

Commercial Advertising: Scheduling The Super Bowl

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IEOR 4405: Production Scheduling

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- The Industry
- The Problem
- Objectives
- Methodology
- Results & Next Steps

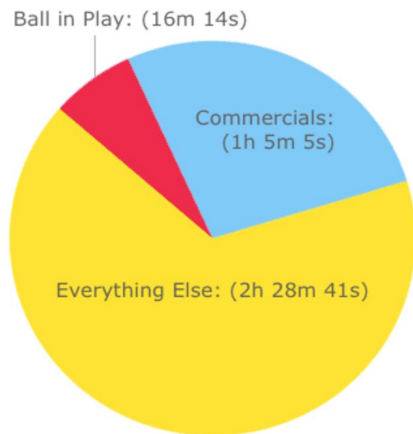


Outline

Super Bowl Advertising at a Glance

- Price for a 30 second spot - \$5 million
- Viewership average of 111.9 million people across 54.3 million homes
- Commercial scheduling currently done by hand

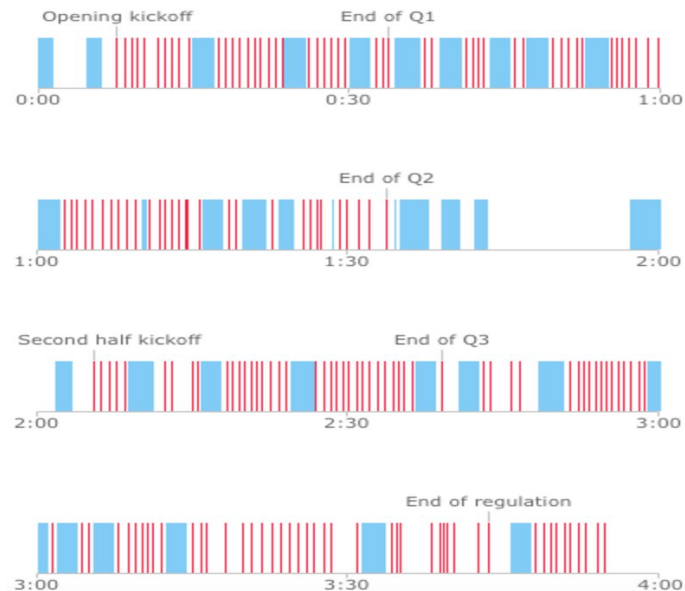
Superbowl Broadcast Time Proportions



Superbowl Broadcast Time Allocation

0:00-4:00 = Broadcast Timestamp

■ = Ball in Play
■ = Commercial



Tackling the Problem

- There has to be a more efficient way of choosing and scheduling commercials.
 - Advertiser demand is higher than the available supply of slots.
 - Each broadcaster has different and sometimes conflicting interests.
- Devise a schedule that is optimal and properly accounts for these interests.



Our Objectives

1. Maximize **revenue** for the broadcaster
2. Maximize **return per dollar spent** for the advertiser
3. Maximize **customer satisfaction**

Methodologies

- I. Deterministic Models
- II. Integer Programming
- III. Heuristic Approach (looking ahead)



Data, Assumptions and Estimations

- Historical Super Bowl commercial data spanning the last **three** years: 2017, 2016, 2015
- **Data points:**
 - Commercial duration
 - Average rating of commercial
- **Assumptions:**
 - Broadcast time is divided into 4 quarters
 - Viewership increases linearly from the first to the fourth quarter
 - Commercial time is divided into 15s slots (totaling 260, 15s slots)
 - Price paid by a company for a commercial increases by 0.5% from quarter to quarter to reflect viewership increase



Data, Assumptions and Estimations cont.

- **Estimations**

- Price paid by individual company to air their particular commercial
 - Prices are not publicly disclosed
 - Depends on company size, Super Bowl advertising history, and expectations
- Return/dollar spent scale of 1-10 to air the commercial
 - Captures the return value that a company gets from investing in a commercial
 - Depends on company size, brand recognition, and product offered

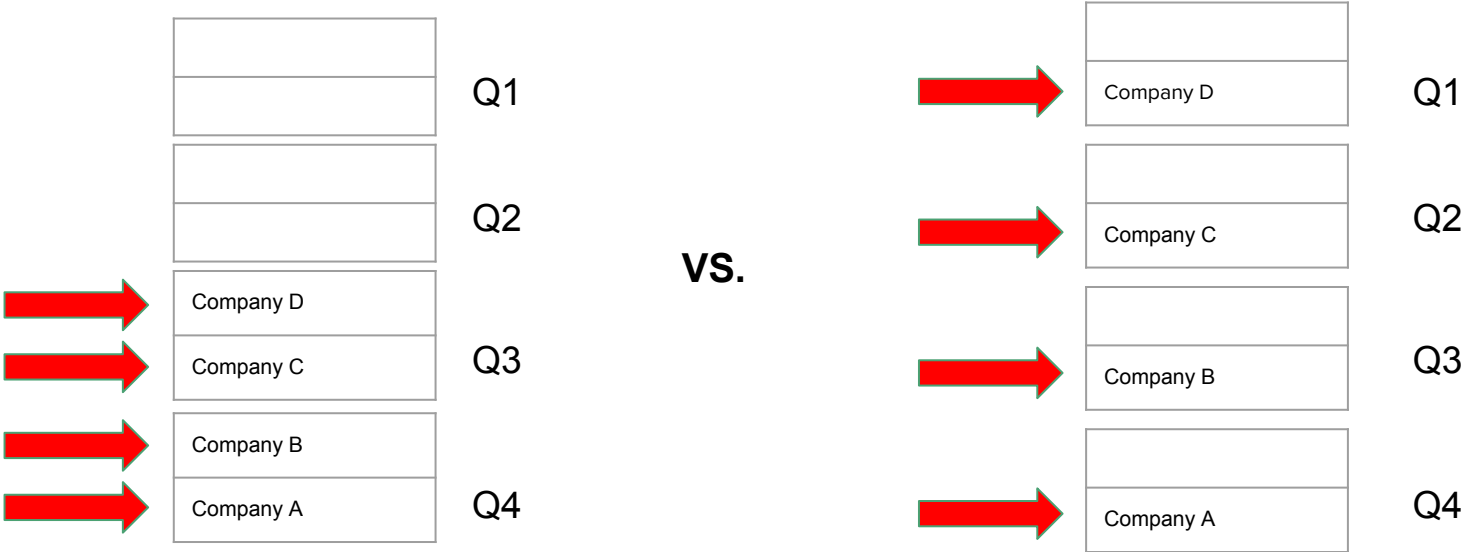


Deterministic Model

- Maximizing Revenue

Algorithm 1: “Highest Paying Last” - Place highest paying company in last spot

Algorithm 2: Rank company who pays most in the last spot of every quarter

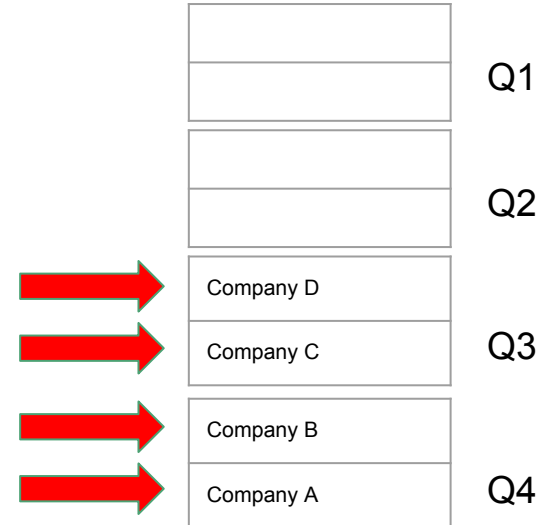


Deterministic Model cont.

- Maximizing Customer Satisfaction
 - Place the highest rated company in the last spot of each quarter until all segments are filled.

Rationale:

- Super Bowl is a strong source of revenue and publicity.
- Strong desire to host again in the future.
- Ability to quantify and to demonstrate superior satisfaction enhances chance of being selected.

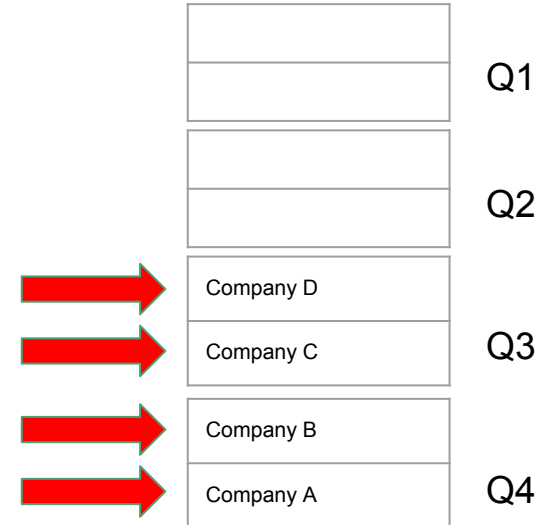


Deterministic Model cont.

- Maximizing Return per Dollar Spent
 - Place the company with the highest return rating in the last slot of each quarter, and continue for the remaining ads until the segment is filled.

Rationale:

- Quantified return per dollar spent on Super Bowl commercial.
- Increased incentive for companies to advertise.
- Ability to charge higher airing prices in the future.



Deterministic Model Solutions

- Maximizing Revenue

	Revenue (millions)	Average Customer Satisfaction	Average Return per Dollar Spent	Duration (sec)
Algorithm 1:	789.83	5.26	448	3900
Algorithm 2:	812.93	5.17	476	3900

→ Optimal schedule is generated by Algorithm 2: “Highest Paying Last” - Place highest paying advertiser in last spot.



Deterministic Model Solutions cont.

- Maximizing Customer Satisfaction

	Customer Satisfaction	Revenue (millions)	Return per Dollar Spent	Duration (sec)
Schedule 1:	5.36	788.17	473	3900
Schedule 2:	5.36	789.12	473	3900
Schedule 3:	5.36	788.17	473	3900
Schedule 4:	5.36	788.17	473	3900

→ The optimal schedule is the one that generates the highest revenue of \$789.12 million.



Deterministic Model Solutions cont.

- Maximizing Return per Dollar Spent

	Return per Dollar Spent	Revenue (millions)	Return per Dollar Spent	Duration (sec)
Schedule 1:	517	783.30	5.19	3900

→ The algorithm schedule generates 1 optimal schedule.



IP Formulation

→ Maximizing Revenue:

Let i denote company from 1 ... n

j denote commercial segment from 1 ... 4

Let P_{ij} = price that company i pays to air in segment j

S_j = the max amount of slots in segment j

s_{ij} = the number of slots that company i takes up in segment j

$x_{ij} = 1$ if company i airs in segment j , 0 otherwise

$$\max \sum_i^n \sum_j^4 P_{ij} \cdot x_{ij}$$

$$\text{s. t. } \sum_i^n s_{i1} \leq S_1, \quad \sum_i^n s_{i2} \leq S_2$$

$$\sum_i^n s_{i3} \leq S_3, \quad \sum_i^n s_{i4} \leq S_4$$

$$\sum_i^n \sum_j^4 x_{ij} \leq 1$$

$$x_{ij} \in \{0,1\}$$



IP Formulation

→ Maximizing Customer Satisfaction:

Let i denote company from 1 ... n

j denote commercial position from 1 ... n

Let r_i = rating for company i

t_j = value for being placed in position j

$V_{ij} = r_i \cdot t_j$ = customer satisfaction for company i in position j

$x_{ij} = 1$ if company i airs in position j , 0 otherwise

d_{ij} = duration of company i in position j

$$\max \sum_i^n \sum_j^n r_i \cdot t_j \cdot x_{ij} = \sum_i^n \sum_j^n V_{ij} \cdot x_{ij}$$

$$\text{s. t. } \sum_i^n \sum_j^n x_{ij} \cdot d_{ij} \leq 3900$$

$$x_{ij} \in \{0,1\}$$

$$t_j \in [1,n]$$



IP Formulation

→ Maximizing Return per Dollar Spent:

Let i denote company from 1 ... n

j denote commercial position from 1 ... n

Let u_i = return per dollar value for company i

t_j = value for being placed in position j

$R_{ij} = u_i \cdot t_j$ = return for company i in position j

$x_{ij} = 1$ if company i airs in position j , 0 otherwise

d_{ij} = duration of company i in position j

$$\max \sum_i^n \sum_j^n u_i \cdot t_j \cdot x_{ij} = \sum_i^n \sum_j^n R_{ij} \cdot x_{ij}$$

$$\text{s.t. } \sum_i^n \sum_j^n x_{ij} \cdot d_{ij} \leq 3900$$

$$x_{ij} \in \{0,1\}$$

$$t_j \in [1, n]$$

$$u_j \in [1, 10]$$



IP Solutions

- Most 0-1 integer programs are classified as ***NP-hard*** problems.
- After many attempts using various optimization software on the complete data set, we came to the conclusion that the problem is too computationally complex to solve.

→ decision variables, $n = 432$

→ linear constraints, $m = 112$

$$O(2^n \text{ poly}(n, m))$$

⇒ *Our next step is to take an **heuristic approach**.*



Conclusions and Next Steps

- Deterministic Model
 - Algorithm 2 gives the optimal schedule for maximizing revenue.
 - Outperforms algorithm 1 under every metric except customer satisfaction.
 - Basic algorithmic approach to the scheduling problem outperforms hand scheduling.
- Integer Program
 - NP-hard, too computationally complex for our model led us to an heuristic approach.
- Heuristic Approach
 - Simulated Annealing and Tabu Search
 - Theory of algorithms are ready to be implemented as a next step.
 - Algorithm will maximize customer satisfaction and return on per dollar spent.



Thank You!
Questions?

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