

Broadcast Scheduling for Mobile Marketing

Bert De Reyck
Zeger Degraeve

London Business School

Mobile Marketing

- **Precision Marketing via permission-based ads using mobile phones (SMS text messaging)**
- **Penetration of mobile phones in UK¹**
 - 70%
 - 80% for young adults (18-24 years)
- **Use of text messaging¹**
 - 68% of mobile phone owners use text messaging
 - 95% for teenagers and young adults
- **Permission-based¹**
 - 24% of cellphone users agree with receiving text-based advertising
- **Characteristics**
 - low-cost
 - broadcast ads when customers are shopping
 - ads can be targeted and tailored to specific customer profiles (based on age, gender, lifestyle, explicitly expressed preferences)

Zagme

- **Established late 2000 by a graduate of the Sloan Program**
- **Operating in two shopping centers in London (Bluewater & Lakeside)**
- **Initial member base of 80,000, each with profile**
- **Product categories (9)**
 - beauty products, fashion, jewelry, gifts, sport-related products, books, entertainment, restaurants and miscellaneous
- **Advertising**
 - customer logs into system upon arrival by text message
 - receive promotional offers every hour on the hour to avoid saturation
 - majority direct response offers, some generic brand-building
 - additional ad upon activation and de-activation
 - offer consists of free gift or discount at particular store during the day
 - average shopping trip of 4 hours results in six messages
(Barwise and Strong, 2001: 82% prefer three ads per day, younger people more receptive to more frequent adverts)

Broadcast Scheduling

- **Deciding:**
 - What ad to send out to what active customer at what time slot
- **Company has:**
 - List of ads for which the retailer will pay a pre-set amount if broadcast
 - List of active customers with different profiles
- **Construct a broadcast schedule that balances the needs of the retailers and the customers**
- **The schedule is constructed for a week:**
 - Different offers at the same time on different days
 - 12 hourly time slots per day, plus activation and de-activation ad

Objectives - The Retailer's

Perspective

- **Revenues**
 - not all retailers pay for service, paying clients should get priority
 - star classification: 4* / 3* / 2* / 1*, resulting in priorities
- **Timing of ads**
 - retailer specifies preferred time for each offer (three preferences + extra)
 - pre-booking: advance payment and guaranteed broadcast
 - minimum / maximum number of broadcasts per ad
- **Target for ads**
 - twelve different customer segments
 - gender (M / F)
 - age (-18, 18-24, 25-34, 35-44, 45-54, 55+)
 - ad can be targeted to one or more customer segments
 - determines capacity of each segment

Objectives - The Customer's

Perspective

- **Customer satisfaction, increases with ...**
- **... offer attractiveness**
 - star classification: 4* / 3* / 2* / 1*, based on expected response (4* offers are free gifts or deep discounts for popular products, 1* offers are generic brand building messages)
- **... offers that match the personalized customer profiles**
 - three offers of different types broadcast in each time slot
- **... offers that are received at an appropriate time**
 - 12 timeslots of one hour per day (10am-11am through 9pm-10pm), + activation and de-activation slot
 - Retailers/schedulers specify appropriate timeslots for their ads
- **... variety between offers received (some modelling constraints)**
 - offer can only be broadcast once a day
 - offers broadcast in consecutive timeslots should be of different type
 - offer cannot be broadcast on consecutive days in same timeslot
 - maximum variety between offers broadcast to different customer segments
 - an offer cannot be used more than once in a 7-hour time window
 - Minimum 3 hour gap between ad in first, second and/or third schedule

Objectives - The Company's Perspective

- **Multiple objectives: balancing needs of both retailers and customers**
 - weighing objectives ?
 - prioritizing objectives ?
- **Priority list: 16 classes of combined client-offer quality**

Client Quality	Offer Quality	Priority (low value is high priority)
4*	4* / 3* / 2* / 1*	1 / 3 / 8 / 12
3*	4* / 3* / 2* / 1*	2 / 5 / 9 / 13
2*	4* / 3* / 2* / 1*	4 / 6 / 11 / 14
1*	4* / 3* / 2* / 1*	7 / 10 / 15 / 16

- **Time preference handled in similar way**
- **Client and offer quality have priority over time preference**
- **Priorities in the objective function:**
 - multiplying the relevant decision variables with appropriate weights
 - Weights are set such that a choice with lower priority, if enforced in the schedule, will result in a lower objective function if it forces a choice with a higher priority out of the schedule

Objective Function Coefficients

Client Quality	Offer Quality	Preference ¹	Priority ²	Objective Coefficients	Alternative Coefficients
4*	1*	P	1	512	10
4*	4*	2	2	256	9
3*	4*	1	3	128	8
3*	4*	3	4	64	7
4*	3*	1	5	32	6
2*	3*	1	6	16	5
1*	3*	1	7	8	4
1*	3*	3	8	4	3
2*	2*	2	9	2	2
1*	1*	1	10	1	1

¹ low value means high preference ('P' is pre-booked)

² low value means high priority

- Allocating the ad with the highest priority results in a higher objective function value compared to allocating all the other available ads to their preferred timeslot, i.e. no trade-offs
- Matching the highest-priority offer's time preference is deemed equally important relative to simultaneously matching the preference of offers with priority 5 and 7 (objective coefficients 6 and 4)

Offer
Air Born Kites - 1
Air Born Kites - 2
all:sports
Artworld
Baron Jon
Base
Bears'n'Bunnies
Big Blue Rock
Club Golf
Dome Bar Café - Meal
Dome Bar Café - Coffee
GT Recollections - 1
GT Recollections - 2
Giant Clothing
Hargreaves
Into the Void
Just Leathers
L'occitane
Letter Box
Lush - A
Lush - B
Mikey
Mish Mash
Morgan
Nando's - 1
Nando's - 2
Nando's - 3
Nando's - 4
Pecksniff's - 1
Pecksniff's - 2
Pilot
Pizza Hut
PizzaExpress - Meal
PizzaExpress - Wine

((!))ZagMe		TUESDAY											
		Bluewater											
		Female 17 or less	Female 18-24	Female 25-34	Female 35-44	Female 45-54	Female 55 & over	Male 17 or less	Male 18-24	Male 25-34	Male 35-44	Male 45-54	Male 55 & over
Activate													
	10.00												
	11.00												
	12.00												
	13.00												
	14.00												
	15.00												
	16.00												
	17.00												
	18.00												
	19.00												
	20.00												
	21.00												
Deactivate													

London
Business
School

Ad Input Sheet

Offer	Client	Quality	Type	Min	Max
Air Born Kites - 1	2	2	SP	1	4
Air Born Kites - 2	2	2	SP	1	4
all:sports	4	3	SP	4	4
Artworld	2	3	MI	1	4
Baron Jon	2	3	FA	1	4
Base	2	4	FA	1	4
Bears'n'Bunnies	2	2	GI	1	4
Big Blue Rock	2	4	SP	1	4
Club Golf	4	2	SP	3	4
Dome Bar Café - Meal	3	2	RE	3	4
Dome Bar Café - Coffee	3	3	RE	3	4
GT Recollections - 1	4	2	MI	2	4
GT Recollections - 2	4	3	MI	2	4
Giant Clothing	3	3	FA	1	4
Hargreaves	3	2	SP	1	4
Into the Void	2	1	MI	1	4
Just Leathers	2	1	FA	1	4
L'occitane	2	3	BE	1	4
Letter Box	2	2	MI	1	4
Lush - A	3	3	BE	1	4
Lush - B	3	3	BE	1	4
Mikey	3	3	JE	1	4
Mish Mash	1	2	FA	1	4
Morgan	3	2	FA	1	4
Nando's - 1	p	3	RE	1	4
Nando's - 2	p	4	RE	1	4
Nando's - 3	p	3	RE	1	4
Nando's - 4	p	3	RE	2	4
Pecksniff's - 1	4	4	BE	1	4
Pecksniff's - 2	4	3	BE	1	4
Pilot	3	2	FA	1	4
Pizza Hut	3	2	RE	1	4
PizzaExpress - Meal	3	2	RE	1	4
PizzaExpress - Wine	3	2	RE	1	4

Customer Segment Input Sheet

CAMPAIGN DESCRIPTION

CUSTOMER SEGMENT

F17 F18 F25 F35 F45 F55 M17 M18 M25 M35 M45 M55

Air Born Kites - 1

Air Born Kites - 2

all:sports

Artworld

Baron Jon

Base

Bears'n'Bunnies

Big Blue Rock

Club Golf

Dome Bar Café - Meal

Dome Bar Café - Coffee

GT Recollections - 1

GT Recollections - 2

Giant Clothing

Hargreaves

Into the Void

Just Leathers

L'occitane

Letter Box

Lush - A

Lush - B

Mikey

Mish Mash

Morgan

Nando's - 1

Nando's - 2

Nando's - 3

Nando's - 4

Pecksniff's - 1

Pecksniff's - 2

Pilot

Pizza Hut

PizzaExpress - Meal

PizzaExpress - Wine

Timeslot Preference input sheet

**CAMPAIGN
DESCRIPTION**

MONDAY

TUESDAY

A 10 11 12 13 14 15 16 17 18 19 20 21 D A 10 11 12 13 14 15 16 17 18 19 20 21 D

Air Born Kites - 1

Air Born Kites - 2

all:sports

Artworld

Baron Jon

Base

Bears'n'Bunnies

Big Blue Rock

Club Golf

Dome Bar Café - Meal

Dome Bar Café - Coffe

GT Recollections - 1

GT Recollections - 2

Giant Clothing

Hargreaves

Into the Void

Just Leathers

L'occitane

Letter Box

Lush - A

Lush - B

Mikey

Mish Mash

Morgan

Nando's - 1

Nando's - 2

Nando's - 3

Nando's - 4

Pecksniff's - 1

Pecksniff's - 2

Pilot

Pizza Hut

PizzaExpress - Meal

PizzaExpress - Wine

2/3

1

P

P

forbidden

**London
Business
School**

Illustrative Schedule

MONDAY

Time Slot	Female 17 or less A	Female 18-24 B	Female 25-34 C	Female 35-44 D	Female 45-54 E
Activate	all:sports - SP	all:sports - SP <i>Yo! Sushi 50% day - RE</i>	all:sports - SP <i>Yo! Sushi 50% day - RE</i>	all:sports - SP	all:sports - SP
10.00	GT Recollections 1 - MI <i>Pontis - RE</i> <i>Quicksilver 1 - SP</i>	PizzaExpress 1 - RE <i>Top Shop - FA</i> <i>The Bonsai House - MI</i>	Dome Bar Café Coffee - RE <i>Wallis - FA</i> <i>Quicksilver 6 - SP</i>	Lush A - BE <i>Dome Bar Café Coffee - RE</i> <i>Artworld - MI</i>	Suits You - FA <i>Artworld - MI</i> <i>Pontis - RE</i>
11.00	Dome Bar Café Coffee - RE <i>Top Shop - FA</i> <i>GT Recollections 2 - MI</i>	Lush A - BE <i>Dome Bar Café Coffee - RE</i> <i>Quicksilver 5 - SP</i>	Pilot - FA <i>Pontis - RE</i> <i>Waterstones Britney - BO</i>	GT Recollections 1 - MI <i>Giant Clothing - FA</i> <i>Pontis - RE</i>	Lush A - BE <i>Waterstones Travel - BO</i> <i>The Bonsai House - MI</i>
12.00	Lush A - BE <i>Dome Bar Café Meal - RE</i> <i>World of Football - SP</i>	Yo! Sushi 20% - RE <i>Watch It - JE</i> <i>Warehouse - FA</i>	Lush A - BE <i>Top Shop - FA</i> <i>World of Football - SP</i>	Quicksilver 6 - SP <i>Mikey - JE</i> <i>L'occitane - BE</i>	Dome Bar Café Coffee - RE <i>GT Recollections 2 - MI</i> <i>Club Golf - SP</i>
13.00	Big Blue Rock - SP <i>L'occitane - BE</i> <i>Warehouse - FA</i>	Quicksilver 6 - SP <i>Giant Clothing - FA</i> <i>Waterstones FPD - BO</i>	Yo! Sushi 20% - RE <i>Watch It - JE</i> <i>L'occitane - BE</i>	Yo! Sushi 20% - RE <i>Wallis - FA</i> <i>GT Recollections 2 - MI</i>	Quicksilver 6 - SP <i>Dome Bar Café Meal - RE</i> <i>Wallis - FA</i>
14.00	Yo! Sushi 20% - RE <i>Giant Clothing - FA</i> <i>all:sports - SP</i>	Pontis - RE <i>all:sports - SP</i> <i>L'occitane - BE</i>	Quicksilver 6 - SP <i>Dome Bar Café Coffee - RE</i> <i>Warehouse - FA</i>	Mish Mash - FA <i>Artworld - MI</i> <i>Dome Bar Café Meal - RE</i>	Yo! Sushi 20% - RE <i>L'occitane - BE</i> <i>Artworld - MI</i>
15.00	GT Recollections 2 - MI <i>Quicksilver 5 - SP</i> <i>Watch It - JE</i>	Quicksilver 5 - SP <i>GT Recollections 2 - MI</i> <i>Wallis - FA</i>	Giant Clothing - FA <i>Quicksilver 4 - SP</i> <i>The Bonsai House - MI</i>	The Bonsai House - MI <i>World of Football - SP</i> <i>Giant Clothing - FA</i>	Warehouse - FA <i>Quicksilver 1 - SP</i> <i>Mikey - JE</i>

$$Max \sum_{o=1}^{|O|} \sum_{d=1}^7 \sum_{s=1}^{14} \sum_{c=1}^{12} \sum_{p=1}^3 p_{odscp} x_{odscp}$$

$$Min \max_{o=1..|O|; d=1..7; s=1..14} \left\{ \sum_{c=1}^{12} x_{odsc1} \right\}$$

$$\sum_{o=1}^{|O|} x_{odscp} \leq 1$$

$$d = 1..7; s = 1..14; c = 1..12; p = 1..3$$

Capacity

$$\sum_{s=1}^{14} x_{odscp} \leq 1$$

$$o = 1..|O|; d = 1..7; c = 1..12; p = 1..3$$

Intra-day offer repetition

$$x_{odsc1} + x_{o(d+1)sc1} \leq 1$$

$$o = 1..|O|; d = 1..6; s = 1..14; c = 1..12$$

Inter-day offer repetition

$$\sum_{o \in T_t} x_{odsc1} + \sum_{o \in T_t} x_{od(s+1)c1} \leq 1$$

$$d = 1..6; s = 1..14; c = 1..12; t = 1..|T|$$

Consecutive type repetition

$$\sum_{o \in T_t} \sum_{p=1}^3 x_{odscp} \leq 1$$

$$d = 1..7; s = 1..14; c = 1..12; t = 1..|T|$$

Inter-schedule type repetition

$$\sum_{p=1}^3 \sum_{w=1}^3 x_{od(s+w)cp} \leq 1$$

$$o = 1..|O|; d = 1..7; s = 1..10; c = 1..12$$

Inter-schedule offer repetition

$$\sum_{d=1}^7 \sum_{s=1}^{14} x_{odsc1} \geq l_{oc1}$$

$$o = 1..|O|; c = 1..12$$

Demand

$$\sum_{d=1}^7 \sum_{s=1}^{14} x_{odsc1} \leq u_{oc1}$$

$$o = 1..|O|; c = 1..12$$

Solution Methodology

- **IP model**
 - 352,800 decision variables
 - 235,584 constraints
- **Decomposition 1 - along 3 schedules**
 - relax inter-schedule constraints
 - generate 3 schedules sequentially
 - results of previously generated schedule(s) are removed from the decisions
 - affects optimality?
- **Decomposition 2 - along 12 customer segments**
 - optimise inter-customer segment diversity (objective 2) heuristically
 - generate schedules for each customer segment separately
- **36 IPs**
 - 9,800 variables
 - 18,036 constraints

Results

- **Faster Scheduling**

- Manual Scheduling: priority ranking based on client and offer quality
 - team of four people
 - about two days
 - linearly related to number of shopping malls
- Automated System
 - 10 minutes (2 GHz PC) to generate 3 schedules
 - interactive (completely or partially)
 - parallel scheduling

- **Better Schedules**

- customer satisfaction
 - measured by the quality of the resulting broadcast schedule
 - more attractive offers are broadcast
 - offers match customer profiles much better
 - more offers are broadcast at their preferred time (actually doubled)
 - More variety and diversity among ads in different customer segments
 - guaranteed prevention of intra-day and inter-day and inter-schedule repetition
 - retailer satisfaction
 - higher customer satisfaction should result in higher response rate
 - fewer schedule errors (e.g. ads broadcast at inappropriate time)
-

Comparison with Manual Schedule

- Week of 2-8 April 2001

((!!)ZagMe
Daily Slot Summary
Bluewater

Munday 2nd April

PAGE 2	Time Slot	Female 17 or less A	Female 18-24 B	Female 25-34 C	Female 35-44 D	Female 45-54 E	Female 55 & over F	Male 17 or less G	Male 18-24 H	Male 25-34 I	Male 35-44 J	Male 45-54 K	Male 55 & over L
	9.00 M												
	10.00 N	Lush (A) →						Aarnold →					
	11.00 O	World of football →				Dockers →		Madisons →					
	12.00 P	Costa Coffee →		Argentens →				Watch IT →					
	13.00 Q	E-Cue →		Hape & Clay →		Costa Coffee →		RM Williams →		dust Leathers →			
	14.00 R	Argentens →		Dockers →		Costa Coffee →		Ngar News →		RM Williams Party Party →		RM Williams →	
	15.00 S	Pilsen →		Sephora →				Pizzatit Pizza Express →		Kids →			
	16.00 T	Pizzatit Pizza Express →		Kids →				Hangreaves →		Bawon Jon →			
	17.00 U	Morgan →		Lush (C) →				Bawon Jon →		N'garden News →			
	18.00 V	Lush (D) →		dust leathers →				Airborn Kites →					
	19.00 W	Madisons →						Blunder News →		Dane Barr →			
	20.00 X	dust leathers →		La Senza (D) →				Dockers →					
	21.00 Y												
	22.00 Z												

02075368825; INT BY: ZAGME;

Comparison with Manual Schedule

- **Manually, 27% (out of 1,176) were allocated to 1st, 2nd, 3rd preferred time slot – Scheduler doubled this to 55%**
- **Manually: 1st: 18%, 2nd: 5%, 3rd: 4% - Scheduler doubled this to 1st: 38%, 2nd: 9%, 3rd: 8%**
- **Manually, 121 (10%) unused time slots because of limited time and oversight**
- **Manually, 17 ads broadcast to inappropriate customer segments (2.5% of time slots) – checking manually was too difficult or too time-consuming**
- **Manually, 48 ads broadcast of same type as previously broadcast ad (4.5% of broadcasts)**
- **Manually, 11 ads broadcast on consecutive days in same time slot**
- **Manually, diversity among ads simultaneously broadcast to different customer segments was largely ignored due to complexity**
- **Manually, very basic second schedule by taking first schedule and shifting it forward in time led to ads broadcast when not appropriate, e.g. when shop was already closed**

London Business School Manually, no third schedule constructed so that some customers did not receive ads if the first two were already blocked

Limitations and Future Research

- **Not fast enough?**
 - interactivity requires response time in order of seconds
 - Solutions
 - RISK computer
 - multi-level branch-and-bound algorithm
- **Measurement of customer response**
 - collect individual response data
 - modify customer profile (Bayesian updating)
 - maximise expected response rates
 - charge retailer based on response rate (guaranteed)
 - broadcast to individual customers instead of segments
- **New technology**
 - broadcast ads depending on location of customers (from push to pull)