

# 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.

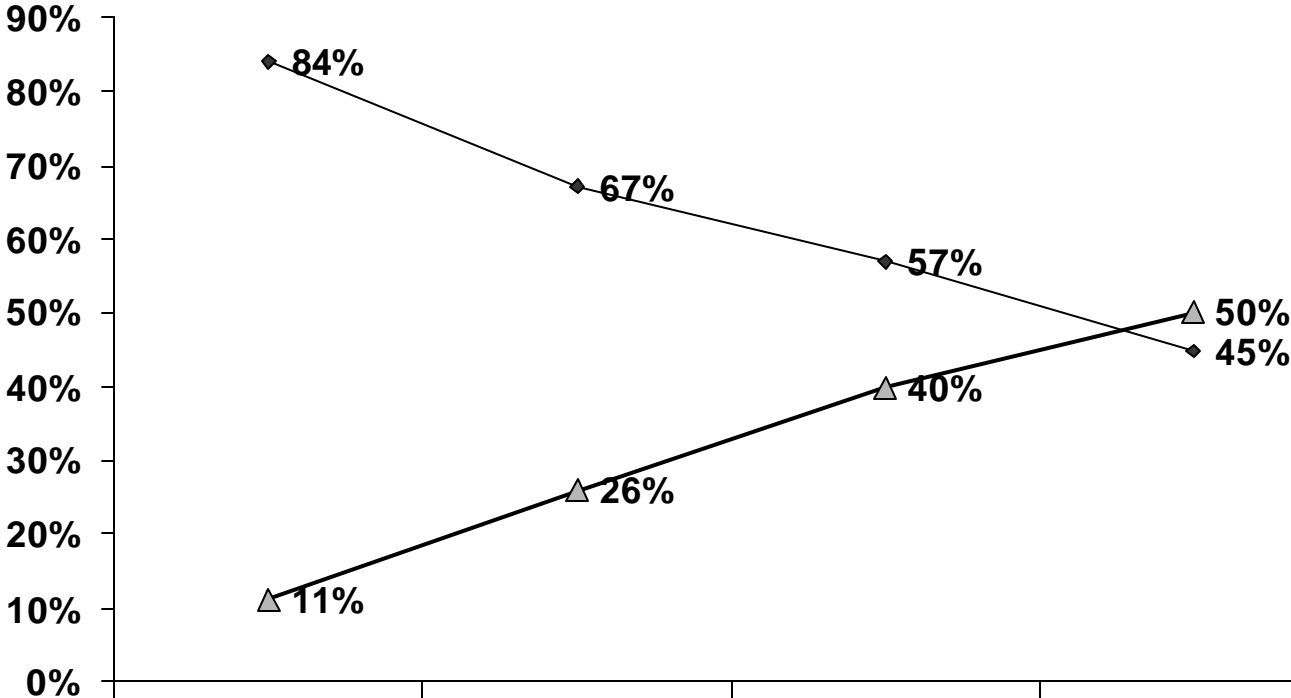
# Call Centers in Banking

- 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 (\*)



◆ Cost Center	84%	67%	57%	45%
▲ Profit Center	11%	26%	40%	50%

# Growth in the Financial Services Industry

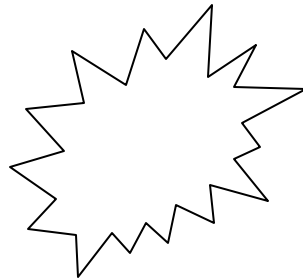
- Mature markets: Increase “share-of-wallet”
- Existing customers are better sales prospects (Felvey 1982)
- Dislike for telemarketing
- Sales increasingly in the form of cross-selling (Kresbach, 2002; Walker, 2003)
- Cross-selling as an important CRM initiative
- Call centers as a key customer contact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

# Cross-selling basics

Data-mining  
Training & incentives

Customer reaction

Try to Cross-sell?



“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

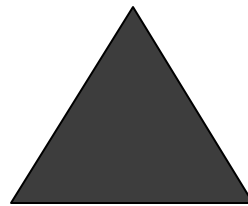
# The Basic Trade-off

**Revenue enhancement**

**Service Quality**

Who is likely to buy?

- Real-time automation
- Historical data



Current load in system

- Talk times
- Call volumes

Key questions: When to cross-sell?  
To whom to cross-sell?

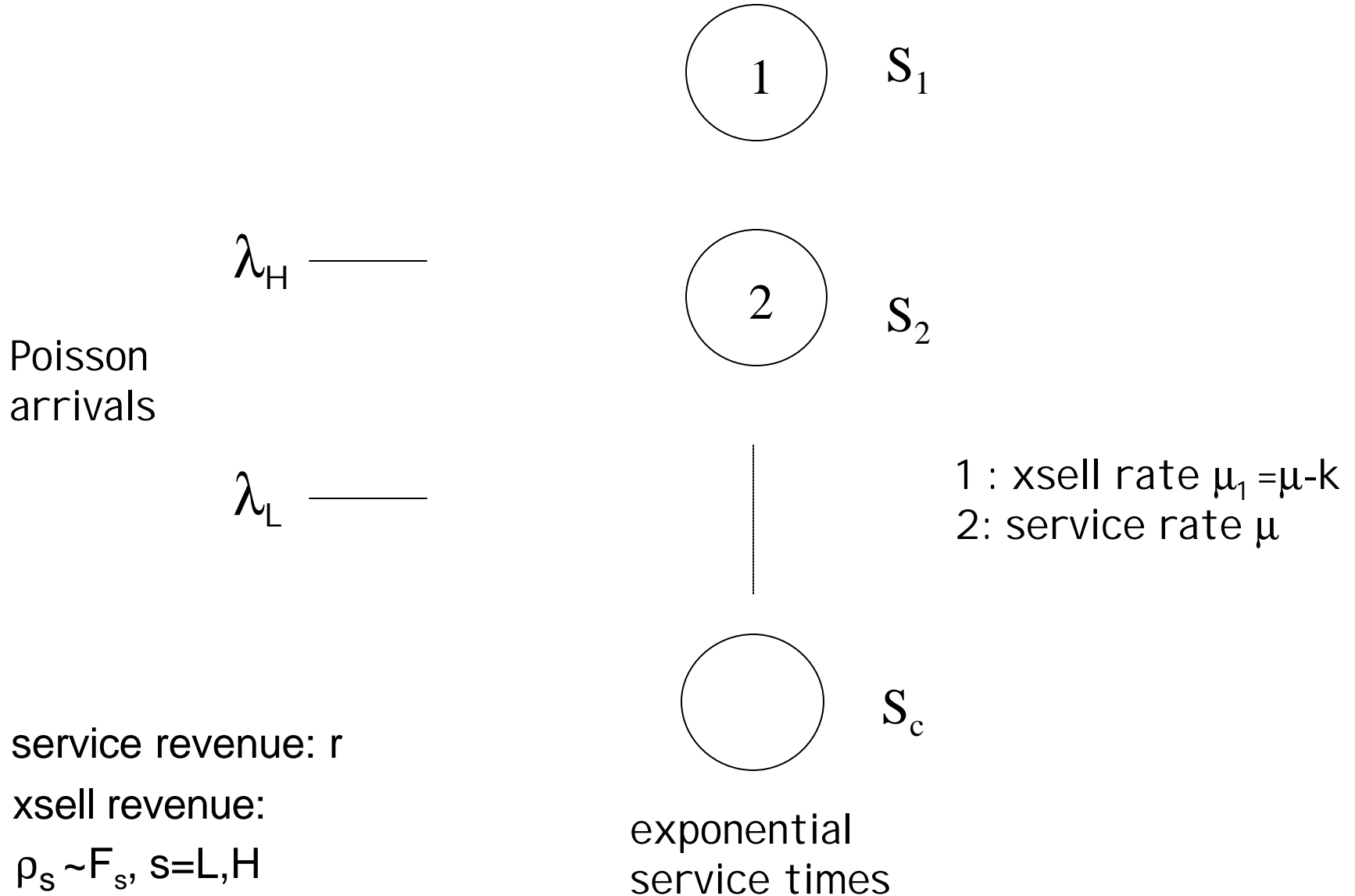
# Cross-selling and Operations

- 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



# 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):  $a(x_1, x_2, \mathbf{r}_s, s) = \begin{cases} 1 & \text{if xsell} \\ 0 & \text{if service} \end{cases}$
- 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

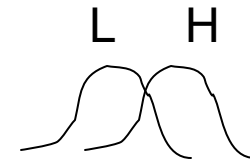
- Aggregation of customers into homogeneous groups according to their cross-sell revenue generation potentials.

- 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:  $\bar{\mathbf{r}}_s = \inf\{x : P(\mathbf{r}_s \leq x) = 1\}$

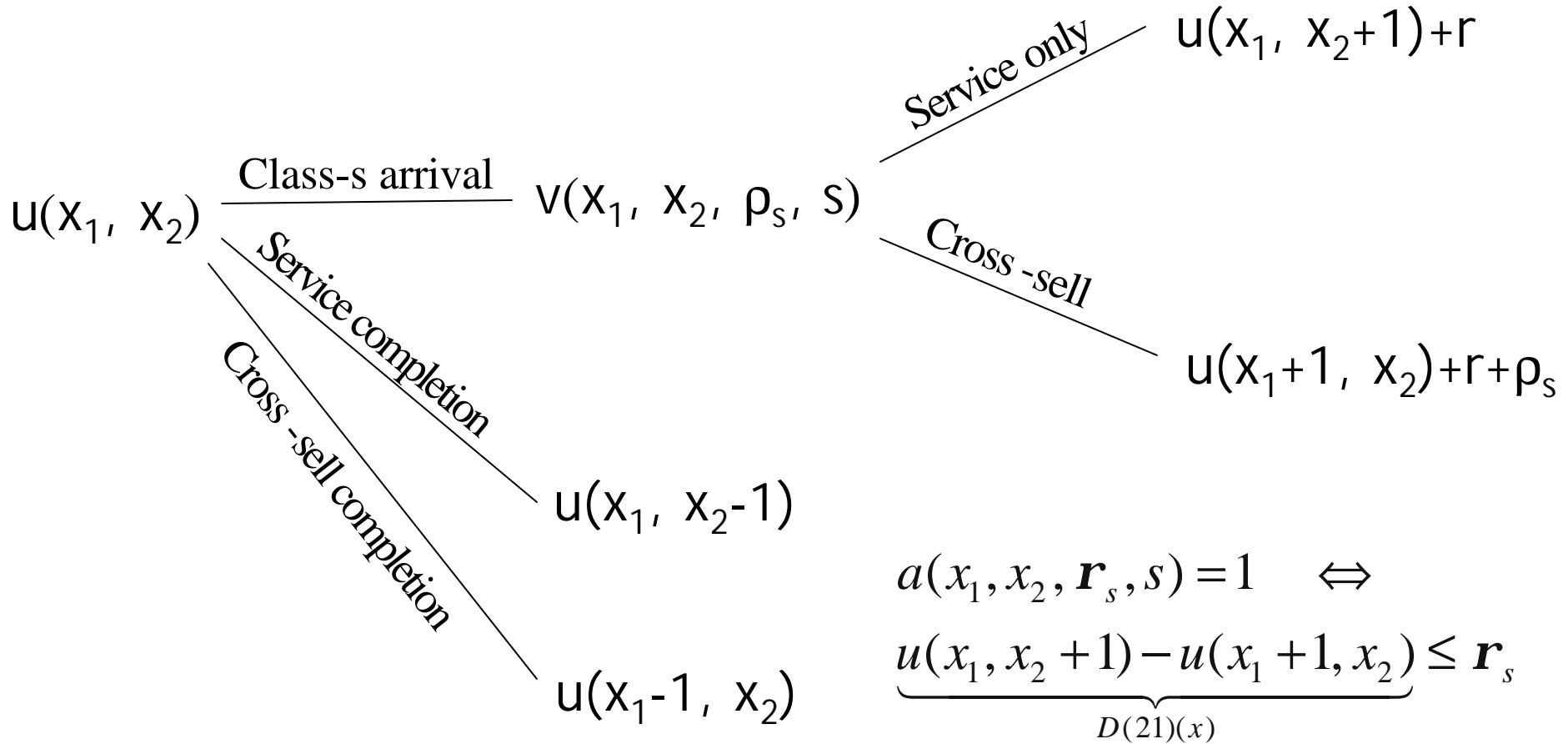
Lower bound on random revenues:  $\underline{\mathbf{r}}_s = \sup\{x : P(\mathbf{r}_s \leq x) = 0\}$

		Segments in marketing
Possible scenarios:	Scenario 1: $\underline{\mathbf{r}}_L \leq \bar{\mathbf{r}}_L \leq \underline{\mathbf{r}}_H \leq \bar{\mathbf{r}}_H$	discrete
	Scenario 2: $\underline{\mathbf{r}}_L \leq \underline{\mathbf{r}}_H \leq \bar{\mathbf{r}}_L \leq \bar{\mathbf{r}}_H$	overlapping
	Scenario 3: $\underline{\mathbf{r}}_H \leq \underline{\mathbf{r}}_L \leq \bar{\mathbf{r}}_L \leq \bar{\mathbf{r}}_H$	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



# 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  $x$

$$a(x_1, x_2, \mathbf{r}_s, s) = 1 \quad \Leftrightarrow \quad D(21)(x) \leq \mathbf{r}_s$$

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

$$\text{Scenario 1 : } \underline{r}_L \leq \bar{r}_L \leq \underline{r}_H \leq \bar{r}_H$$

$$\text{Scenario 2 : } \underline{r}_L \leq \underline{r}_H \leq \bar{r}_L \leq \bar{r}_H$$

# 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  $D(21) < \underline{\rho}_s$  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: $\underline{r}_L \leq \bar{r}_L \leq \underline{r}_H \leq \bar{r}_H$

- 1) If  $\frac{\mathbf{l}_H + \mathbf{l}_L}{\mathbf{l}_H + \mathbf{l}_L + \mathbf{m}} \frac{\mu - \mu_1}{\mu_1} \leq \frac{\bar{r}_H}{r}$ , there are preferred class - H calls.
- 2) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \underline{r}_H$ , class - H is preferred.
- 3) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \bar{r}_L$ , class - H is preferred and there are preferred class - L calls.
- 4) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \underline{r}_L$ , both class - L and class - H are preferred.

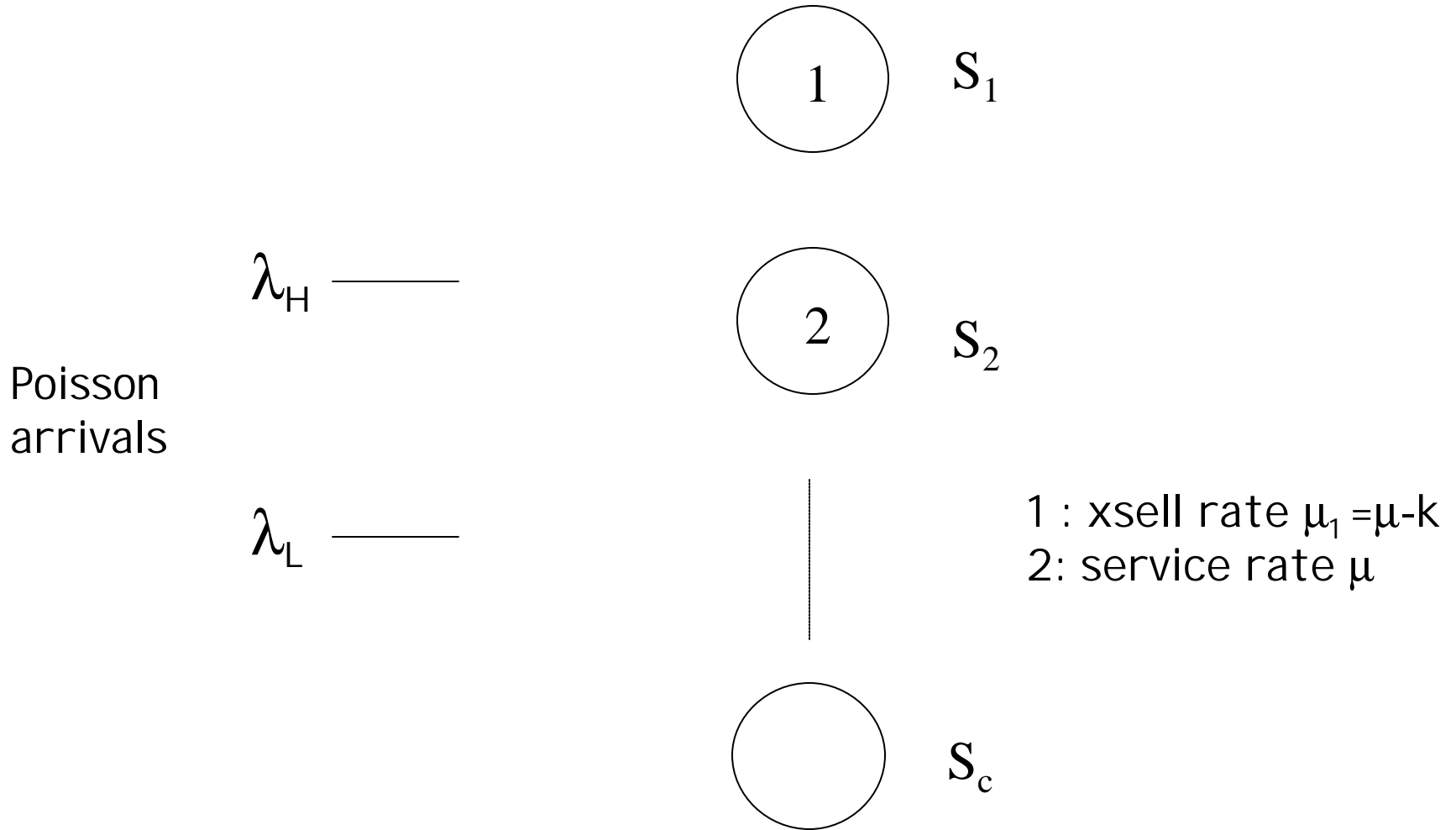
# Proposition for Scenario 2: $\underline{r}_L \leq \underline{r}_H \leq \bar{r}_L \leq \bar{r}_H$

- 1) If  $\frac{\mathbf{l}_H + \mathbf{l}_L}{\mathbf{l}_H + \mathbf{l}_L + \mathbf{m}} \frac{\mu - \mu_1}{\mu_1} \leq \frac{\bar{r}_H}{r}$ , there are preferred class - H calls.
- 2) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \bar{r}_L$ , there are both preferred class - H and class - L calls.
- 3) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \underline{r}_H$ , class - H is preferred and there are preferred class - L calls.
- 4) If  $\frac{\mu - \mu_1}{\mu} (\bar{r}_H + r) \leq \underline{r}_L$ , 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.

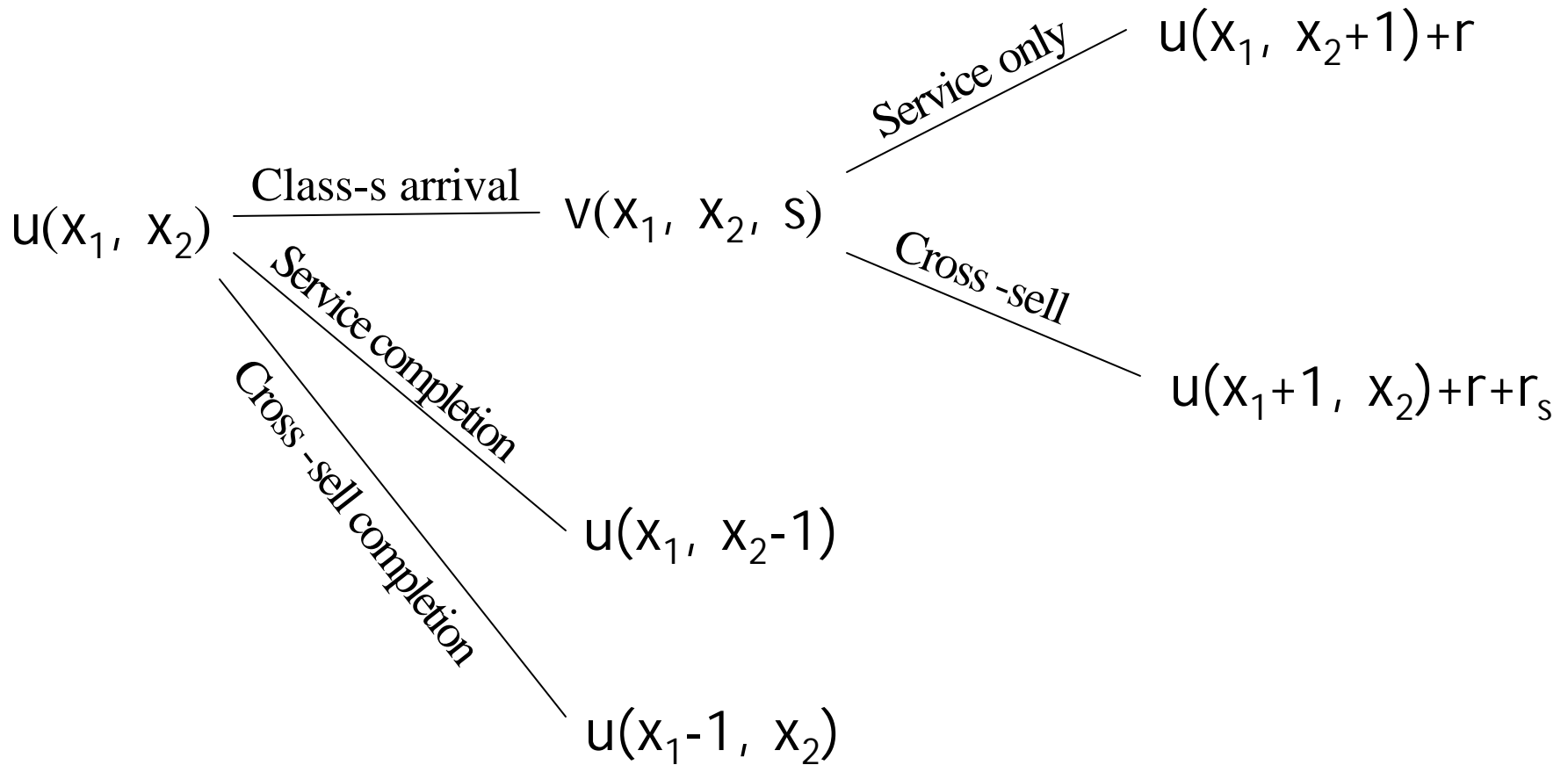
# Model with fixed revenues



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

exponential  
service times

# Illustration of the Model



$$a(x_1, x_2, s) = 1 \iff D(21)(x) \leq r_s$$

# 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 Take  $\mu=1.2\mu_1$
  - Close sale: Talk time of a xsell is increased about 50% of a service  $\mu=1.5\mu_1$
- 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: $0 \leq \bar{r}_L \leq \underline{r}_H \leq \bar{r}_H$

1) If  $\frac{\mathbf{l}_H + \mathbf{l}_L}{\mathbf{l}_H + \mathbf{l}_L + \mathbf{m}} \frac{\mu - \mu_1}{\mu_1} \leq \frac{1}{5} \leq \frac{\bar{r}_H}{r}$ , there are preferred class - H calls.

Practically, this is always true.

2) If  $\bar{r}_H + r \leq 6\underline{r}_H$ , class - H is preferred.

??

3) If  $\bar{r}_H + r \leq 6\bar{r}_L$ , class - H is preferred and there are preferred class - L calls.

4) If  $\bar{r}_H + r \leq 0$ , both class - L and class - H are preferred.

Practically, this is never true.

# Close sale x-sell for Scenario 1 $0 \leq \bar{r}_L \leq \underline{r}_H \leq \bar{r}_H$

1) If  $\frac{\mathbf{l}_H + \mathbf{l}_L}{\mathbf{l}_H + \mathbf{l}_L + \mathbf{m}} \frac{\mu - \mu_1}{\mu_1} \leq \frac{1}{2} \leq \frac{\bar{\mathbf{r}}_H}{r}$ , there are preferred class - H calls.

Practically, this is always true.

2) If  $\bar{\mathbf{r}}_H + r \leq 3\underline{\mathbf{r}}_H$ , class - H is preferred.

??

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

4) If  $\bar{\mathbf{r}}_H + r \leq 0$ , both class - L and class - H are preferred.

Practically, this is never true.

# Numerical examples for forward cross-sell

- Average service call duration : 2.5 minutes       $m = 0.4$
- Forward cross-sell service duration : 3 minutes       $m_1 = 0.333$
- Service revenue : 1 unit       $r = 1$
- Highest revenue : 100 units       $\bar{r}_H = 100$
- Lowest revenue : 0 units       $\underline{r}_L = 0$
- All revenues are assumed to be uniform.       $r_s \sim U(\underline{r}_s, \bar{r}_s)$
- Discount rate : 1       $b = 1$
- Arrival rate ratio : 1/3       $l_L = 3l_H$

# Numerical examples for close sale cross-sell

- Average service call duration : 2.5 minutes  $m = 0.4$
- Forward cross-sell service duration : 3.75 minutes  $m_1 = 0.267$
- Service revenue : 1 unit  $r = 1$
- Highest revenue : 100 units  $\bar{r}_H = 100$
- Lowest revenue : 0 units  $\underline{r}_L = 0$
- All revenues are assumed to be uniform.  $r_s \sim U(\underline{r}_s, \bar{r}_s)$
- Discount rate : 1  $b = 1$
- Arrival rate ratio : 1/3  $l_L = 3l_H$

# Scenario 1: $\bar{r}_L = 5$      $r_{-H} = 10$

$I_H = 50$		$I_L = 150$
c	Range for D(21)(x)	u(0,0)
6	0.79	131
16	0.78-0.79	340
26	0.78-0.79	539
36	0.77-0.79	728

36	class-H only	668
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$I_H = 10$		$I_L = 30$
c	Range for D(21)(x)	u(0,0)
6	0.75-0.76	121
16	0.68-0.76	285
26	0.57-0.75	408
36	0.45-0.75	498

36	class-H only	454
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$$u^H(0,0) \sim 91\%u(0,0)$$

Scenario 1:  $\bar{r}_L = 30$

$r_{-H} = 50$

$I_H = 50$		$I_L = 150$
c	Range for D(21)(x)	u(0,0)
6	1.47	244
16	1.46-1.47	633
26	1.45-1.47	1004
36	1.43-1.47	1355

$I_H = 10$		$I_L = 30$
c	Range for D(21)(x)	u(0,0)
6	1.40-1.43	225
16	1.27-1.42	531
26	1.06-1.40	760
36	0.83-1.39	928

36	class-H only	894
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36	class-H only	608
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$u^H(0,0) \sim 66\%u(0,0)$

# 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?