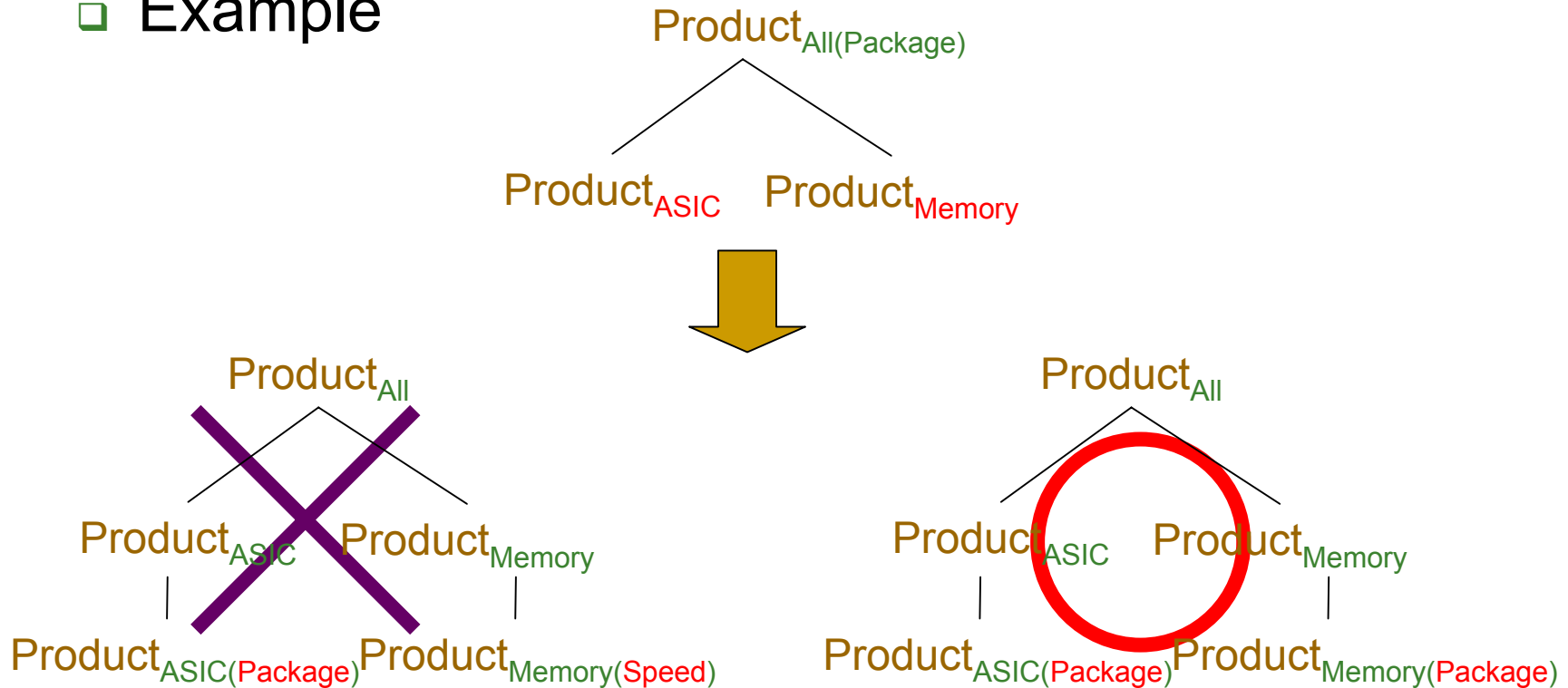


Disaggregate by one of the middle nodes or one of the attributes at one step

Optional Planning Constrains

- There are optional constrains that can be set to prevent irrational hierarchical relations

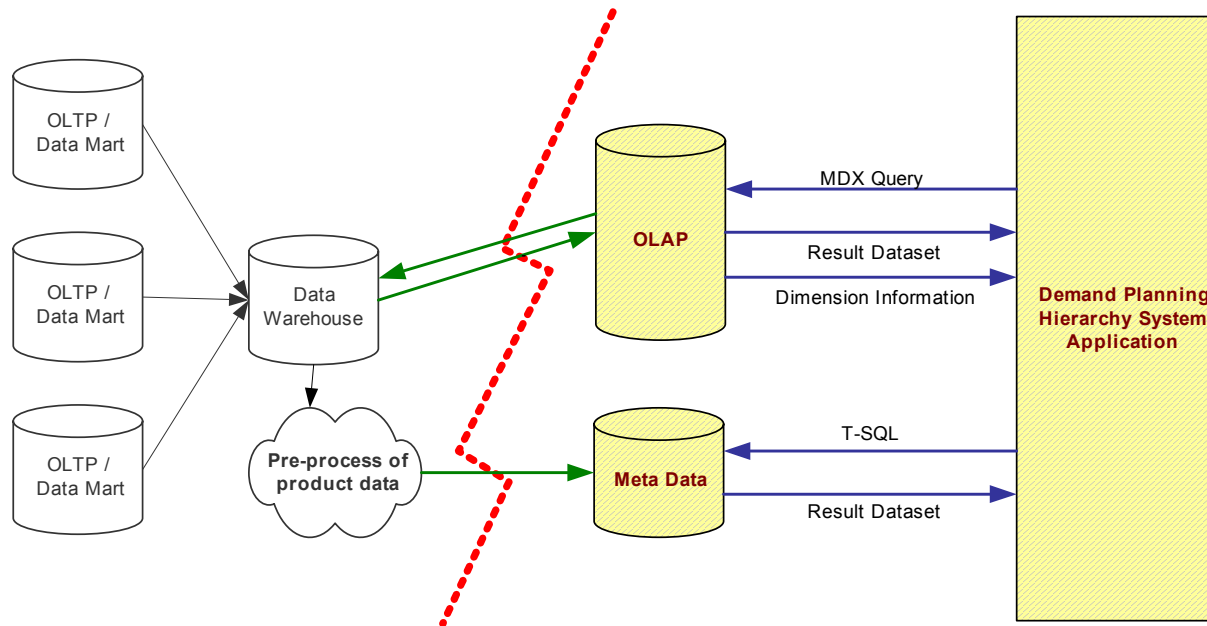
- Example



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System Architecture

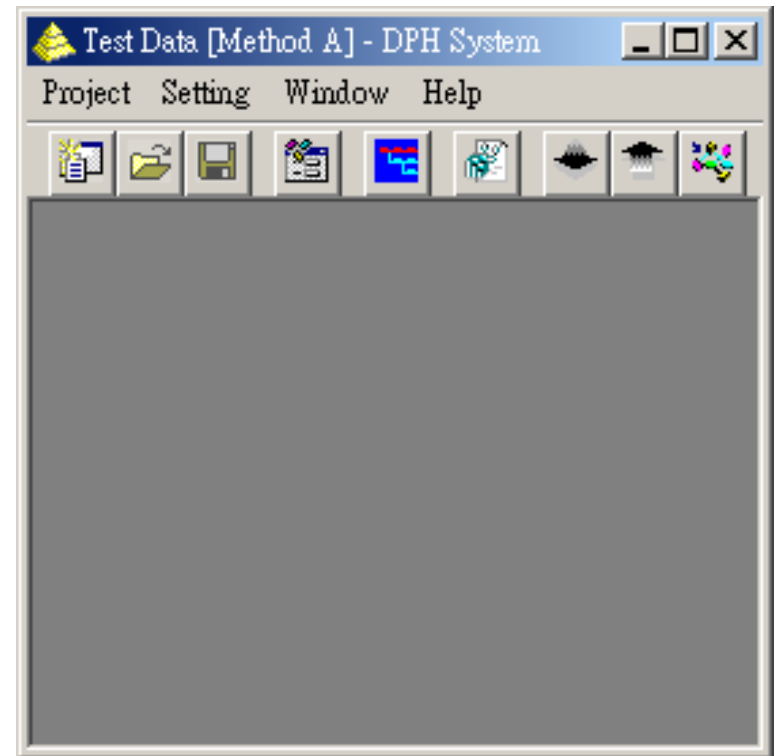


DPH System – System Architecture

- DPH system, OLAP database, metadata database can be located in one system or separated systems
- Platform: .NET; Language: C#

DPH System Preview

- Planning Flow
 - Create a New Project
 - New Project Wizard
 - Allocate Dimensions
 - Solve DPH Network
 - Top-down Greedy Search
 - Button-up Greedy Search
 - Dynamic Programming Search



DPH System – User Interface


DPH System Demo

-
- **New Project Wizard**
 - **Dimension Allocation**
 - **Solve DPH Network**

New Project Wizard

Step 1 of 5:

New Project Wizard



Step 1: Disaggregation Strategy

Description:

1. Select a disaggregation strategy
2. Check the check box if optional disaggregation constrain is applied

Balanced Disaggregation

Unbalanced Disaggregation

Optional Disaggregation Constrain

Cancel Back **Next** Finish

DPH System – New Project Wizard

New Project Wizard (cont.)

Step 2 of 5:

New Project Wizard

Step 2: Meta Data Connection

Field Description:

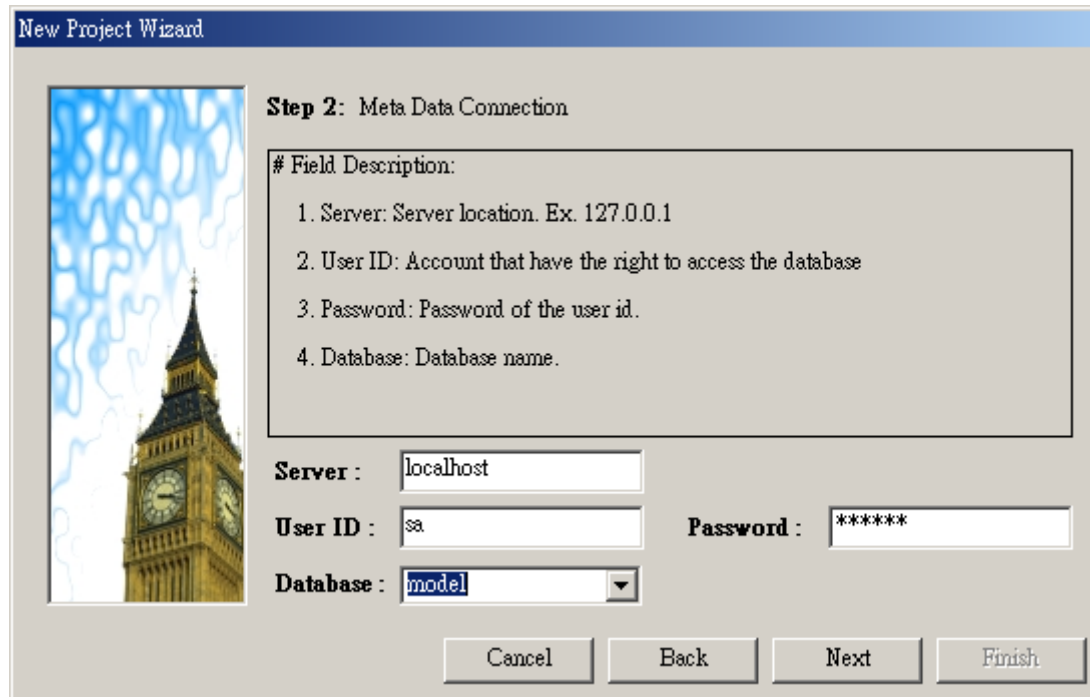
1. Server: Server location. Ex. 127.0.0.1
2. User ID: Account that have the right to access the database
3. Password: Password of the user id.
4. Database: Database name.

Server :

User ID : Password :

Database :

Cancel Back Next Finish



DPH System – New Project Wizard

New Project Wizard (cont.)

Step 3 of 5:

New Project Wizard

Step 3: Product Hierarchy Information Tables

Field Description:

1. Product Info. Table: Table that describes product information.
2. Node Table: Table that describes the nodes in product hierarchy.
3. Attribute Table: Table that describes the attributes in product hierarchy.

Product Info. Table :

Node Table :

Attribute Table :

DPH System – New Project Wizard

New Project Wizard (cont.)

Step 4 of 5:

New Project Wizard

Step 4: OLAP Connection

Field Description:

1. Server: Server location. Ex. 127.0.0.1
2. User ID: Account that have the right to access the OLAP database.
3. Password: Password of the user id.
4. Database: Name of OLAP database.
5. Cube: Cube name.

Server :

User ID : Password :

Database : Cube :

DPH System – New Project Wizard

New Project Wizard (cont.)

Step 5 of 5:


New Project Wizard

Step 5: Project Name and Project Root

Fields Description:

1. Project Name: Name of this project.
2. Project File: Project file name and path.

Project Name :

Project File : 

DPH System – New Project Wizard

Dimension Allocation

Step 1 of 2:

[DPH System] Dimension Allocation

Cube Name Selected Cube

Dimensions

- 0. GeographyD
- 1. LevelsofmetalD
- 2. PackageD
- 3. PartNoD
- 4. PgD
- 5. ProcessorD
- 6. SizeD
- 7. SpeedD
- 8. TargetapplD
- 9. TechnologyD
- 10. TimeD

Measure
[Measures].[Quantity]

Time
[]

Product Hierarchy
[]

Product Attributes
[]

Part Number
[]

Geography
[]

Other Dimensions
[]

Demo Default Close

Dimension Allocation (cont.)

Step 2 of 2:

[DPH System] Dimension Allocation

Cube Name Selected Cube

Measure
[Measures].[Quantity]

Dimensions

Time
10.TimeD

Product Hierarchy
4.PgD

Product Attributes
1.LevelsofmetalD
2.PackageD
5.ProcessorD
6.SizeD
7.SpeedD
8.TargetapplD
9.TechnologyD

Part Number
3.PartNoD

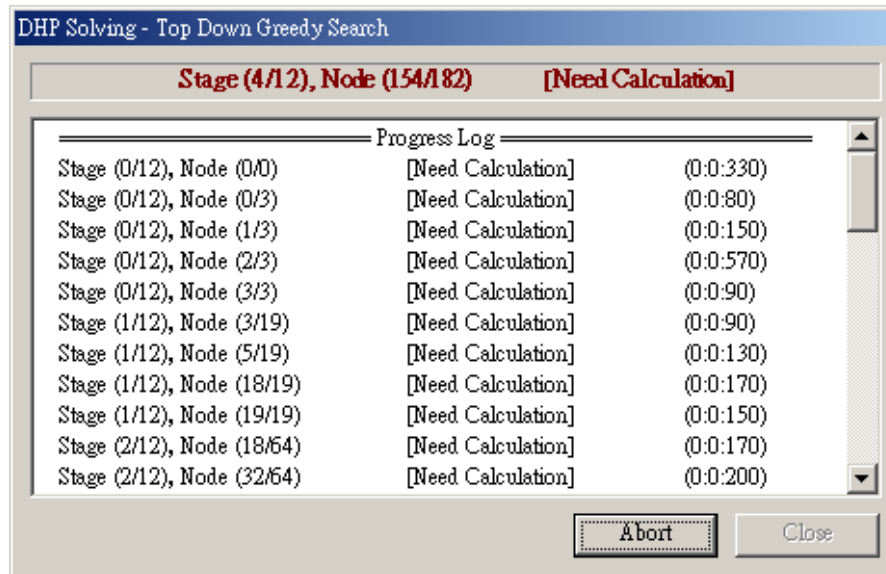
Geography
0.GeographyD

Other Dimensions

Demo Default Close

Solve DPH Network

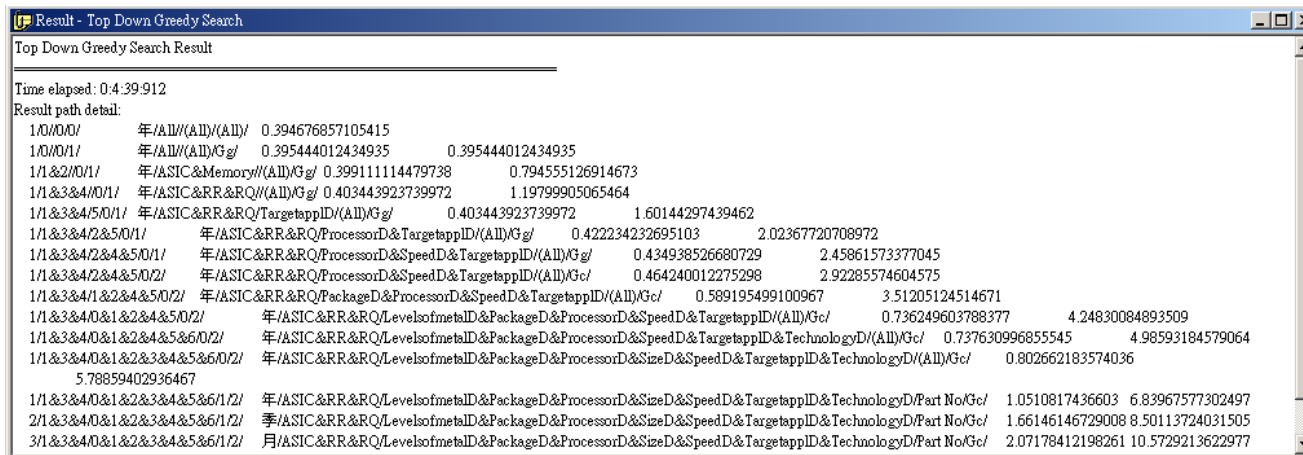
UI 1 of 2:



DPH System – Top-Down Search: Calculation

Solve DPH Network (cont.)

UI 2 of 2:



Result - Top Down Greedy Search

Top Down Greedy Search Result

Time elapsed: 0:4:39.912

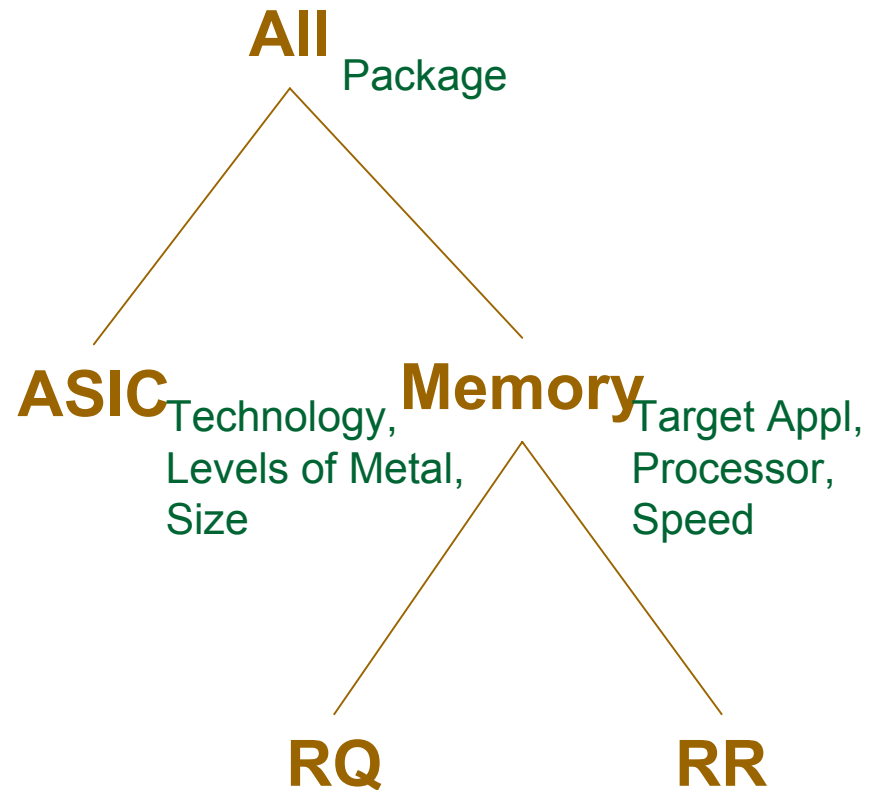
Result path detail:

1/0/0/0/	年/ASIC/(All)/(All)/	0.394676857105415		
1/0/0/1/	年/ASIC/(All)/Gg/	0.395444012434935	0.395444012434935	
1/1&2/0/1/	年/ASIC&Memory/(All)/Gg/	0.399111114479738	0.794555126914673	
1/1&3&4/0/1/	年/ASIC&RR&RQ/(All)/Gg/	0.403443923739972	1.19799905065464	
1/1&3&4/5/0/1/	年/ASIC&RR&RQ/TargetappID/(All)/Gg/	0.403443923739972	1.60144297439462	
1/1&3&4/2&5/0/1/	年/ASIC&RR&RQ/ProcessorD&TargetappID/(All)/Gg/	0.422234232695103	2.02367720708972	
1/1&3&4/2&4&5/0/1/	年/ASIC&RR&RQ/ProcessorD&SpeedD&TargetappID/(All)/Gg/	0.434938526680729	2.45861573377045	
1/1&3&4/2&4&5/0/2/	年/ASIC&RR&RQ/ProcessorD&SpeedD&TargetappID/(All)/Gc/	0.464240012275298	2.92285574604575	
1/1&3&4/1&2&4&5/0/2/	年/ASIC&RR&RQ/PackageD&ProcessorD&SpeedD&TargetappID/(All)/Gc/	0.589195499100967	3.51205124514671	
1/1&3&4/0&1&2&4&5/0/2/	年/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SpeedD&TargetappID/(All)/Gc/	0.736249603788377	4.24830084893509	
1/1&3&4/0&1&2&4&5&6/0/2/	年/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SpeedD&TargetappID&TechnologyD/(All)/Gc/	0.737630996855545	4.98593184579064	
1/1&3&4/0&1&2&3&4&5&6/0/2/	年/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SizeD&SpeedD&TargetappID&TechnologyD/(All)/Gc/	0.802662183574036		
5.78859402936467				
1/1&3&4/0&1&2&3&4&5&6/1/2/	年/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SizeD&SpeedD&TargetappID&TechnologyD/Part No/Gc/	1.0510817436603	6.83967577302497	
2/1&3&4/0&1&2&3&4&5&6/1/2/	季/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SizeD&SpeedD&TargetappID&TechnologyD/Part No/Gc/	1.66146146729008	8.50113724031505	
3/1&3&4/0&1&2&3&4&5&6/1/2/	月/ASIC&RR&RQ/LevelsofmetalD&PackageD&ProcessorD&SizeD&SpeedD&TargetappID&TechnologyD/Part No/Gc/	2.07178412198261	10.5729213622977	

DPH System – Top-Down Search: Result

Case Study

- Dimension Considered:
 - Product
 - Time
 - Customer / Geography
- Product Dimension
 - Total number of attributes*1: 8
 - Prior case: 4
 - Possible attribute combination: 1,126,182,528
 - One-product case: 325,863



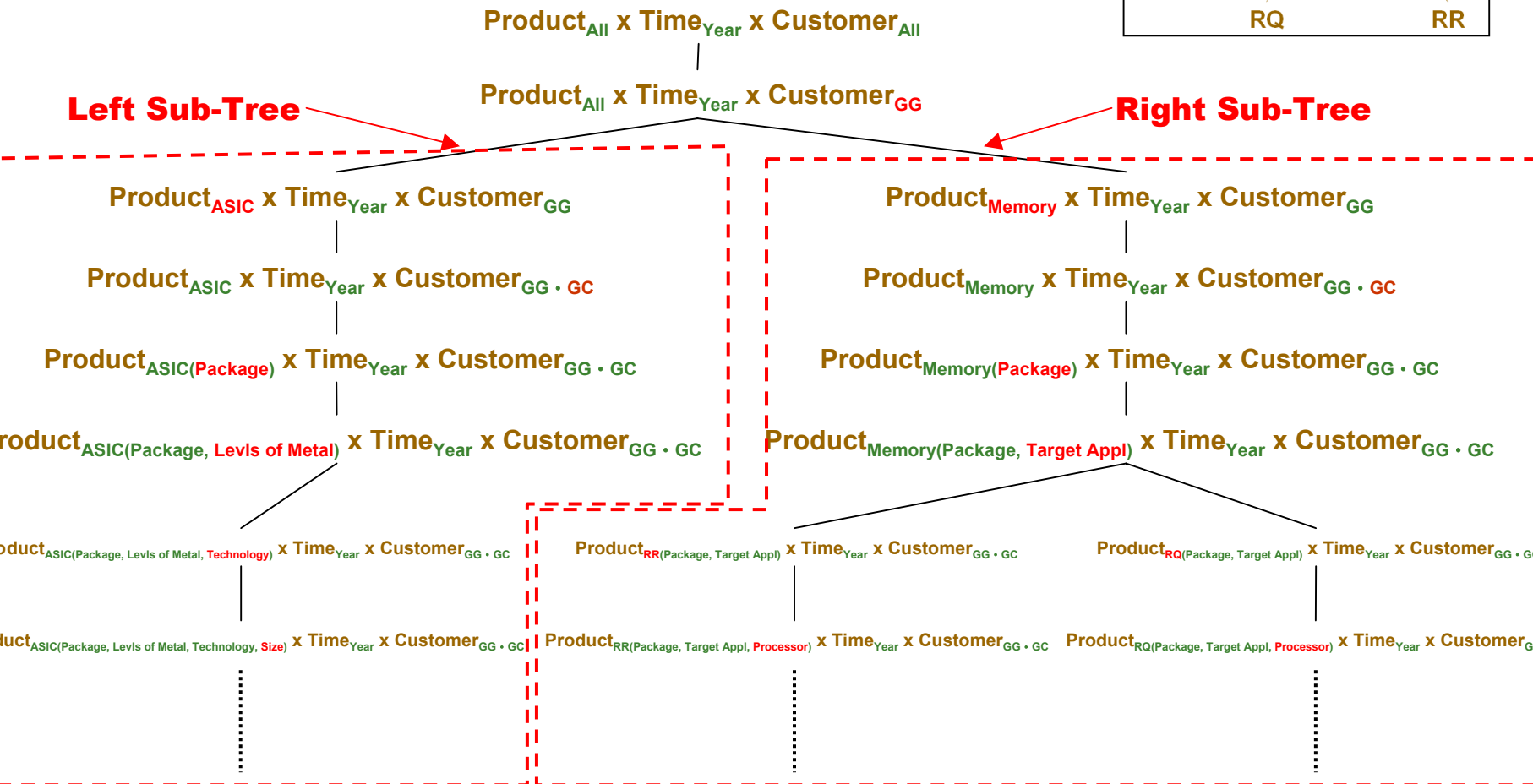
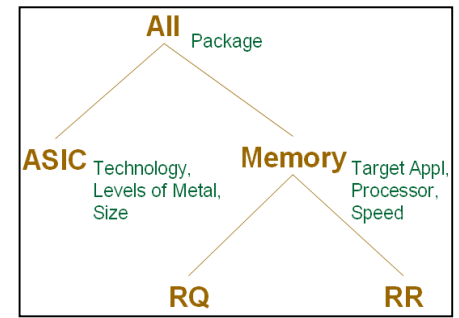
Case Study – Product Hierarchy

*1. Part Number is also considered

Case Study – Performance

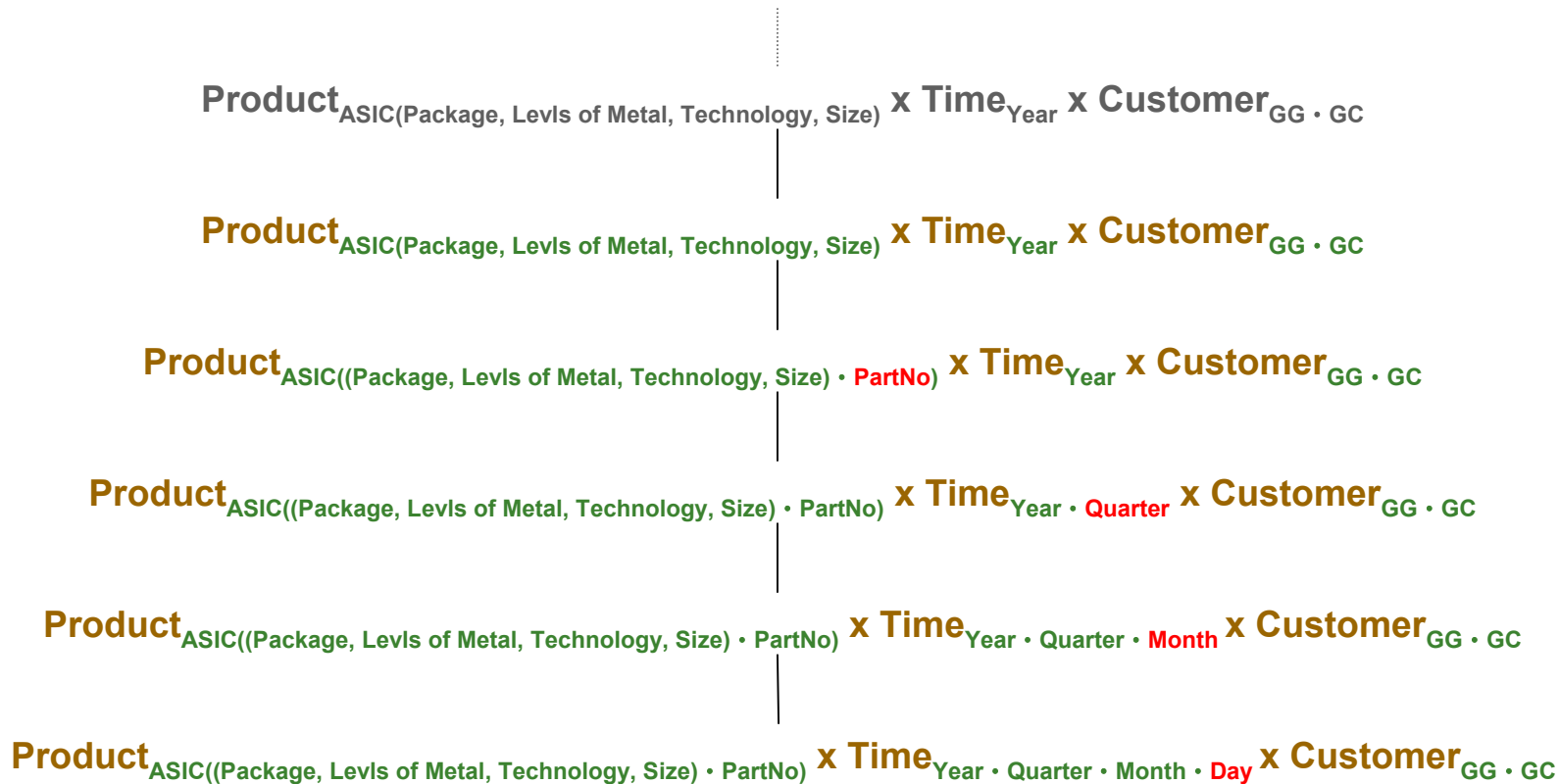
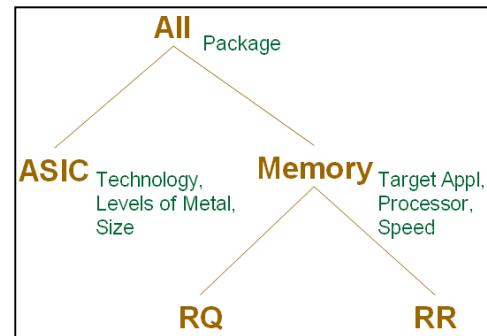
- System Architecture: stand along
 - CPU: Pentium 4-m, 1.4G
 - Memory: 512MB
 - Planning Strategy: Balanced DPH
 - Solving Time Cost (H:M:S):
 - Weekly demand plan:
 - Top-down search: 0:3:19
 - Button-up search: 0:11:55
 - Dynamic programming search: 0:28:9
 - Daily demand plan:
 - Top-down search: 0:4:26
 - Button-up search: 1:15:50
 - Dynamic programming search: 2:22:22
-

Case Study – DP Search



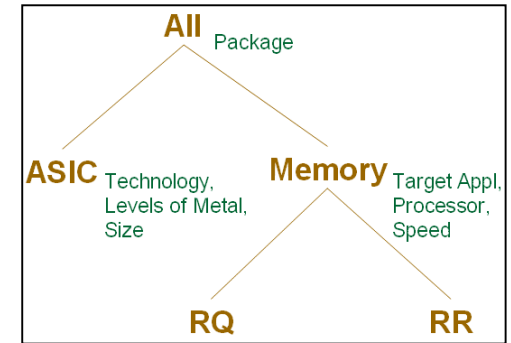
Case Study – DP Search (cont.)

■ Left sub-tree



Case Study – DP Search (cont.)

■ Right sub-tree



Feature Works

- DPH - what-if analysis
- Computation time improvement