Chapter 8: Aggregate Planning in the SC

Readings and Assignment: See Course Web

1. What is Aggregate Planning (AP)?
2. Role of AP in a SC
3. AP strategies
4. AP techniques
5. Cut-and-Try method for AP
6. Optimizing AP by LP/Excel Solver
7. APS in SCM, CPFR
8. Implementation issues

1. What is Aggregate Planning?

Suppose the figure to the right represents forecast demand in units.

Now suppose this lower figure represents the aggregate capacity of the company to meet demand.

What we need to do is to balance out the demand and the capacity supply.

- Balancing Aggregate Demand and Aggregate Production Capacity (the production rate, workforce levels and inventory ...)

Managerial Practice

Whirlpool Corporation (www.whirlpoolcorp.com) is a leading producer of room air conditioners. The demand for window units is highly seasonal and also depends on variations in the weather. Typically, Whirlpool begins production of room air conditioners in the fall and holds them as inventory until they are shipped in the spring. Building inventory in the slack season allows the company to level production rates over much of the year and yet satisfy demand in the peak periods (spring and summer) when retailers are placing most of their orders. However, when summers are hotter than usual, demand increases dramatically and stockouts can occur. If Whirlpool increases output and the summer is hot, it stands to increase its sales and market share. But if the summer is cool, the company is stuck with expensive inventories of unsold machines. Whirlpool prefers to make its production plans based on the average year, taking into account industry forecasts for total sales and traditional seasonalities. Because of Whirlpool’s increasing global operations, its aggregate planning process smoothes out regional variations in demand. For example, the particular strong results in North America and Europe more than offset weak economic and business conditions in Latin America and Asia.

Seasonality patterns depend on the weather and product, and in turn affect aggregate plans. Aggregate plans for processes further downstream in the value chain can also be affected. Here a sales associate talks on the phone to a customer near two Whirlpool dryers in the appliance department of a Sears store.

Managerial Inputs

- Current machine capacities
- Plans for future capacities
- Workforce capacities
- Current staffing level

Distribution and marketing
- Customer needs
- Demand forecasts
- Competition behavior

Accounting and finance
- Cost data
- Financial condition of firm

Aggregate plan
- Materials
  - Supplier capabilities
  - Storage capacity
  - Materials availability

Engineering
- New products
- Product design changes
- Machine standards

Human resources
- Labor-market conditions
- Training capacity

Aggregate Planning

- A process by which a company determines levels of capacity, production, subcontracting, inventory, stockouts and even pricing over a specified time horizon.

Goal: Specify the optimal combination (tradeoff) of

- Production
  - Production rate (units completed per unit of time)
- Capacity (regular time, overtime, subcontract)
  - Workforce level (number of workers/units of capacity)
  - Overtime (the overtime production planned)
  - Machine capacity level (units of machine capacity needed)
  - Subcontracting (the subcontracted or outsourced capacity)
- Inventory
  - Backlog (demand not satisfied but carried over to future period)/lost sales
  - Inventory on hand (inventory carried from previous period)
- Prices
  - To maximize the firm's profit over the planning horizon

Product group or broad category (aggregation)

Intermediate-range planning period: 6-18 months
Outputs of Aggregate Plan

- **Production quantity**
  - from regular time, overtime, and subcontracted time: used to determine number of workers and supplier purchase levels

- **Inventory held**
  - used to determine how much warehouse space and working capital is needed

- **Backlog/stockout quantity**
  - used to determine what customer service levels will be

- **Machine capacity increase/decrease**
  - used to determine if new production equipment needs to be purchased

A poor aggregate plan can result in lost sales, lost profits, excess inventory, or excess capacity

Aggregate Planning Objectives

- Minimize Costs/Maximize Profits
- Maximize Customer Service
- Minimize Inventory Investment
- Minimize Changes in Production Rates
- Minimize Changes in Workforce Levels
- Maximize Utilization of Plant and Equipment
- …

Overview of major operational planning activities

- **Long-range**
  - Process Planning
  - Strategic Capacity Planning

- **Intermediate-range**
  - Aggregate Planning
  - Master Production Scheduling
  - Material Requirements Planning
  - Order Scheduling
  - Weekly Workforce & Customer Scheduling

- **Short-range**
  - Material Requirements Planning (MRP)
  - Capacity Requirements Planning (CRP)
  - Purchasing Planning and Control
  - Inventory Status Data
  - Weekly Workforce & Customer Scheduling
  - Daily Workforce & Customer Scheduling
### Aggregate Planning Process

**Determine requirements for planning horizon**

**Identify alternatives, constraints, and costs**

**Prepare prospective plan for planning horizon**

- **Is the plan acceptable?**
  - No
  - Yes

**Move ahead to next planning session**

**Implement and update the plan**

### 2. Key Strategies for AP

- **Chase**
  - Matching the production rate to the order rate by hiring and laying off employees as the order rate varies

- **Level**
  - Maintain a stable workforce working at a constant output rate. Shortages and surpluses are absorbed by fluctuating inventory levels, order backlogs, and lost sales.

- **Time flexibility from workforce or capacity**
  - Vary the output by varying the number of hours worked through flexible work schedules or overtime

- **Some combination of the strategies**

### 3. Aggregate Planning Techniques

- **Cut-and-try**
  - Simple method
  - Involving costing out various production planning alternatives and selecting the one that is best
  - Elaborate spreadsheets are developed to facilitate the decision process

- **Math. Programming (LP/IP/GP ...)**
  - Highly effective
  - System optimization
  - What-if analysis, scenario analysis

- **Simulation**
  -...

### Example 1

**Aggregate Planning: Unit Demand and Cost Data**

Suppose we have the following unit demand and cost information:

<table>
<thead>
<tr>
<th>Demand/mo.</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4500</td>
<td>5500</td>
<td>7000</td>
<td>10000</td>
<td>8000</td>
<td>6000</td>
</tr>
</tbody>
</table>

- **Materials**: $5/unit
- **Holding costs**: $1/unit per mo.
- **Marginal cost of stockout**: $1.25/unit per mo.
- **Hiring and training cost**: $200/worker
- **Layoff costs**: $250/worker
- **Labor hours required**: .15 hrs/unit
- **Straight time labor cost**: $8/hour
- **Beginning inventory**: 250 units
- **Productive hours/worker/day**: 7.25
- **Paid straight hrs/day**: 8
- **Beginning labor force**: 7
### 4. Cut-and-Try method

Given the demand and cost information below, what are the aggregate hours/worker/month, units/worker, and dollars/worker?

<table>
<thead>
<tr>
<th>Demand/mo</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,500</td>
<td>5,500</td>
<td>7,000</td>
<td>10,000</td>
<td>8,000</td>
<td>6,000</td>
<td></td>
</tr>
</tbody>
</table>

| Productive hours/worker/day | 7.25 |
| Paid straight hrs/day       | 8    |
| Labor hours required        | .15  |

Given the demand and cost information below, what are the aggregate hours/worker/month, units/worker, and dollars/worker?

<table>
<thead>
<tr>
<th>Days/mo</th>
<th>22</th>
<th>19</th>
<th>21</th>
<th>21</th>
<th>22</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hrs/worker/mo</td>
<td>159.5</td>
<td>137.75</td>
<td>152.25</td>
<td>152.25</td>
<td>159.5</td>
<td>145</td>
</tr>
<tr>
<td>Units/worker/mo</td>
<td>1,063.33</td>
<td>918.33</td>
<td>1,015</td>
<td>1,015</td>
<td>1,063.33</td>
<td>966.6</td>
</tr>
<tr>
<td>$/worker/mo</td>
<td>$1,408</td>
<td>1,216</td>
<td>1,344</td>
<td>1,344</td>
<td>1,408</td>
<td>1,280</td>
</tr>
</tbody>
</table>

### Chase Strategy

(Varying workforce by hiring & firing to meet demand)

<table>
<thead>
<tr>
<th>Days/mo</th>
<th>22</th>
<th>19</th>
<th>21</th>
<th>21</th>
<th>22</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hrs/worker/mo</td>
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<td>1,344</td>
<td>1,408</td>
<td>1,280</td>
</tr>
</tbody>
</table>

#### Jan
- Labor force: 7
- Demand: 4,500
- Beg. inv.: 250
- Net req.: 4,250
- Req. workers: 3.997
- Hired: 3
- Fired: 1
- Workforce: 4
- Ending inventory: 0

#### Feb
- Labor force: 7
- Demand: 5,500
- Beg. inv.: 0
- Net req.: 5,500
- Req. workers: 5.989
- Hired: 1
- Fired: 2
- Workforce: 6
- Ending inventory: 0

#### Mar
- Labor force: 6
- Demand: 7,000
- Beg. inv.: 0
- Net req.: 7,000
- Req. workers: 6.897
- Hired: 3
- Fired: 0
- Workforce: 9
- Ending inventory: 0

#### Apr
- Labor force: 9
- Demand: 10,000
- Beg. inv.: 0
- Net req.: 10,000
- Req. workers: 9.852
- Hired: 7
- Fired: 2
- Workforce: 14
- Ending inventory: 0

#### May
- Labor force: 14
- Demand: 8,000
- Beg. inv.: 0
- Net req.: 8,000
- Req. workers: 7.524
- Hired: 10
- Fired: 3
- Workforce: 17
- Ending inventory: 0

#### Jun
- Labor force: 17
- Demand: 6,000
- Beg. inv.: 0
- Net req.: 6,000
- Req. workers: 6.207
- Hired: 8
- Fired: 7
- Workforce: 11
- Ending inventory: 0

### Complete Calculations

Below are the complete calculations for the remaining months in the six month planning horizon.

<table>
<thead>
<tr>
<th>Demand/mo</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,500</td>
<td>5,500</td>
<td>7,000</td>
<td>10,000</td>
<td>8,000</td>
<td>6,000</td>
<td></td>
</tr>
</tbody>
</table>

| Beg. inv. | 250 |
| Net req.  | 4,250 | 5,500 | 7,000 | 10,000 | 8,000 | 6,000 |

| Hired | 3 |
| Fired | 1 |
| Workforce | 4 | 6 | 7 | 10 | 8 |
| Ending inventory | 0 | 0 | 0 | 0 | 0 |

### Material Costs

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>$21,250.00</td>
<td>$27,500.00</td>
<td>$35,000.00</td>
<td>$50,000.00</td>
<td>$40,000.00</td>
<td>$30,000.00</td>
<td>$203,750.00</td>
</tr>
</tbody>
</table>

| Labor | 5,627.59 | 7,282.76 | 9,268.97 | 13,241.38 | 10,593.10 | 7,944.83 | 53,958.02 |

| Hrly cost | $600.00 | $400.00 | $200.00 | $600.00 | $1,200.00 |

| Total cost | $750.00 | $500.00 | $250.00 | $1,500.00 |

| Total cost | $260,408.00 |
**Chase Strategy**

- Production rate is synchronized with demand by varying machine capacity or hiring and laying off workers as the demand rate varies.
- However, in practice, it is often difficult to vary capacity and workforce on short notice.
- Expensive if cost of varying capacity is high.
- Negative effect on workforce morale.
- Results in low levels of inventory.
- Should be used when inventory holding costs are high and costs of changing capacity are low.

**Level Workforce Strategy:**

(Fixed workforce/production level and use inventory to surplus and shortage)

Let's take the same Example 1 problem and show how to use the Level Workforce strategy.

<table>
<thead>
<tr>
<th>Jan</th>
<th>Demand</th>
<th>Beg. inv.</th>
<th>Net req.</th>
<th>Workers</th>
<th>Production</th>
<th>Ending inventory</th>
<th>Surplus</th>
<th>Shortage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,500</td>
<td>250</td>
<td>4,250</td>
<td>6</td>
<td>6,380</td>
<td>2,130</td>
<td>2,130</td>
<td>0</td>
</tr>
</tbody>
</table>

The workforce level is fixed as 6 workers.

The calculations for the remaining months in the six month planning horizon.

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
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<th>May</th>
<th>Jun</th>
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<tr>
<td>Demand</td>
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<td>8,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Beg. inv.</td>
<td>250</td>
<td>2,130</td>
<td>2,140</td>
<td>1,230</td>
<td>-2,680</td>
</tr>
<tr>
<td>Net req.</td>
<td>4,250</td>
<td>3,370</td>
<td>4,860</td>
<td>8,770</td>
<td>10,680</td>
</tr>
<tr>
<td>Workers</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Production</td>
<td>6,380</td>
<td>5,510</td>
<td>6,090</td>
<td>6,090</td>
<td>6,380</td>
</tr>
<tr>
<td>Ending inventory</td>
<td>2,130</td>
<td>2,140</td>
<td>1,230</td>
<td>-2,680</td>
<td>-4,300</td>
</tr>
<tr>
<td>Surplus</td>
<td>2,130</td>
<td>2,140</td>
<td>1,230</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shortage</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,680</td>
<td>4,300</td>
</tr>
</tbody>
</table>

Note, if we recalculate this sheet with 7 workers we would have a surplus.

Below are the complete calculations for the remaining months in the six month planning horizon with the other costs included.

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>5,500</td>
<td>7,000</td>
<td>10,000</td>
<td>8,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Beg. inv.</td>
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<td>6</td>
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<td>6,380</td>
<td>5,510</td>
<td>6,090</td>
<td>6,090</td>
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</tr>
<tr>
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<td>2,140</td>
<td>1,230</td>
<td>-2,680</td>
<td>-4,300</td>
</tr>
<tr>
<td>Surplus</td>
<td>2,130</td>
<td>2,140</td>
<td>1,230</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shortage</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,680</td>
<td>4,300</td>
</tr>
<tr>
<td>Labor</td>
<td>$8,448</td>
<td>$7,296</td>
<td>$8,064</td>
<td>$8,064</td>
<td>$8,448</td>
</tr>
<tr>
<td>Material</td>
<td>31,900</td>
<td>27,550</td>
<td>30,450</td>
<td>30,450</td>
<td>31,900</td>
</tr>
<tr>
<td>Carrying</td>
<td>2,130</td>
<td>2,140</td>
<td>1,230</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stockout</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,350</td>
<td>5,375</td>
</tr>
</tbody>
</table>

Note, the total costs under this strategy are less than under Chase.
Level Strategy

- Maintain stable machine capacity and workforce levels with a constant output rate
- Shortages and surpluses result in fluctuations in inventory levels over time
- Inventories that are built up in anticipation of future demand or backlogs are carried over from high to low demand periods
- Better for worker morale
- Large inventories and backlogs may accumulate
- Should be used when inventory holding and backlog costs are relatively low

Aggregate Planning Strategies

PLANNING STRATEGIES FOR AGGREGATE PLANS

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Possible Alternatives during Slack Season</th>
<th>Possible Alternatives during Peak Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chase #1: vary workforce level to match demand</td>
<td>Layoffs</td>
<td>Hiring</td>
</tr>
<tr>
<td>2. Chase #2: vary output rate to match demand</td>
<td>Layoffs, undertime, vacations</td>
<td>Hiring, overtime, subcontracting</td>
</tr>
<tr>
<td>3. Level #1: constant workforce level</td>
<td>No layoffs, building anticipation inventory, undertime, vacations</td>
<td>No hiring, depleting anticipation inventory, overtime, subcontracting, backorders, stockouts</td>
</tr>
<tr>
<td>4. Level #2: constant output rate</td>
<td>Layoffs, building anticipation inventory, undertime, vacations</td>
<td>Hiring, depleting anticipation inventory, overtime, subcontracting, backorders, stockouts</td>
</tr>
</tbody>
</table>

5. Optimizing AP by LP and Excel Solver

Example 2: Red Tomato Tools

- A small manufacturer (assembling) of gardening equipment
- All demand is to be met. The demand for gardening tools is highly seasonal.
Demand forecast and costs data for Red Tomato:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>$10/unit</td>
</tr>
<tr>
<td>Inventory holding cost</td>
<td>$2/unit/month</td>
</tr>
<tr>
<td>Marginal cost of a stockout</td>
<td>$5/unit/month</td>
</tr>
<tr>
<td>Hiring and training costs</td>
<td>$300/worker</td>
</tr>
<tr>
<td>Layoff cost</td>
<td>$500/worker</td>
</tr>
<tr>
<td>Labor hours required</td>
<td>4/unit</td>
</tr>
<tr>
<td>Regular time cost</td>
<td>$4/hour</td>
</tr>
<tr>
<td>Over time cost</td>
<td>$6/hour</td>
</tr>
<tr>
<td>Cost of subcontracting</td>
<td>$30/unit</td>
</tr>
</tbody>
</table>

The capacity is determined mainly by the size of its workforce.

- No limits on subcontracting, inventories and stockouts/backlogs
- Tool price is $40/unit
- At the beginning of January, the starting inventory holding is 1000 tools and 80 employees
- 20 working days in each month and 8 hours per day
- No employee works more than 10 hours of overtime per month
- The ending inventory holding at the end of June is at least 500 units. No stockouts at the end of June

The optimization principles:

- Minimize costs
- Maximize profits
- Minimize inventory levels
- Minimize changes in work force levels
- Minimize use of overtime
- Minimize use of subcontracting
- Minimize changes in production rates
- Minimize number of machine setups
- Minimize idle time for plant and personnel
- Maximize customer service
- ...

Key Strategies for AP:

- Chase
  - matching the production rate to the order rate by hiring and laying off employees as the order rate varies
- Level
  - Maintain a stable workforce working at a constant output rate. Shortage and surpluses are absorbed by fluctuating inventory levels, order backlogs, and lost sales.
- Time flexibility from workforce or capacity
  - Vary the output by varying the number of hours worked through flexible work schedules or overtime

Some combination of the strategies

LP/IP

Graphical presentation of Red Tomato AP problem

Using graphs for analysis and understanding of the model structure!!
Define Decision Variables

- $W_t$ = Workforce size for month $t$, $t = 1, ..., 6$
- $H_t$ = Number of employees hired at the beginning of month $t$, $t = 1, ..., 6$
- $L_t$ = Number of employees laid off at the beginning of month $t$, $t = 1, ..., 6$
- $P_t$ = Production in month $t$, $t = 1, ..., 6$
- $I_t$ = Inventory at the end of month $t$, $t = 1, ..., 6$
- $S_t$ = Number of units stocked out at the end of month $t$, $t = 1, ..., 6$
- $C_t$ = Number of units subcontracted for month $t$, $t = 1, ..., 6$
- $O_t$ = Number of overtime hours worked in month $t$, $t = 1, ..., 6$

Decision Objective:

Minimize Total Cost

\[ \text{Cost of Regular time labor + Hiring and training + layoffs + Overtime labor + holding inventory + stocking out + subcontracting + material} \]

Decision Constraints - (1)

- Monthly inventory balance
  
  \[ \text{(Node balancing for product flow, Inflow = Outflow.)} \]

Decision Constraints - (2)

- Workforce size for each month is based on hiring and layoffs
  
  \[ \text{(Node balancing for workforce flow network, Inflow = Outflow.)} \]
Decision Constraints - (3)

Monthly production cannot exceed capacity

\[
\text{Actual production each month} \leq \text{The amount that can be produced each month with its workforce}
\]

(Link the production with the capacity)

Decision Constraints - (4)

Monthly OT cannot exceed 10 hr./hd./mth.

Use Excel “Solver”:

Aggregate Planning

Demand Forecast

<table>
<thead>
<tr>
<th>Month</th>
<th>Demand Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1,600</td>
</tr>
<tr>
<td>February</td>
<td>3,000</td>
</tr>
<tr>
<td>March</td>
<td>3,200</td>
</tr>
<tr>
<td>April</td>
<td>3,000</td>
</tr>
<tr>
<td>May</td>
<td>2,200</td>
</tr>
<tr>
<td>June</td>
<td>2,200</td>
</tr>
</tbody>
</table>

Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials cost/unit</td>
<td>$10</td>
</tr>
<tr>
<td>Inventory holding cost/ unit/month</td>
<td>$2</td>
</tr>
<tr>
<td>Marginal cost of stockout/unit/month</td>
<td>$5</td>
</tr>
<tr>
<td>Hiring and training cost/worker</td>
<td>$300</td>
</tr>
<tr>
<td>Layoff cost/worker</td>
<td>$500</td>
</tr>
<tr>
<td>Labor hours required/ unit</td>
<td>$4</td>
</tr>
<tr>
<td>Regular time cost/ hour</td>
<td>$4</td>
</tr>
<tr>
<td>Overtime cost/ hour</td>
<td>$6</td>
</tr>
<tr>
<td>Marginal subcontracting cost/unit</td>
<td>$30</td>
</tr>
</tbody>
</table>

The Optimal Plan
Use Excel for Scenarios / What-if analysis

- Increased demand fluctuation (Refer to Example 5.1)
- Increase in holding cost (from $2 to $6, Refer to Example 5.2)
- Over time cost drops to $4.1 per hour

<table>
<thead>
<tr>
<th>Month</th>
<th>Demand Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1,000</td>
</tr>
<tr>
<td>February</td>
<td>3,000</td>
</tr>
<tr>
<td>March</td>
<td>3,800</td>
</tr>
<tr>
<td>April</td>
<td>4,800</td>
</tr>
<tr>
<td>May</td>
<td>2,000</td>
</tr>
<tr>
<td>June</td>
<td>1,400</td>
</tr>
</tbody>
</table>

Collaborative Planning, Forecasting, and Replenishment (CPFR)

- CPFR is recognized as a breakthrough business model for planning, forecasting, and replenishment.
- Emphasizes a sharing of consumer purchasing data among and between supply chain partners.
- Creates a direct link between the consumer and the supply chain. The plan and the forecast are entered by suppliers and buyers into an Internet accessible system.
- Within established parameters, any of the participating partners is empowered to change the forecast (- Centralized and shared information !)
- Only a few CPFR initiatives have been made public, but results are impressive.

CPRF Model:

- Collaborative Planning across supply chain...
- Aggregate (integrated) planning for multiple products; decision units; function areas; chain parties; regions...
CPFR: Collaborative Planning, Forecasting and Replenishment

## Retailer and Manufacturer Enterprise Tasks that Support Collaboration

<table>
<thead>
<tr>
<th>Retailer Tasks</th>
<th>Collaboration Tasks</th>
<th>Manufacturer Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor Management</td>
<td>Collaboration Arrangement</td>
<td>Account Planning</td>
</tr>
<tr>
<td>Category Management</td>
<td>Joint Business Plan</td>
<td>Market Planning</td>
</tr>
<tr>
<td>POS Forecasting</td>
<td>Sales Forecasting</td>
<td>Market Data Analysis</td>
</tr>
<tr>
<td>Replenishment Planning</td>
<td>Order Planning/Forecasting</td>
<td>Demand Planning</td>
</tr>
</tbody>
</table>

### Network Architecture

- **Enterprise Software**
- **Web Browser**
- **E-mail**
- **Fax**
- **Alerts**
- **XML**
- **Savi Data Center**
- **Supplier**
- **Savi Data Appliance**
- **Handheld Devices**
- **Satellite**
- **Cellular**
- **Savi Mobile Data Appliance**
- **Factory**
- **Distribution Center**
- **Customer**

### Network Architecture Diagram

- **Internet**
- **Ethernet 802.11**
- **Savi Site Server**
- **Savi Data Center**
- **Customer**
- **Enterprise Software**
- **Web Browser**
- **E-mail**
- **Fax**
- **Alerts**

### APS System Modules

<table>
<thead>
<tr>
<th>Resource Management</th>
<th>Requirements Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Management</td>
<td>Resource Allocation</td>
</tr>
</tbody>
</table>

**APS Examples:**
- Demand management
- Factory planning
- Transportation planning
- Integrated resource planning
- Supply chain design
- Pricing

### Application Interface

- **BUYER**
  - Item Table
  - Forecast Table
  - Promotions Table
- **SELLER**
  - Item Table
  - Forecast Table
  - Promotions Table

### Table

<table>
<thead>
<tr>
<th>ITEM NUMBER</th>
<th>RTLR'S FORECAST</th>
<th>MFR. FORECAST</th>
<th>DELTA</th>
<th>TOLERANCE</th>
<th>OKT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234567890001</td>
<td>1200</td>
<td>1150</td>
<td>50</td>
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<tr>
<td>1234567890002</td>
<td>1400</td>
<td>9000</td>
<td>5000</td>
<td>2000</td>
<td>y</td>
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<tr>
<td>1234567890003</td>
<td>320</td>
<td>350</td>
<td>20</td>
<td>50</td>
<td>y</td>
</tr>
</tbody>
</table>
**APS Characteristics**
- Driven by forecast and order requirements
- Constrained resource planning
- Integrated supply chain decision making
- Time phased
- Requires high data integrity and accuracy

**Key Features of APS**
- Constraint management
- Concurrent planning
- Synchronized planning
- Modeling
- Optimization
- Simulation
- Available-to-promise capability

**7. Implementation issues**
- It is important to perform AP over as wide a scope of the supply chain as is reasonably possible
- Make plans flexible to cope with forecasts errors
- Use safety stock or safety capacity to cope with uncertainties
- ...

**A real Hong Kong case ...**