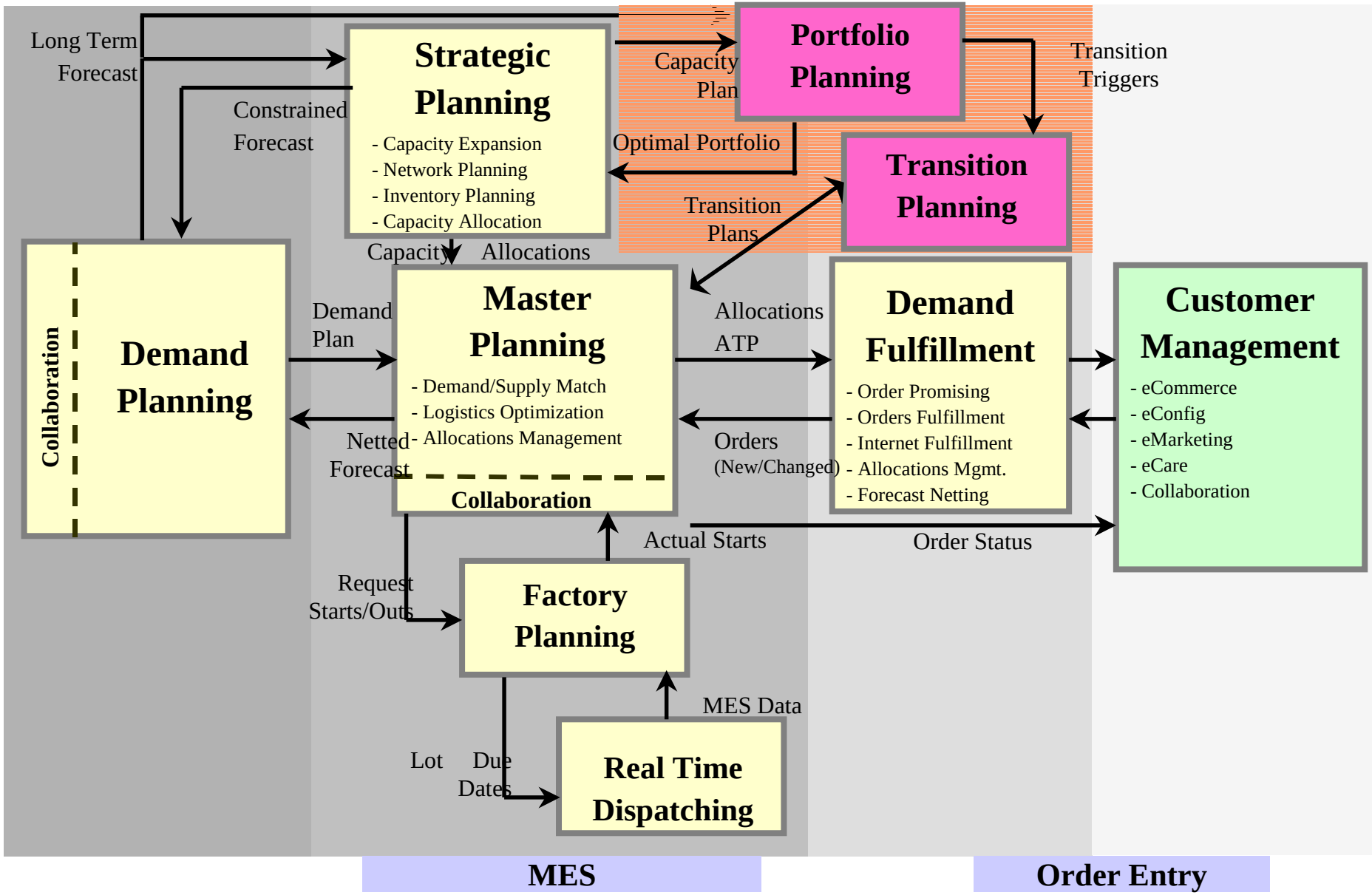
Task 879.1: Intelligent Demand Aggregation and Forecasting

Task Leader: Argon Chen

Investigators: Ruey-Shan Guo

Shi-Chung Chang

Demand Planning in SCP (Example: i2's Solution)



Issues of Demand Planning

- Most unreliable info in planning activities: demand forecast
- Demand uncertainty propagates and magnified through supply chain: bullwhip effect
- Aggregating demand for less demand uncertainty: risk pooling (but how?)
- Different perspectives of demand: customer, technology, product type, sales region, etc
- Uses of demand forecast in manufacturing planning: for material planning? or capacity allocation?

Practice of Demand Forecast

- Qualitative
  - Also Known as "Judgmental" or Subjective
  - Using intuitive or gut feelings based on their experience and savvy
  - Aggregated Demand Forecast: Bottom-up vs. top-down vs. middle-out
- Quantitative
  - Also known as "Mathematical" or Objective
  - Time-series forecasts
  - OLAP
  - Data mining

Benefits from Demand Aggregation

- Intuitively speaking
  - Aggregation achieve the effects of risk pooling
    - High demand from one customer will be offset by low demand from the other
    - Keeping the same service level by fewer inventories
- Statistically speaking
  - Reduce the variation dramatically

Constraints of Aggregation

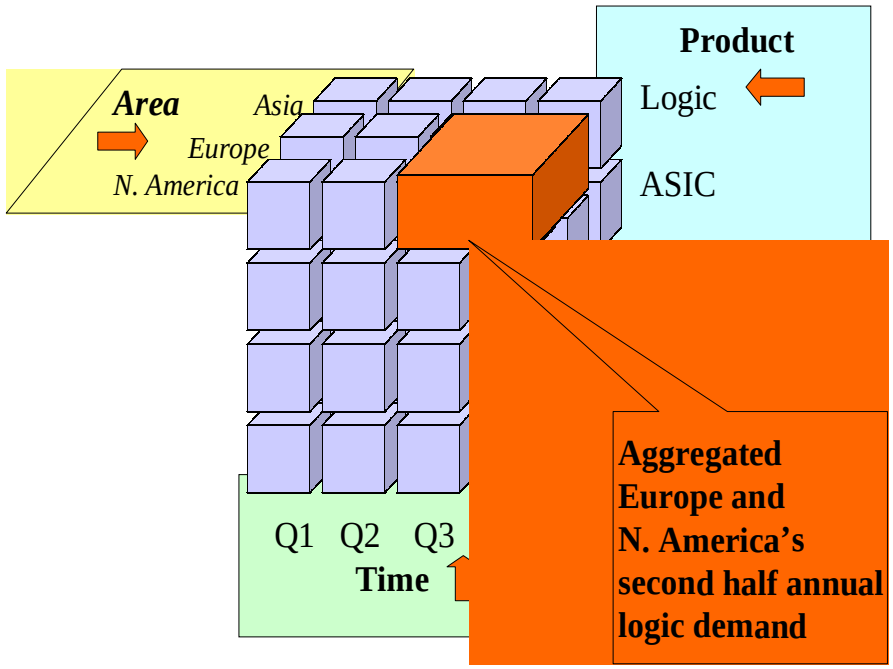
- Aggregation cannot be universally applied to all situations
- When we use aggregation policy
  - Resolution is lower
  - Detailed information is lost
  - Lead time becomes longer
  - And some other factors change

Demand Forecast with Aggregation

- *Bottom-up approach*: Forecast from the most detailed level and then roll up to a sales region or product family
- *Top-down approach*:Forecast from an aggregated level and then break down the forecast by region or product
- *Middle-out approach*: Forecast from a mid-aggregation level and then break down to detailed level or roll up to a higher degree of aggregation

Demand Planning Tool

- Multi-dimensional “slice-and-dice” analysis to provide different views: on-line analytic processing (OLAP) technology



- **No existing tools provide analytical aggregation methodologies**

Research Scope

- Production Types
  - Make to stock
  - Engineer to Order
- Demand Types
  - time-invariant vs. time-variant
  - from aggregation of two demands to combinatorial aggregation of multiple demands
  - from single perspective to multiple perspective

Deliverables

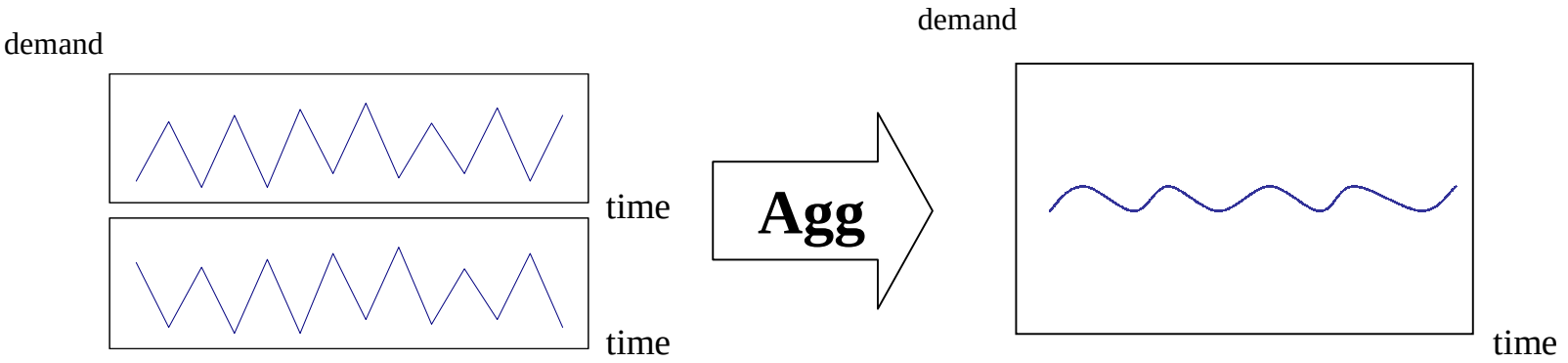
- Intelligent multidimensional demand aggregation/disaggregation strategies (Model, Report) (12/2001)
- Forecasting methodologies for multidimensional aggregated demands (Model, Report) (12/2002)
- Integrated demand aggregation/forecast prototype system (Software, Report) (12/2003)

Current Progress

- Demand aggregation strategy under time-invariant demands – inventory theory
- Demand aggregation strategy under time-variant demands – time series analysis
- Combination strategy
  - Greedy algorithm
  - Heuristics-based algorithm

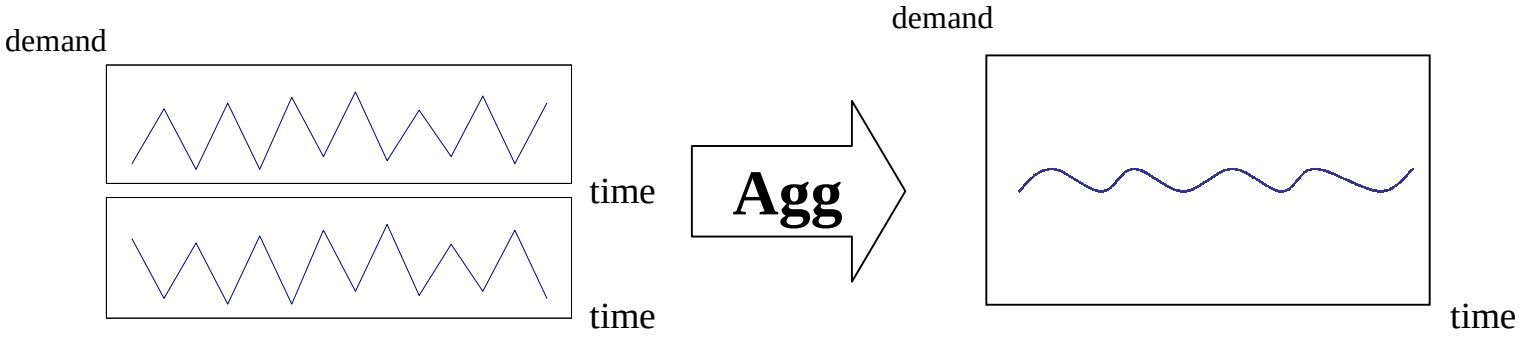
Aggregation Strategy under Time-Invariant Demands

- Aggregation is effective when the correlation of two demands approaches negative
- Aggregation is effective when the variation sizes of two demands are close



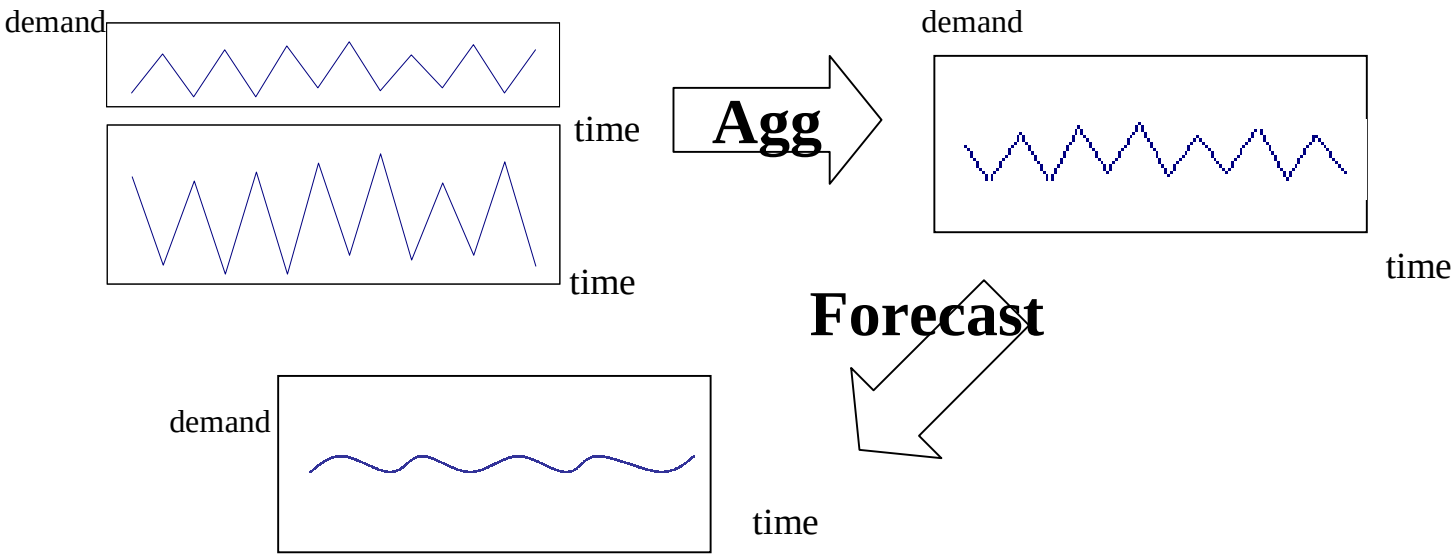
Aggregation Strategy under Time-Variant Demands

- Study vehicle: Correlated time series - VAR(1) model
  - Two theorems and one corollary were developed
- Aggregating without statistical forecast when
  - two demands are negatively correlated **and**
  - the variation sizes are similar



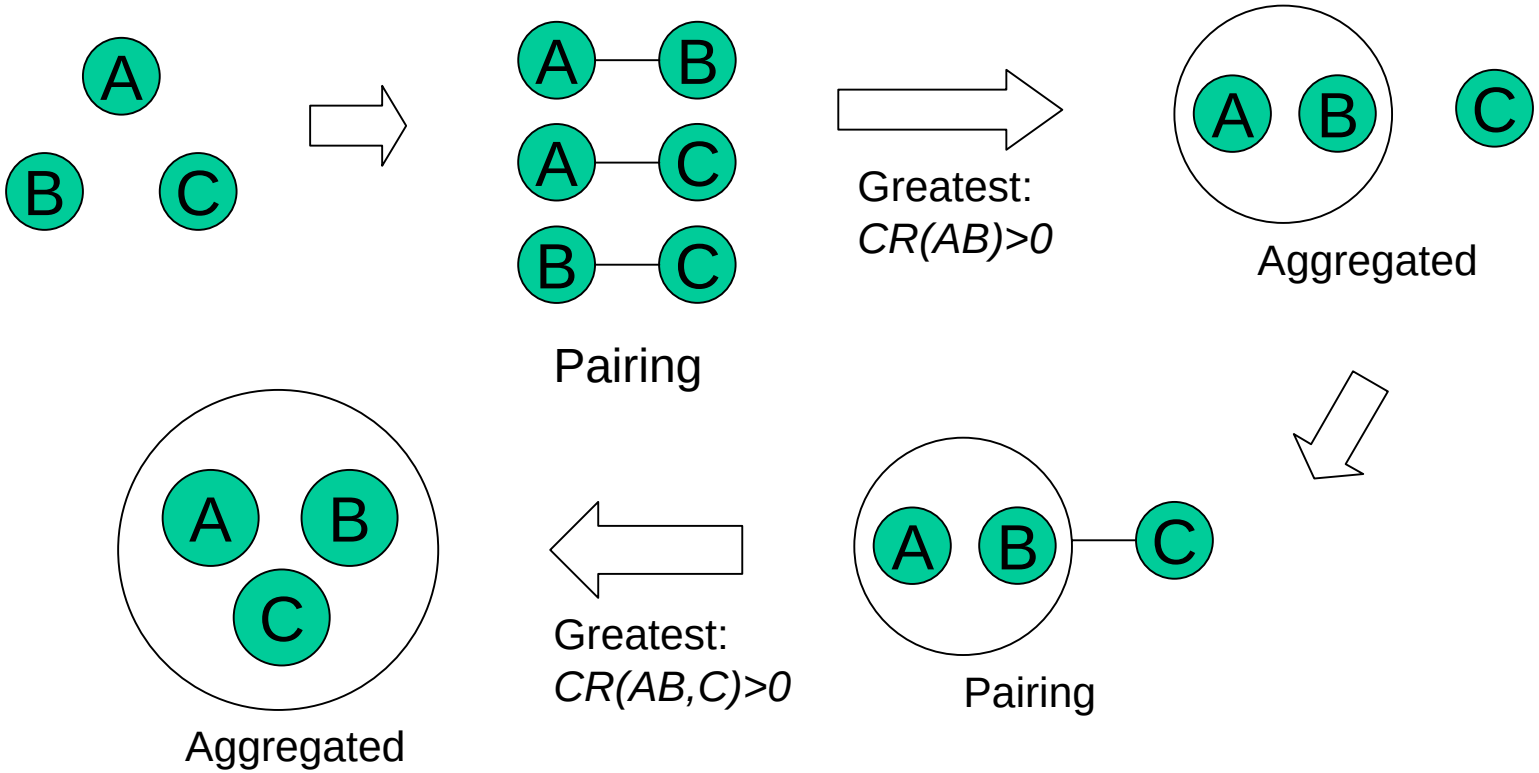
Aggregation Strategy under Time-Variant Demands (Cont'd)

- Aggregation with statistical forecast when
  - the two demands are correlated (negative or positive) **and**
  - the variation sizes are different



Combination Strategy: Greedy Algorithm

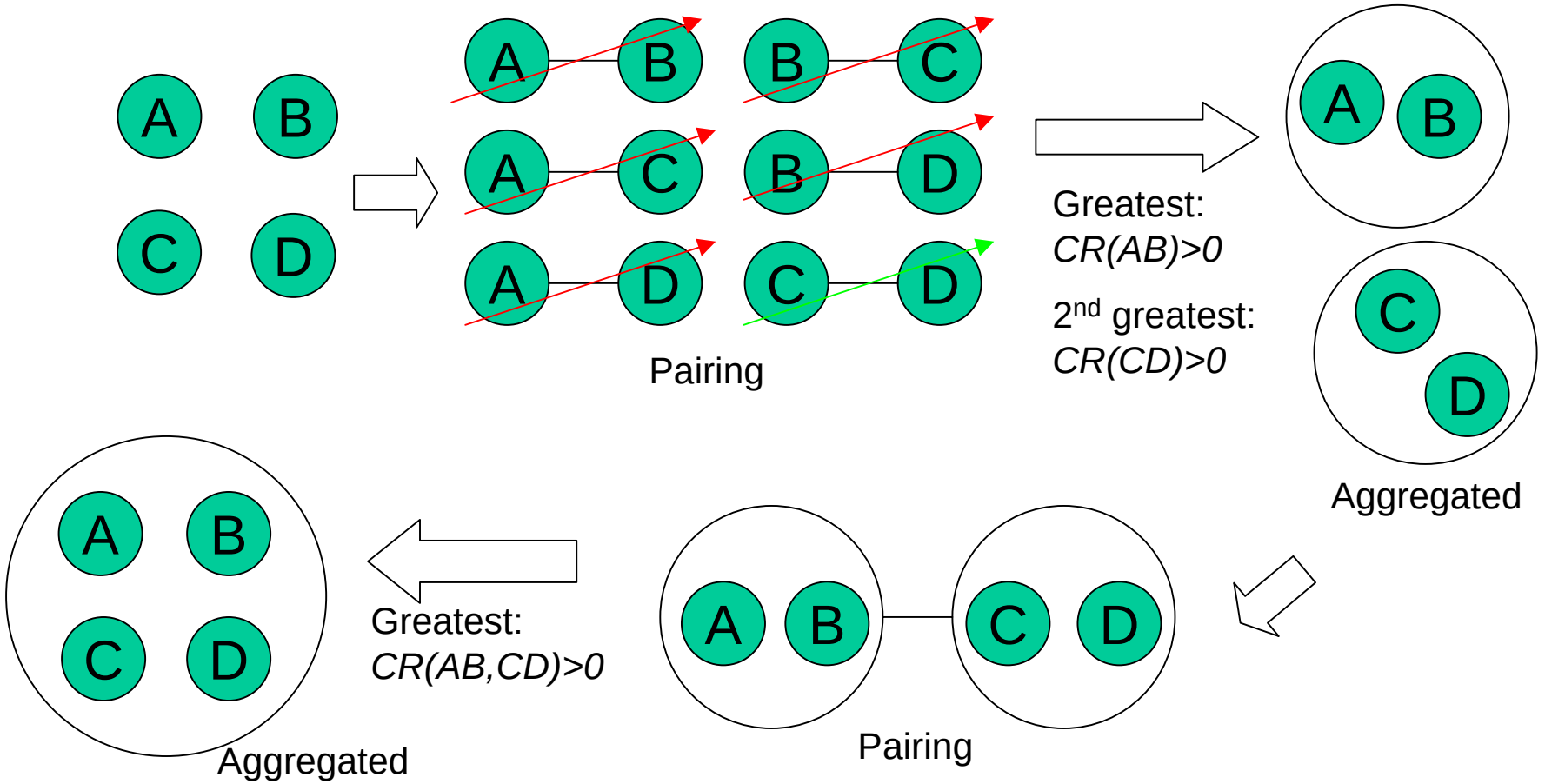
- Using 3 demand sources A, B & C to illustrate: (CR: Cost Reduction)



- A sufficient condition is developed to check the optimality of Greedy algorithm

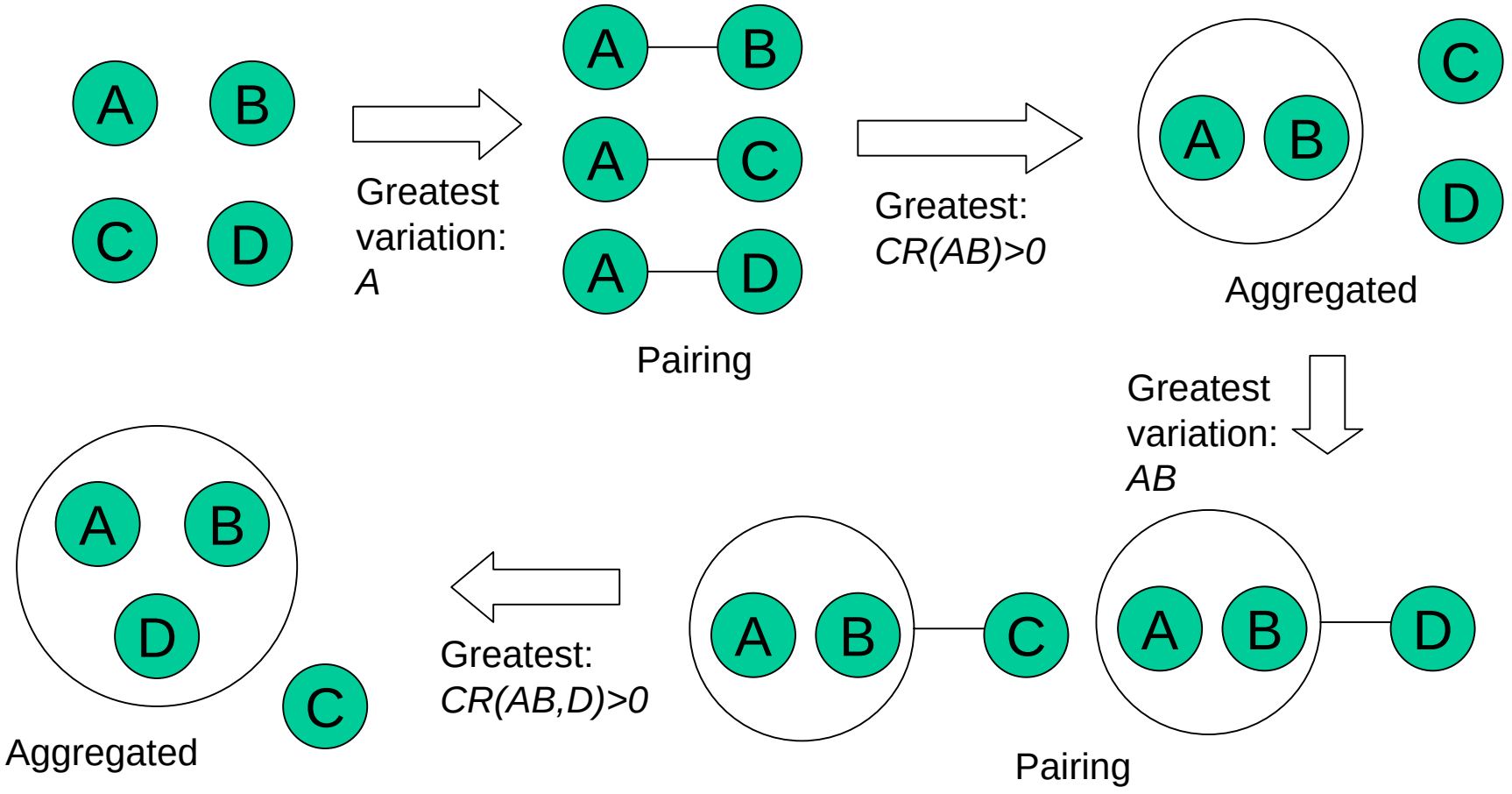
Combination Strategy: Grasping Algorithm

- Using 4 demand sources A, B, C & D to illustrate:



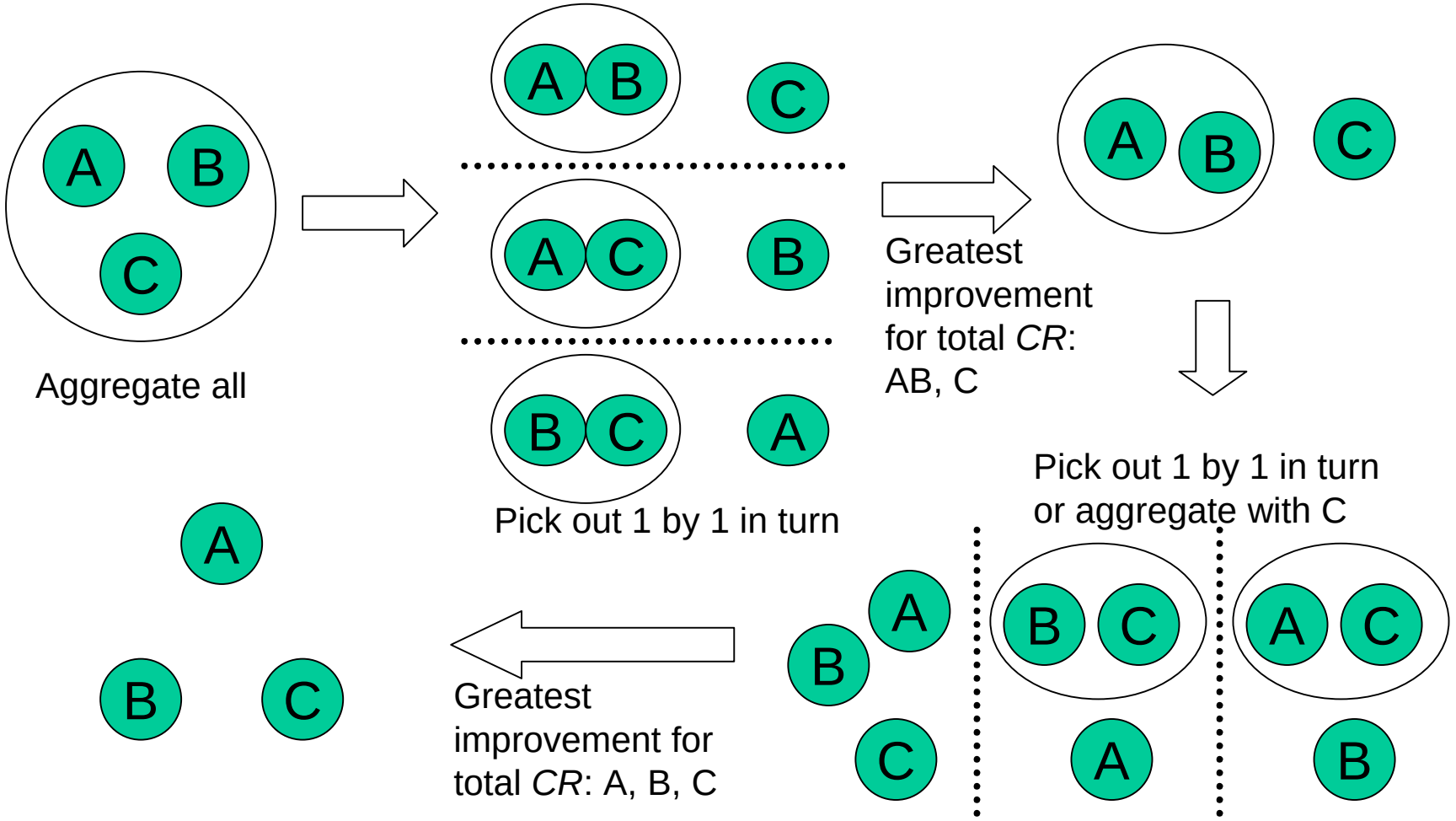
Combination Strategy: GSDF Algorithm

- Using 4 demand sources A, B, C & D to illustrate:



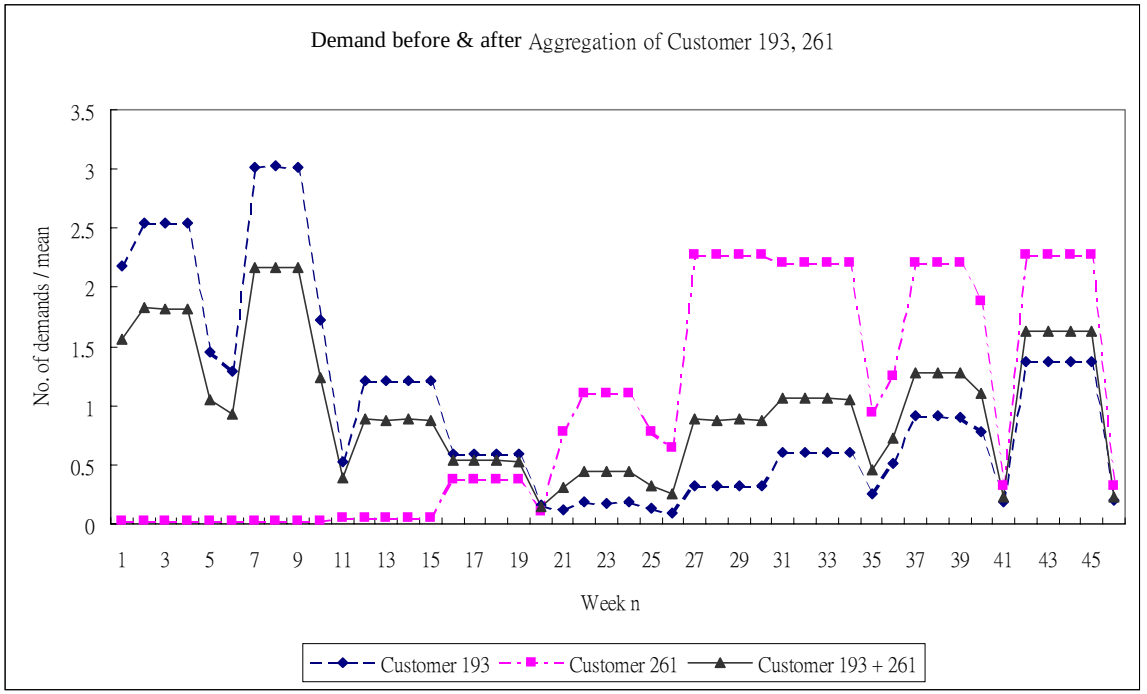
Combination Strategy: Splitting Algorithm

- Using 3 demand sources A, B & C to illustrate:



Case Study: Foundry Demand Data

- Effect of aggregation



  - Middle line: after aggregation — variation smaller than that before aggregation

Suggestions for Combination Strategy

- Greedy algorithm
  - Used when the no. of demand is not too large
- Grasping algorithm
  - Used when the high efficiency of computing is required and no. of demand is large
- GSDF algorithm
  - Used when some target demand sources with large variability are pre-determined to aggregate

Tasks In-Progress

- Aggregation from product hierarchy
- Demand aggregation strategies for capacity planning
- Disaggregation strategies
- Weighted aggregation strategies

Hierarchical Product Demand Planning

- Various hierarchical structures

  G: Generation (μm) F: Function T: Technology (metal layers)

1. *Generation*
|
G.Function
|
G.F.Technology

2. *Generation*
|
G.Technology
|
G.T.Function

3. *Technology*
|
T.Generation
|
T.G.Function

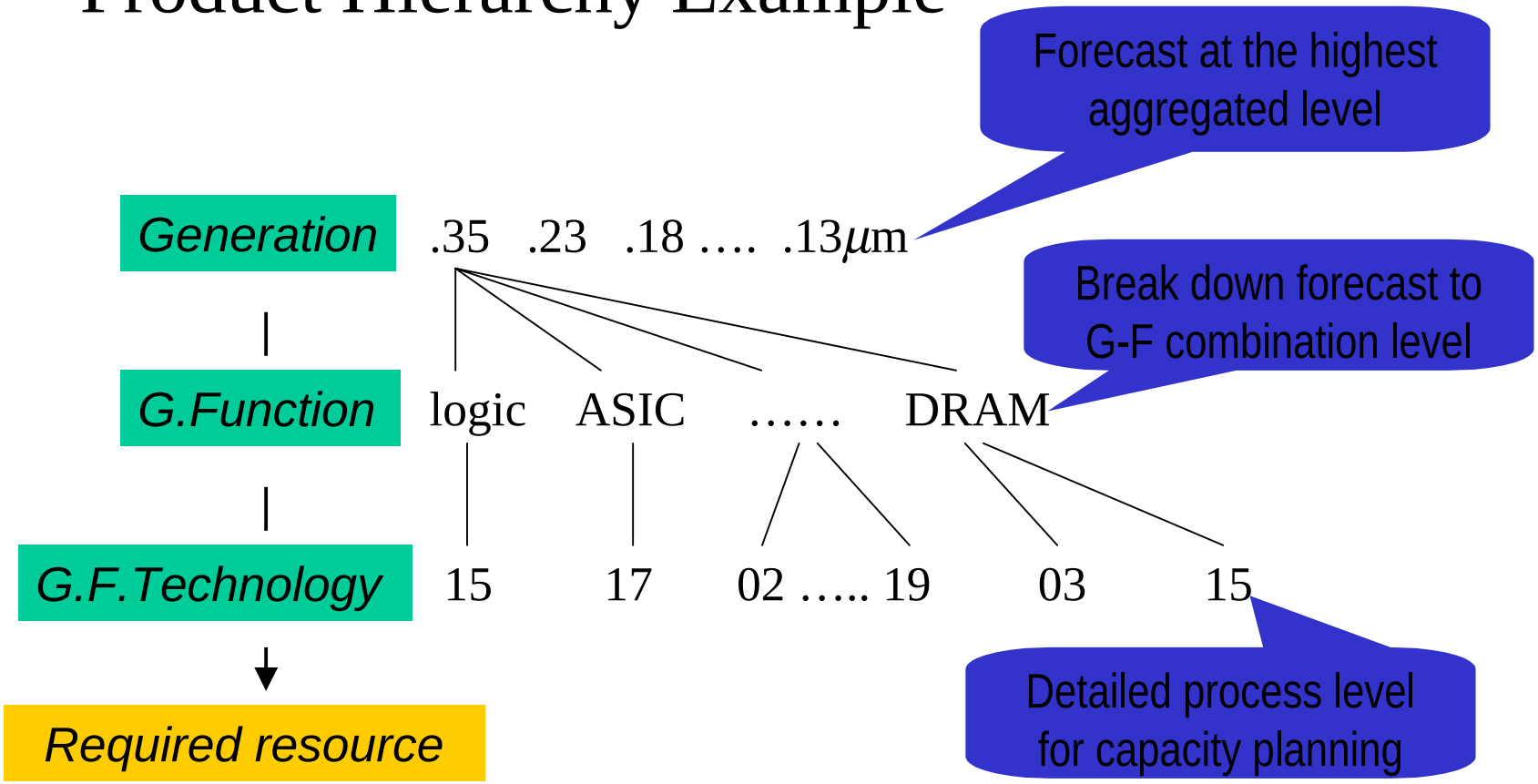
4. *Technology*
|
T.Function
|
T.F.Generation

5. *Function*
|
F.Technology
|
F.T.Generation

6. *Function*
|
F.Generation
|
F.G.Technology

Best hierarchical structure for demand planning?

Product Hierarchy Example

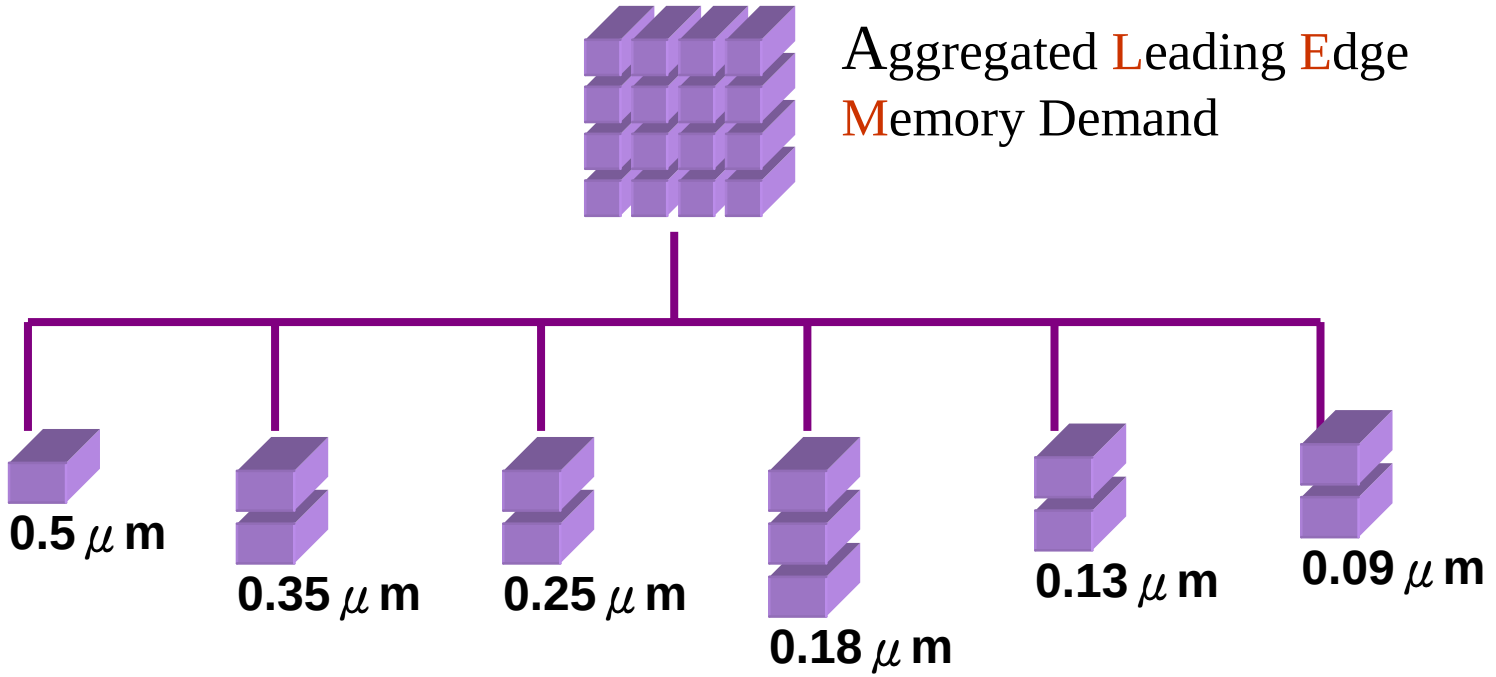


Performance measure:

1. **Sum of forecast errors**
2. **Average coefficient of variation**

Aggregated Demand Forecast

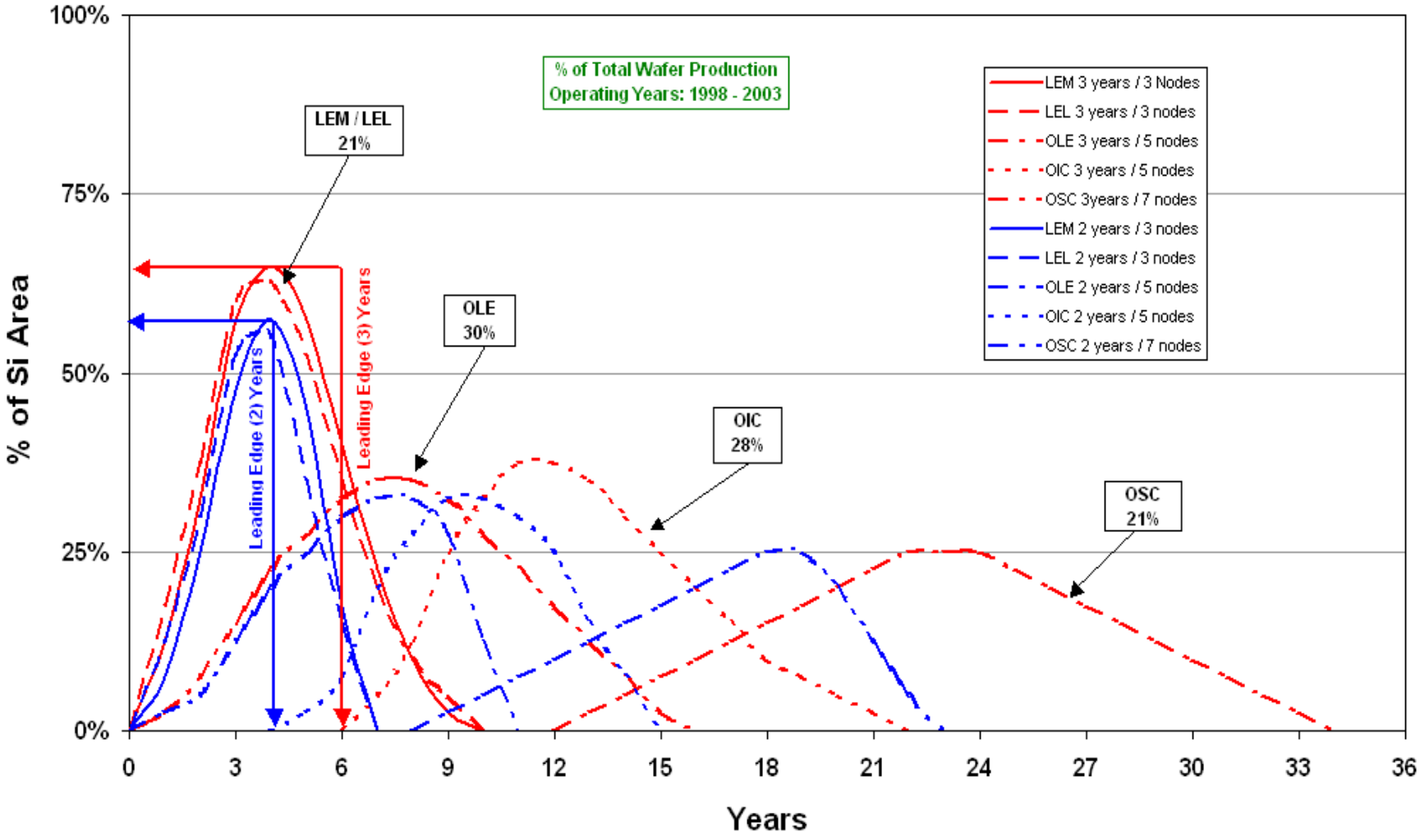
- Example：Product Family



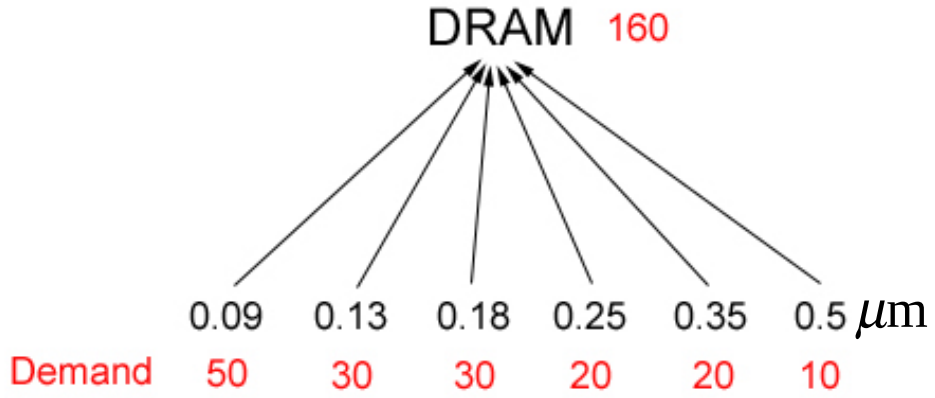
How to break down the forecast to individual product demands ?

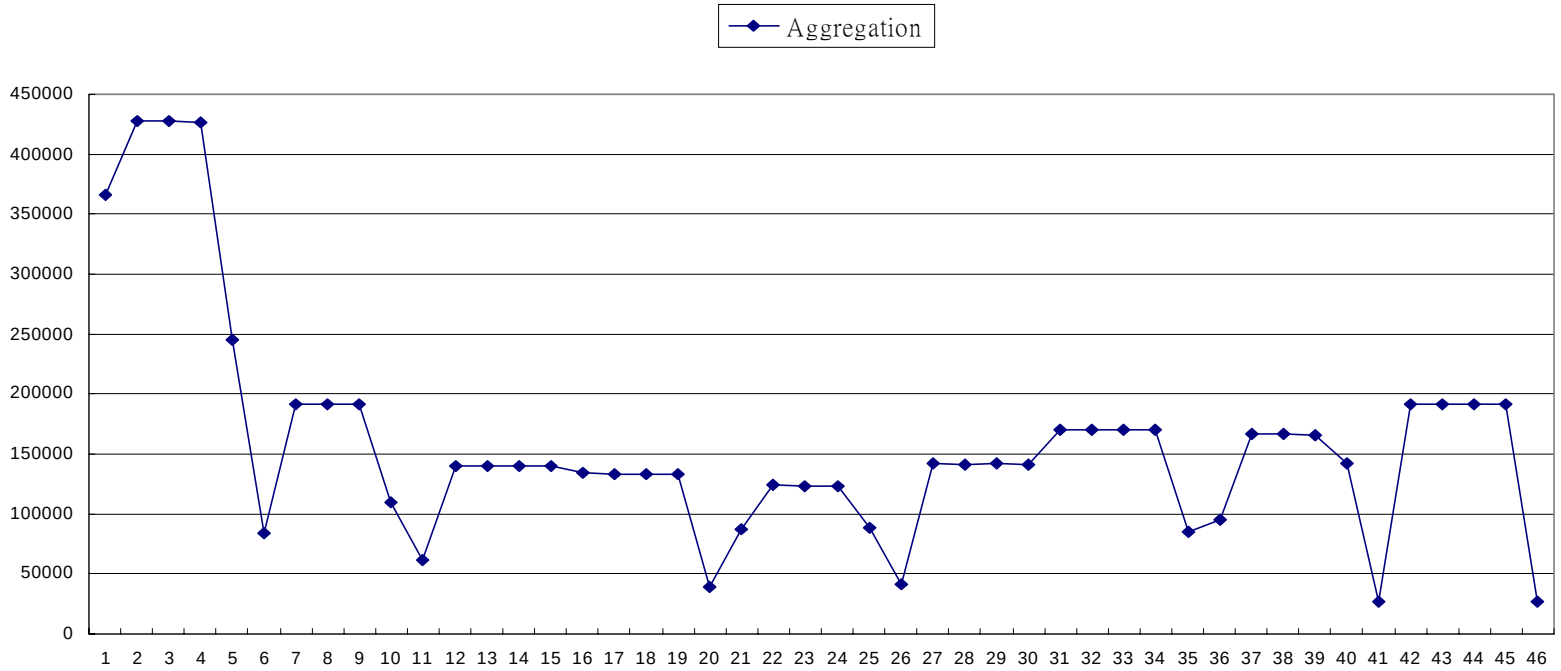
Disaggregating Demand Forecast

- Determine proportion based on product life cycle



Forecasting Aggregated Demand





Forecast with Weighted Aggregated Demand

- Find weights to minimize the CV of aggregated demand