Cross-Selling in Call Centers: Modeling and Optimization

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Outline

- Introduction
  - Call Centers
  - Cross-Selling

- Literature

- Modeling cross-selling in a call center
  - The model with random revenues
  - The model with fixed revenues

- Existence of preferred classes/ preferred customers

- Existence of monotone policies

- Numerical results

- Conclusions
What’s in a typical call center?
Growth in the Call Center Industry

- Number of Call Centers in Europe will grow from 12,750 in 1999 to 28,289 in 2006
  
  Frost & Sullivan

- There are 69,500 call centers in US, growing to approximately 78,000 in 2003
  
  Datamonitor

- The worldwide call center services market totaled US$23B in revenues in 1998, and projected to double to US$58.6B by 2003. Outsourcing is the largest segment, with US$17B in 1998, or 74% of total market, headed for US$42B in 2003
  
  IDC

- There are approximately 4,000,000 agents now working, in call centers in US, with an annual growth rate of 10% in agent position
  
  Stephens Inc.
Call Centers in Banking

- The Tower Group estimates that nearly 39 billion retail banking transactions were conducted in the US during 1999, growing to 44 billion in 2003. Call centers processed 18% of transactions in 1999 and are projected to represent almost 25% of transactions by 2003.

- Two types of banking call centers:
  - *general banking centers*: handling mostly inbound calls and offering support for a wide variety of banking products
  - *monoline centers*: focused on supporting a specific product type; i.e. credit cards

- Global spending by banks on call centers will exceed US$34 billion by 2003, with North American investment accounting for nearly half that total.

- The number of agent seats at inbound banking call centers will grow 12% annually over the next five years to 243,000 seats globally, with the greatest growth occurring in Western Europe and Japan.
Shifting from Cost to Profit Centers

Source: Merchants International 2000

Benchmark Organizational Structures (*)

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2003 (P)</th>
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<tbody>
<tr>
<td>Cost Center</td>
<td>84%</td>
<td>67%</td>
<td>57%</td>
<td>45%</td>
</tr>
<tr>
<td>Profit Center</td>
<td>11%</td>
<td>26%</td>
<td>40%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Note: (*) denotes benchmark organizational structures.
Growth in the Financial Services Industry

- Mature markets: Increase “share-of-wallet”
- Existing customers are better sales prospects (Felvey 1982)
- Dislike for telemarketing
- Sales increasingly in the form of cross-selling (Kresbach, 2002; Walker, 2003)
- Cross-selling as an important CRM initiative
- Call centers as a key customer contact point
Cross-selling basics

Data-mining
Training & incentives

Try to Cross-sell?

Customer reaction

“This new loan option is exactly what I need!”
+ $$$$$

“I don’t want another sales pitch, just transfer the money!”
Lost time, increased waiting!

• Paas and Kuijlen, 2001
• Kamakura et al. 1991, 2003
• Insurance Advocate, 2003
• American Banker, 2003

• Retention: Marple and Zimmerman, 1999
• Churn: Kamakura et al. 2003
• Switch: Kamakura et al. 2003
The Basic Trade-off

Revenue enhancement

- Real-time automation
- Historical data

Who is likely to buy?

Service Quality

- Talk times
- Call volumes

Current load in system

Key questions:
- When to cross-sell?
- To whom to cross-sell?
Cross-selling and Operations

- Aksin and Harker (1999): first model that considers cross-selling impact on service delivery performance and design
- Günes and Aksin (2004): Incentive design for cross-selling; illustrates link to market segmentation
- Byers and So (2003): performance of cross-selling policies that consider queue state information and/or customer profile information.
- Savin, Netessine, and Xiao (2004): cross-selling in e-retailing
Two models of cross-selling

- The model with random revenues
  - Real-time automation
  - Server knows revenue potential of a customer at the beginning of a call

- The model with fixed revenues
  - Analysis of historical segment based data
  - Server makes decision based on expected revenue potential at the beginning of a call
  - At the end of the call, a random revenue is realized
Model with random revenues:
A 2-class c-server no-wait-room system

- Poisson arrivals
- service revenue: $r$
- xsell revenue: $\rho_s \sim F_s, s=L,H$

1: xsell rate $\mu_1 = \mu - k$
2: service rate $\mu$

exponential service times
Markov decision model of the system

- State: \( x=(x_1, x_2) \) & \( (x, \rho_s, s)= (x_1, x_2, \rho_s, s) \)
  - \( x_1 \): number of cross-sell customers
  - \( x_2 \): number of service customers
  - \( \rho_s \): random revenue observed upon the arrival of the call
  - \( s \): class/segment of the incoming call

- Actions (only upon arrivals): \( a(x_1, x_2, \rho_s, s) = \begin{cases} 
1 & \text{if xsell} \\
0 & \text{if service} 
\end{cases} \)

- Objective: maximize total expected \( \beta \)-discounted revenue over an 8-horizon

- Maximal total expected \( \beta \)-discounted revenue:
  \( u(x_1, x_2), v(x_1, x_2, \rho_s, s) \)
Market segmentation

- Aggregation of customers into homogeneous groups according to their cross-sell revenue generation potentials.

- Discrete segmentation: Most widely used
  - In cross-selling, this typically leads to cross-sell to only class-H calls type policy

- Overlapping segmentation:
  - a more realistic and theoretically accurate segmentation scheme. Lilien and Rangaswamy (1998)
Market segmentation based on cross-sell revenues

Upper bound on random revenues: \( \overline{\rho}_s = \inf\{ x : P(\rho_s \leq x) = 1 \} \)

Lower bound on random revenues: \( \underline{\rho}_s = \sup\{ x : P(\rho_s \leq x) = 0 \} \)

Segments in marketing

Possible scenarios:

Scenario 1: \( \underline{\rho}_L \leq \overline{\rho}_L \leq \underline{\rho}_H \leq \overline{\rho}_H \) discrete

Scenario 2: \( \underline{\rho}_L \leq \overline{\rho}_L \leq \overline{\rho}_L \leq \overline{\rho}_H \) overlapping

Scenario 3: \( \underline{\rho}_H \leq \overline{\rho}_L \leq \overline{\rho}_L \leq \overline{\rho}_H \) irrelevant
Literature on dynamic control

- Admission control with random rewards
  - Ghoneim and Stidham (1985): Optimal threshold policies for a system in series
  - Ormeci, Burnetas, Emmons (2002): Optimal threshold policies for a loss system, existence of preferred jobs

- Admission control with fixed rewards
  - Koole (1998), and Altman, Jimenez, Koole (2001): Optimal threshold policies for a loss system
  - Ormeci, Burnetas, van der Wal (2001), and Savin, Cohen, Gans, Katalan (2003): Existence of preferred classes for a loss system
Illustration of the Model

\[ u(x_1, x_2) \]

Class-s arrival

\[ v(x_1, x_2, \rho_s, s) \]

Service only

\[ u(x_1, x_2 + 1) + r \]

Cross-sell

\[ u(x_1 + 1, x_2) + r + \rho_s \]

Service completion

\[ u(x_1, x_2 - 1) \]

Cross-sell completion

\[ u(x_1 - 1, x_2) \]

\[ a(x_1, x_2, \rho_s, s) = 1 \iff \]

\[ u(x_1, x_2 + 1) - u(x_1 + 1, x_2) \leq \rho_s \]

\[ D(21)(x) \]
Definition

- \( D(21)(x) \): Expected loss in future rewards because of the increased load due to the slower service of a cross-sell compared to a pure service call in state \( x \)

\[
a(x_1, x_2, \rho_s, s) = 1 \iff D(21)(x) \leq \rho_s
\]

A threshold on revenues in state \( x \)

\[
D(21) = \max \{ D(21)(x) : 0 = x_1 + x_2 = c \}
\]
Possible policies for scenarios 1 and 2

- **Policy O**: Cross-sell to nobody
- **Policy I**: Cross-sell attempt to chosen calls of segment H only
- **Policy II**: Cross-sell attempt to segment H only
- **Policy III**: Cross-sell attempt to segment H and chosen calls of segment L
- **Policy IV**: Cross-sell attempt to chosen calls of segment H and L
- **Policy V**: Cross-sell attempt to everyone

**Scenario 1**: \( \underline{\rho}_L \leq \underline{\rho}_L \leq \underline{\rho}_H \leq \underline{\rho}_H \)

**Scenario 2**: \( \underline{\rho}_L \leq \underline{\rho}_H \leq \underline{\rho}_L \leq \underline{\rho}_H \)
Preferred calls & classes

- Preferred calls are those that always generate a cross-sell attempt.
  
  If $D(21) < \rho_s$ for all $x$, call $(\rho_s, s)$ is preferred.

- Class $s$ is preferred if all class-$s$ calls always generate a cross-sell attempt.
  
  If $D(21) < \rho_s$ for all $x$, class $s$ is preferred.

- Use of upper bounds on $D(21)$ to find sufficient conditions to have preferred calls/classes.
Proposition for Scenario 1: \( \bar{\rho}_L \leq \bar{\rho}_L \leq \bar{\rho}_H \leq \bar{\rho}_H \)

1) If \( \frac{\lambda_H + \lambda_L}{\lambda_H + \lambda_L + \mu} \frac{\mu - \mu_1}{\mu_1} \leq \frac{\bar{\rho}_H}{r} \), there are preferred class - H calls.

2) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_H \), class - H is preferred.

3) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_L \), class - H is preferred and there are preferred class - L calls.

4) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_L \), both class - L and class - H are preferred.
Proposition for Scenario 2: \( \bar{\rho}_L \leq \bar{\rho}_H \leq \bar{\rho}_L \leq \bar{\rho}_H \)

1) If \( \frac{\lambda_H + \lambda_L}{\lambda_L + \lambda_H + \mu} \frac{\mu - \mu_1}{\mu_1} \leq \frac{\bar{\rho}_H}{r} \), there are preferred class - H calls.

2) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_L \), there are both preferred class - H and class - L calls.

3) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_H \), class - H is preferred and there are preferred class - L calls.

4) If \( \frac{\mu - \mu_1}{\mu} (\bar{\rho}_H + r) \leq \bar{\rho}_L \), both class - L and class - H are preferred.
Note

- There are other conditions to have preferred call/classes, which also depend on arrival rates. However, they are complicated and many systems do not satisfy these conditions.
Model with fixed revenues

- Poisson arrivals
- exponential service times

- service revenue: $r$
- xsell revenue: $r_s$, $s=L,H$

$\lambda_H$ ——— 1: xsell rate $\mu_1 = \mu - k$

$\lambda_L$ ——— 2: service rate $\mu$

$S_1$, $S_2$, $S_c$
Illustration of the Model

\[ u(x_1, x_2) \rightarrow \text{Class-s arrival} \]

\[ v(x_1, x_2, s) \rightleftharpoons \]

\[ u(x_1, x_2-1) \rightarrow \text{Service completion} \]

\[ u(x_1, x_2-1) \rightarrow \text{Cross-sell completion} \]

\[ u(x_1, x_2-1) \rightarrow \text{Cross-sell completion} \]

\[ u(x_1, x_2) \rightarrow \text{Cross-sell completion} \]

\[ u(x_1+1, x_2)+r+r_s \]

\[ D(21)(x) \leq r_s \]

\[ a(x_1, x_2, s) = 1 \iff D(21)(x) \leq r_s \]
Proposition for preferred classes

1) If \((\mu - \mu_1)r \leq \mu_1 r_H\), class - H is preferred.

2) If \(\frac{\mu - \mu_1}{\mu} (r_H + r) \leq r_L\), both class - L and class - H are preferred.
Monotonicity of optimal policy

- Can show under assumption of concavity of $u(x) = u(x_1, x_2)$ in $x_1$

- Implies threshold type policies
Back to cross-selling in call centers

- Attempt + forward: Inbound service representatives attempts a cross-sell and forwards to sales personnel to close and book

- Attempt + close: Inbound service representative has the required capabilities to close and book the sale

- Different talk-time implications
A numerical example

- Two types of cross-selling
  - Forward: Talk time of a xsell is increased about 10-20% of a service
  - Close sale: Talk time of a xsell is increased about 50% of a service

- Assume service call durations ranging from 1.5 minutes to 3 minutes.

- Data on revenues is scarce. Only, service revenue $r$ is believed to be very low compared to cross-sell revenue and the lower bound on $\rho_L$ can be set to 0.
Forward x-sell for Scenario 1:  \[ 0 \leq \rho_L \leq \rho_H \leq \rho_H \]

1) If  \[ \frac{\lambda_H + \lambda_L}{\lambda_H + \lambda_L + \mu} \frac{\mu - \mu_1}{\mu_1} \leq \frac{1}{5} \leq \frac{\rho_H}{r} \], then there are preferred class - H calls. 

   Practically, this is always true.

2) If  \[ \rho_H + r \leq 6\rho_H \], class - H is preferred.

3) If  \[ \rho_H + r \leq 6\rho_L \], class - H is preferred and there are preferred class - L calls.

4) If  \[ \rho_H + r \leq 0 \], both class - L and class - H are preferred.

   Practically, this is never true.
Close sale x-sell for Scenario 1 \( \rho \leq \bar{\rho}_L \leq \bar{\rho}_H \leq \bar{\rho}_H \)

1) If \( \frac{\lambda_H + \lambda_L}{\lambda_H + \lambda_L + \mu} \frac{\mu - \mu_1}{\mu_1} \leq \frac{1}{2} \leq \frac{\bar{\rho}_H}{r} \), there are preferred class - H calls. 
   \text{Practically, this is always true.}

2) If \( \bar{\rho}_H + r \leq 3\bar{\rho}_H \), class - H is preferred.

3) If \( \bar{\rho}_H + r \leq 3\bar{\rho}_L \), class - H is preferred and there are preferred class - L calls.

4) If \( \bar{\rho}_H + r \leq 0 \), both class - L and class - H are preferred.
   \text{Practically, this is never true.}
Numerical examples for forward cross-sell

- Average service call duration: 2.5 minutes \( \mu = 0.4 \)
- Forward cross-sell service duration: 3 minutes \( \mu_1 = 0.333 \)
- Service revenue: 1 unit \( r = 1 \)
- Highest revenue: 100 units \( \bar{\rho}_H = 100 \)
- Lowest revenue: 0 units \( \underline{\rho}_L = 0 \)
- All revenues are assumed to be uniform. \( \rho_s \sim U(\underline{\rho}_s, \bar{\rho}_s) \)
- Discount rate: 1 \( \beta = 1 \)
- Arrival rate ratio: 1/3 \( \lambda_L = 3\lambda_H \)
Numerical examples for close sale cross-sell

- Average service call duration: 2.5 minutes, $\mu = 0.4$
- Forward cross-sell service duration: 3.75 minutes, $\mu_1 = 0.267$
- Service revenue: 1 unit, $r = 1$
- Highest revenue: 100 units, $\bar{\rho}_H = 100$
- Lowest revenue: 0 units, $\rho_L = 0$
- All revenues are assumed to be uniform, $\rho_s \sim U(\underline{\rho}_s, \bar{\rho}_s)$
- Discount rate: 1, $\beta = 1$
- Arrival rate ratio: 1/3, $\lambda_L = 3\lambda_H$
### Scenario 1: $\bar{\rho}_L = 5$  \hspace{1cm} $\bar{\rho}_H = 10$

<table>
<thead>
<tr>
<th>$\lambda_H$</th>
<th>$\lambda_L$</th>
<th>$\bar{\rho}_L$</th>
<th>$\bar{\rho}_H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>150</td>
<td>668</td>
<td>454</td>
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<table>
<thead>
<tr>
<th>$c$</th>
<th>Range for D(21)(x)</th>
<th>$u(0,0)$</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>0.79</td>
<td>131</td>
</tr>
<tr>
<td>16</td>
<td>0.78-0.79</td>
<td>340</td>
</tr>
<tr>
<td>26</td>
<td>0.78-0.79</td>
<td>539</td>
</tr>
<tr>
<td>36</td>
<td>0.77-0.79</td>
<td>728</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\lambda_H$</th>
<th>$\lambda_L$</th>
<th>$\bar{\rho}_L$</th>
<th>$\bar{\rho}_H$</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>36</td>
<td>36</td>
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<th>Range for D(21)(x)</th>
<th>$u(0,0)$</th>
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<tr>
<td>6</td>
<td>0.75-0.76</td>
<td>121</td>
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<tr>
<td>16</td>
<td>0.68-0.76</td>
<td>285</td>
</tr>
<tr>
<td>26</td>
<td>0.57-0.75</td>
<td>408</td>
</tr>
<tr>
<td>36</td>
<td>0.45-0.75</td>
<td>498</td>
</tr>
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$u^H(0,0) \sim 91\% u(0,0)$
Scenario 1: $\bar{\rho}_L = 30 \quad \rho_H = 50$

<table>
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<tr>
<th>$\lambda_H = 50$</th>
<th>$\lambda_L = 150$</th>
<th>$\lambda_H = 10$</th>
<th>$\lambda_L = 30$</th>
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<tr>
<td>c</td>
<td>Range for $D(21)(x)$</td>
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<td>c</td>
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<td>6</td>
<td>1.47</td>
<td>244</td>
<td>6</td>
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<tr>
<td>16</td>
<td>1.46-1.47</td>
<td>633</td>
<td>16</td>
</tr>
<tr>
<td>26</td>
<td>1.45-1.47</td>
<td>1004</td>
<td>26</td>
</tr>
<tr>
<td>36</td>
<td>1.43-1.47</td>
<td>1355</td>
<td>36</td>
</tr>
<tr>
<td>36</td>
<td>class-H only</td>
<td>894</td>
<td>36</td>
</tr>
</tbody>
</table>

$u^H(0,0) \sim 66\%u(0,0)$
Results from the numerical examples

- Variation in the dynamic policy increases as $c$ increases.

- Variation in the dynamic policy increases as $\lambda_H + \lambda_L$ decreases.

- Total expected discounted revenue increases with the total call volume, $\lambda_H + \lambda_L$, (obviously), and the increase is larger for large $c$
  
  (c=6 : 8%, c=16 : 20%, c=26 : 32%, c=36 : 46% when arrival rate triples)

- The thresholds on revenues increase as the cross-sell talk time increases.
Results from the numerical examples

- Dynamic policy does not improve much over the static policy which cross-sells to everybody.

- Dynamic policy improves a lot over the static policy which cross-sells to class-H calls only (ranging from 49%-94%).

- More variation in dynamic policy for more overlapping segments (Scenario 2).
Implications

- Resorting to dynamic optimization rather than simple static policies for cross-selling in call centers will be more beneficial for
  - large call centers
  - with complex call content
  - where segmentation is more difficult
Conclusions and future work

- First multi-server call center model for optimal dynamic cross-selling
  - Waiting? Abandonments?
- Theoretical results characterizing
  - Preferred class/call structure
  - Monotonicity of optimal policy: concavity?
- Preliminary numerical examples: robustness?
- Incentive issues?