Improving Customer Service Operations at Amazon.com

Jin Goo Ki Sung
2007/11/29
Telecom Service/Policy
• Introduction
• Problem Setting
• Literature Review
• Solution Approach
• Result
• **Interface** between customer and company is very important.

• **Effects on**
  - **Customer satisfaction** on the product
  - **Image** of the company
• **On-line market** has developed rapidly

![Graph showing online market growth in Korea](image)

- The Interface of On-line market
  - The features of company’s web site
  - **Contact Center** (Voice, E-mail)
• For good interface, online company should provide a **feedback** in certain amount of time

Need to **schedule** the human resource in contact center

• The objective of this paper
  ◦ Provide the **mathematical programming** to allocate human resource in contact center efficiently

\[
\min \sum_{t=1}^{T} \sum_{(i,j) \in \mathcal{G}} (N_{ij} n_{ij} + O_{ij} o_{ij}) + \sum_{t=1}^{T} \sum_{(i,j) \in \mathcal{G}} H_{ij} h_{ij} + \sum_{t=1}^{T} \sum_{(i,j) \in \mathcal{G}} S_{ij} s_{ij} + \sum_{t=1}^{T} \sum_{i \in \mathcal{P}} F_{t}^{i}
\]
**AMAZON.COM**

- American e-commerce company

**Diversification**

Revenue (from 1997 to 2006) $Mil

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>NA</td>
</tr>
<tr>
<td>1998</td>
<td>1071.10</td>
</tr>
<tr>
<td>1999</td>
<td>8925.63</td>
</tr>
<tr>
<td>2000</td>
<td>7140.67</td>
</tr>
<tr>
<td>2001</td>
<td>5355.50</td>
</tr>
<tr>
<td>2002</td>
<td>3570.39</td>
</tr>
<tr>
<td>2003</td>
<td>1785.17</td>
</tr>
<tr>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
</tbody>
</table>
AMAZON.COM

- Their success came from
  - Steady growth (not fast)

- Diversification
- CSO (Customer Service Organization)

**The Leaders and Best E-Commerce/Transaction Sites**

- Range of e-Gov scores: 57 to 86
- B&N.com: 88
- Amazon: 87
- Ebay: 80
- 1-800Flowers.com: 77
CSO

“We believe that our ability to establish and maintain long-term relationships with customers and to encourage repeat visits and purchases depends on the strength of customer service operations” (Amazon.com 2003, p. 4).

- Provide interface through
  - Website
    - Tracking orders and shipments
    - Reviewing estimated delivery dates
    - Cancelling unshipped items.
  - Contact centers (internal, external)
    - If cannot resolve inquiries using the web site
    - E-mail or phone call (24hours)

- Providing customer with good interface
  - Size the capacity of contact center to respond to customer in certain amount of time

Human Resource Planning
**Problem Setting**

- Schedule the contact center (internal, external)

Considering - Seasonality

The weekly volume of contacts

Contacts divided by 8 Category

** 8 Planning Groups
- Training
  - Training of Customer Service Representative (CSR)

Training of CSR

Problem Setting
**AS-IS (spread sheet based)**

- **Special PG (internal)**
  - Capacity $j >$ Voice $j$
  - Capacity $j =$ Voice $j$
  - Capacity $j =$ E-mail $j$
  - Primary $+$ = Capacity $j$
  - Primary $+$ = Capacity $j$
  - Capacity $j =$ Voice $j$ + E-mail $j$

- **Primary PG**
  - Primary Voice $-$ = Cosourcer
  - Primary Voice $>$ Primary
  - Primary Voice $-$ = Primary Voice
  - Primary $=$ Primary Voice
• Three Issues
  ◦ 1. how they added CSRs to teams?
    • Differences in contracts with cosources, staffing and service levels
    • Average productivity, wage differ among centers
  ◦ 2. Contract terms differ across cosourcers
    • Cost per ‘Contact handled’ vs ‘Fixed charge’
  ◦ 3. Lack of consideration between service objectives and staffing cost
    • Ignore the randomness of arrival rate, handling time
    • No lever to allow CSO manager to consider them
• Gans Et al. (2003)
  ◦ Comprehensive summary of the state of call-center research pertaining to capacity management
• Whitt (1999)
  ◦ Determination of capacity in a setting with two customer classes. (one-immediately, the other response within a day)
• Armony and Maglaras (2004)
  ◦ In a call center, customers can chose service class 1 (call back) or class 2 (wait for expected delay)
• Chen and Henderson (2001)
  ◦ In a call center, service is divided into 2 groups. For higher priority use (tail probability), other classes use Markov’s inequality

• Gans and Zhou (2002)
  ◦ Focused on a situation where 2 classes of customers exist (high and low value). Solve a problem to determine staffing level considering outsourcing lower value class.
• **TO-BE**
  - **Math programming** considering three issues
  - Develop **two stage solution** approach

  • **Adjustment Procedure**
    - Adjust contact forecasts to take into account different source of **uncertainty** and **service level objectives**
    - Hourly forecasts of e-mail and voice contact, average CSR handling time and service-level objectives

  • **Optimization Model**
    - **Mixed integer program**
    - **Minimum-cost capacity plan** for processing the contact forecast
**Adjustment**

- **Step 1**  
  \[ \rho_{v,h} = \frac{\lambda_{v,h}}{\mu_v}, \quad \rho_{e,h} = \frac{\lambda_{e,h}}{\mu_e} \]  
  Without regard to service level objective

- **Step 2** Calculate the \( \tilde{\rho}_{v,h} \)

  With regard to service level objective using Erlang C formula

- **Step 3**  
  \[ \theta_d = \sum_h \rho_{v,h}, \quad \phi_d = \sum_h \rho_{e,h}, \quad \tilde{\theta}_d = \sum_h \tilde{\rho}_{v,h} \]

- **Step 4** If \( \theta_d + \phi_d > \tilde{\theta}_d \), \( \gamma_d = \theta_d \cdot \mu_v \) Else \( \gamma_d = \tilde{\theta}_d \cdot \mu_v \)

  \[ V_t^k = \sum_d \gamma_d \]

- **Step 5**  
  \[ E_t^k = \sum_d \phi_d \cdot \mu_e \]

The collection of adjusted forecasts becomes input to the optimization model.
Formulation in MILP

- Objective Function

\[
\min \sum_{t=1}^{T} \sum_{(i,j) \in \mathcal{G}} (N_{t}^{ij} n_{t}^{ij} + O_{t}^{ij} o_{t}^{ij}) + \sum_{t=1}^{T} \sum_{\{(i,j) \in \mathcal{G} | i=1\}} H_{t}^{ij} h_{t}^{ij} \\
+ \sum_{t=1}^{T} \sum_{\{(i,j) \in \mathcal{G} | i \neq 1\}} S_{t}^{ij} s_{t}^{ij} + \sum_{t=1}^{T} \sum_{i \in \mathcal{I}} F_{t}^{i} \\
- \sum_{t=1}^{T} \sum_{i \in \mathcal{I}} \sum_{k=2}^{R_{i}^{k}} F_{t}^{i} y_{k,t}^{i} + \sum_{t=1}^{T} \sum_{i \in \mathcal{I}} \sum_{k=1}^{R_{i}^{k}} U_{k,t}^{i} x_{k,t}^{i}
\]
• Formulation in MILP
  ◦ Constraints

\[
\sum_{(i,j) \in \mathcal{S}} v_{i}^{j,1} + \sum_{i \in \mathcal{C}} c_{i}^{1} \geq V_{t}^{1}, \quad t = 1, \ldots, T,
\]

\[
\sum_{(i,j) \in \mathcal{S}} e_{i}^{j,1} + \sum_{i \in \mathcal{C}} c_{i}^{1} \geq E_{t}^{1}, \quad t = 1, \ldots, T,
\]

\[
\sum_{\{(i,j) \in \mathcal{S} | i=k\}} v_{i}^{j,k} \geq V_{t}^{k}
\]

\[
\forall k \in \mathcal{C}, k \neq 1, t = 1, \ldots, T,
\]

\[
\sum_{\{(i,j) \in \mathcal{S} | i=k\}} e_{i}^{j,k} \geq E_{t}^{k}
\]

\[
\forall k \in \mathcal{C}, k \neq 1, t = 1, \ldots, T,
\]
Formulation in MILP

- Constraints

\[
\begin{align*}
\mu_{ij,t}^{-1}v_{ij,t} + \sum_k \mu_{ij,k}e_{ij,k} & \leq (1 - \delta_{ij})(n_{ij} + o_{ij}) \\
\forall (i, j) & \in G, \ t = 1, \ldots, T, \\
o_{ij} & \leq \gamma_{ij}n_{ij} \\
\forall (i, j) & \in G, \ t = 1, \ldots, T, \\
W_{ij}w_{ij} & \geq n_{ij} \\
\forall (i, j) & \in G, \ t = 1, \ldots, T, \\
\omega_{ij}^{1j}(1 - \alpha_{ij}) - d_{ij,t} - \sum_{i \in F \ |\ i \neq 1} s_{ij} + h_{ij,t-1} & = \omega_{ij}^{1j} \\
\forall j & \in L, \ t = 1, \ldots, T, \\
\omega_{ij}^{1j}(1 - \alpha_{ij}) - d_{ij,t} + s_{ij} & = \omega_{ij}^{1j} \\
\forall (i, j) & \in G, \ i \neq 1, \ t = 1, \ldots, T,
\end{align*}
\]
Optimization Model

- Formulation in MILP
  - Constraints

\[
\begin{align*}
    v_{i,j,k}^t &\leq \beta_{i,j,k}^t v_t^k \\
    \forall (i, j) &\in \mathcal{G}, \forall k &\in \mathcal{K}, t = 1, \ldots, T, \\
    e_{i,j,k}^t &\leq \beta_{i,j,k}^t e_t^k \\
    \forall (i, j) &\in \mathcal{G}, \forall k &\in \mathcal{K}, t = 1, \ldots, T, \\
    c_i^t &\leq \xi_i^t v_i^1 \quad \forall i &\in \mathcal{P}, t = 1, \ldots, T, \\
    c_i^t &\leq \xi_i^t e_i^1 \quad \forall i &\in \mathcal{E}, t = 1, \ldots, T, \\
    \sum_{i \in \mathcal{P}} c_i^t &\leq \xi_p^t v_t^1, \quad t = 1, \ldots, T, \\
    \sum_{i \in \mathcal{E}} c_i^t &\leq \xi_e^t e_t^1, \quad t = 1, \ldots, T,
\end{align*}
\]
• Formulation in MILP
  ◦ Constraints

\[
\begin{align*}
  x^i_{k,t} - B^i_k y^i_{k,t} &\leq 0 \\
  \forall i \in \mathcal{X}, \ k = 1, \ldots, R^i - 1, \ t = 1, \ldots, T, \\
  x^i_{k,t} - (B^i_{k-1} + 1)y^i_{k,t} &\geq 0 \\
  \forall i \in \mathcal{X}, \ k = 2, \ldots, R^i, \ t = 1, \ldots, T, \\
  c^i_t &= \sum_{k=1}^{R^i} x^i_{k,t} \quad \forall i \in \mathcal{X}, \ t = 1, \ldots, T, \\
  \sum_{k=1}^{R^i} y^i_{k,t} &= 1 \quad \forall i \in \mathcal{X}, \ t = 1, \ldots, T,
\end{align*}
\]
Formulation in MILP

- Constraints

\[
M(1 - z_t^i) \geq (1 + \xi^i)c_{i-1}^i - c_i^i \\
\forall i \in \mathcal{Q}, t = 1, \ldots, T,
\]

\[
Mz_t^i \geq c_i^i - (1 + \xi^i)c_{i-1}^i \quad \forall i \in \mathcal{Q}, t = 1, \ldots, T,
\]

\[
M(1 - \hat{z}_t^i) \geq c_i^i - (1 - \xi^i)c_{i-1}^i \\
\forall i \in \mathcal{Q}, t = 1, \ldots, T,
\]

\[
M\hat{z}_t^i \geq (1 - \xi^i)c_{i-1}^i - c_i^i \quad \forall i \in \mathcal{Q}, t = 1, \ldots, T,
\]

\[
M(1 - \hat{z}_t^i) \geq c_{i+\omega}^i - (1 + \xi^i)c_t^i \\
\forall i \in \mathcal{Q}, t = -\Omega^i + 1, \ldots, T, \omega = 1, \ldots, \Omega^i,
\]

\[
-M(1 - \hat{z}_t^i) \leq c_{i+\omega}^i - (1 - \xi^i)c_t^i \\
\forall i \in \mathcal{Q}, t = -\Omega^i + 1, \ldots, T, \omega = 1, \ldots, \Omega^i,
\]
• Experiment
  ◦ Planning Horizon = 52 weeks (1 year)
  ◦ 134,000 constraints, 16,000 variables (1000 integer)
  ◦ CPLEX on an HP 9000 superdome server
  ◦ Takes less than 5 minutes (spread sheet 1 day)

• Results
  ◦ Save Time, enable additional scenario analysis
  ◦ Considers ‘Three Issues’ not considered in AS-IS
  ◦ Increases annual operational cost savings
• Reference는 아직 다 정리가 안되어 정리 되는데로 다시 보내드리겠습니다.