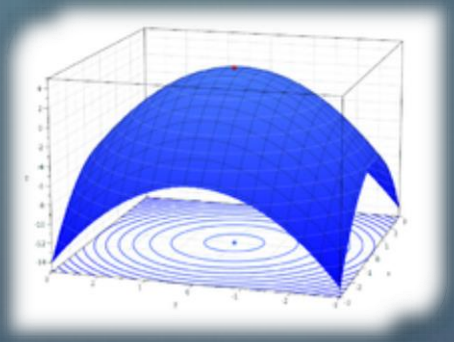
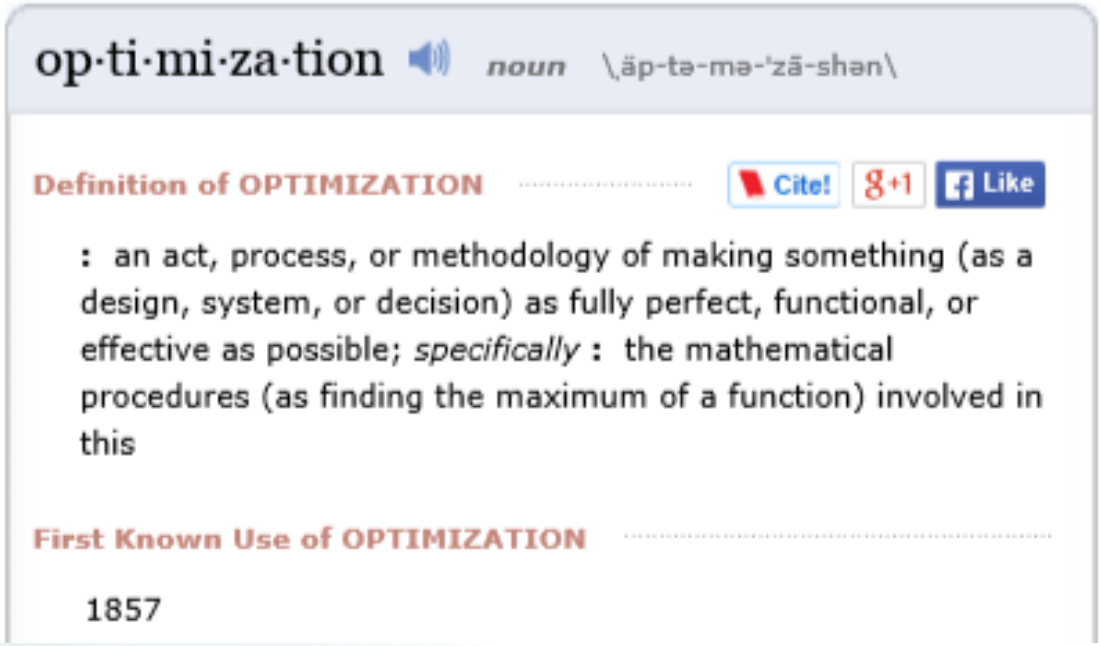
Lityx

Introduction to Constrained Optimization



What Is Constrained Optimization?



op·ti·mi·za·tion *noun* \ˌäp-tə-mə-ˈzā-shən\

Definition of OPTIMIZATION

: an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible; *specifically* : the mathematical procedures (as finding the maximum of a function) involved in this

First Known Use of OPTIMIZATION

1857

\+ Constraints

(any restrictions)

Example:

I want to maximize new accounts. How much should I spend marketing to each of my channels such that I do not spend more than $10MM total and no channel has a CPA > $100?

What Is Constrained Optimization?

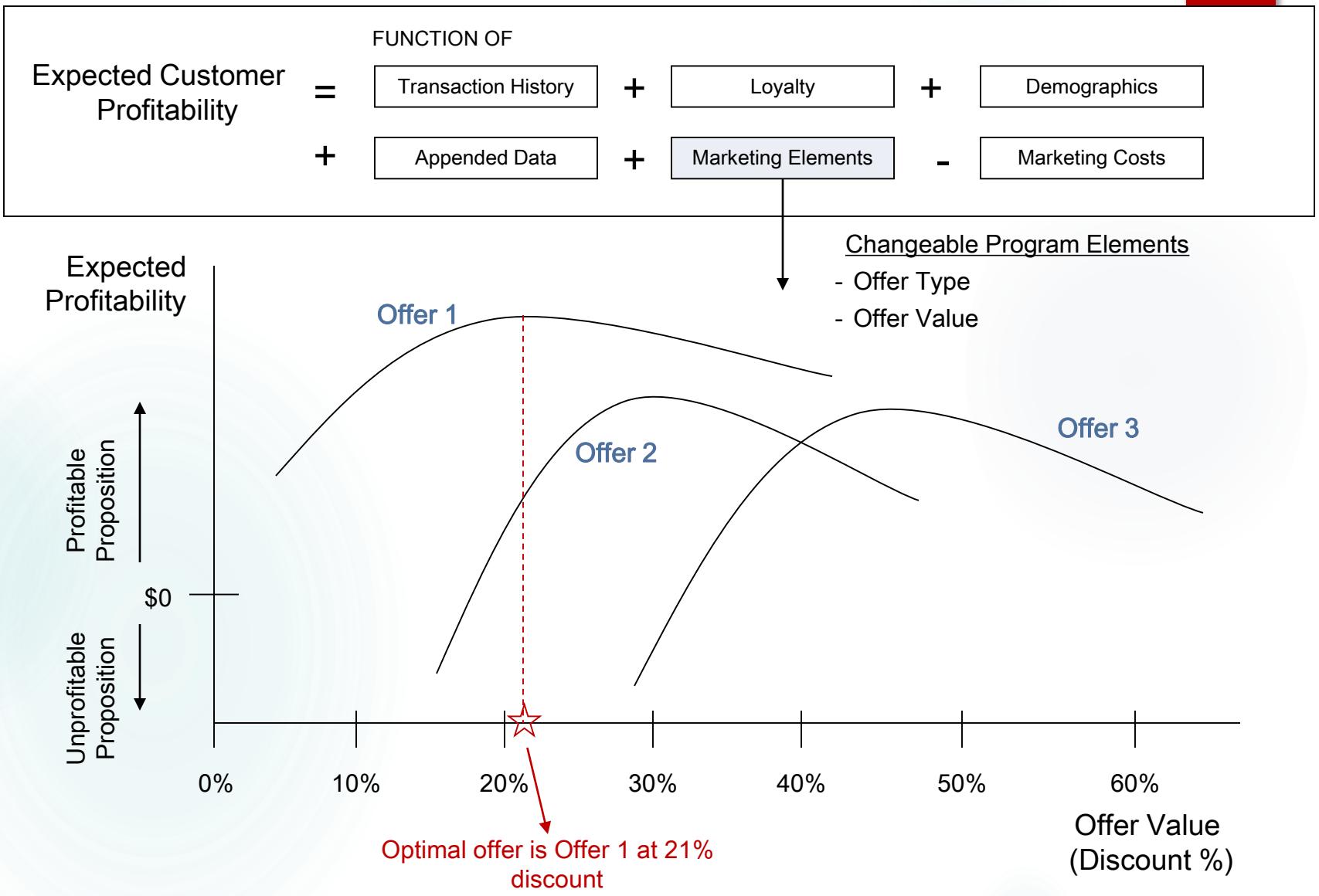
Constrained Optimization is the process of determining the optimal outcome for a stated objective in the presence of stated constraints.

Dimensions	Constraints	Solution	Example
0	0	Market all or none	Optimize revenue or cost
0	1	Rank order all	Marketing budget
1	1	Rank order by dim	Marketing budget by channel
1	2	Rank order by dim	Channel max spend and min spend
2+	2+	LityxIQ	Channel max spend with product min performance

Optimization Examples

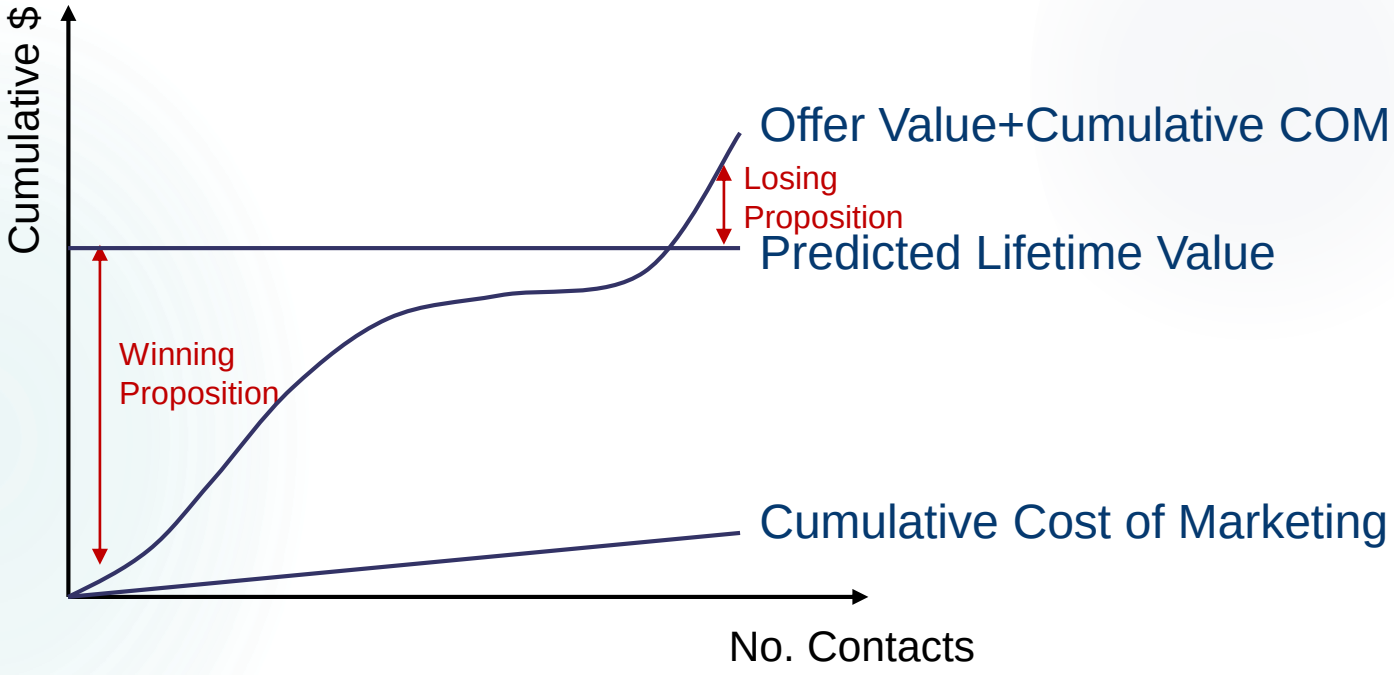
- **Offer Optimization**
  - What is the optimal offer or sequence of offers to give to a customer or prospect, in order to maximize profits?
- **Channel Optimization**
  - What is the optimal customer/prospect contact channel (or sequence of channels) to maximize profitability?
- **Campaign Optimization**
  - Who do we target in order to maximize campaign ROI (and not just campaign response)?
- **Budget and Media Optimization**
  - How do we optimally allocate marketing budget to media and/or direct channels?

Offer Optimization Example



Contact Optimization Example

The optimal number of contacts will entice the customer as early as possible, using as small a percentage of their potential lifetime value as possible.



This Will Take Practice

- LityxIQ eliminates the need to understand how the optimization is being done and provides a straightforward structured setup, but still requires an understanding of how to breakdown the business problem correctly.

- There is a deep body of knowledge associated with the understanding of optimization problems and degrees in fields such as Operations Research that specialize in this area.

- Using LityxIQ you can take advantage of that knowledge without needing to understand how it is working. Like PredictIQ, you do not need to understand the algorithms in order to build a strong model.

- With OptimizeIQ you can solve very complicated business problems by understanding how to set them up and then leave the complication to the software.

OPTIMIZEIQ

Overview

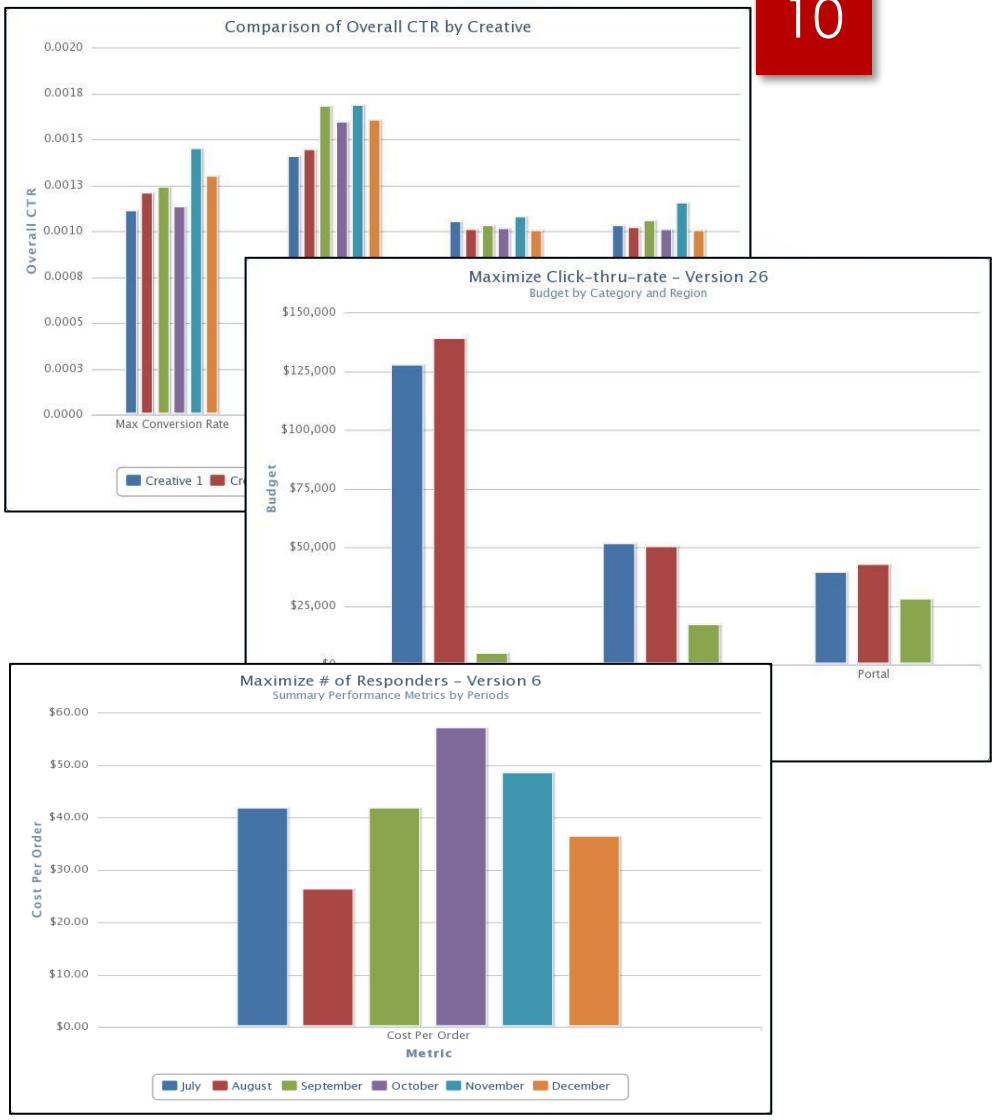
OptimizeIQ is a classical operations research based solver that help users determine the best choice among many options. Like all solvers in order for it to tell you want you would like to know you have to define some things about your situation to be solved.

1) What are you looking to maximize or minimize?
2) What constraints exist or could exist that you would like to understand the impact of?
3) What decisions need to be made that affect the objective?

"OptimizeIQ is an optimization tool that determines the optimal outcome for a stated objective in the presence of stated constraints"

Marketing Optimization

- Optimize marketing budget/resources across customer segments, products, channels, and other business dimensions
- Optimize media spend within and across channels
- Optimize individual customer communications to maximize profitability

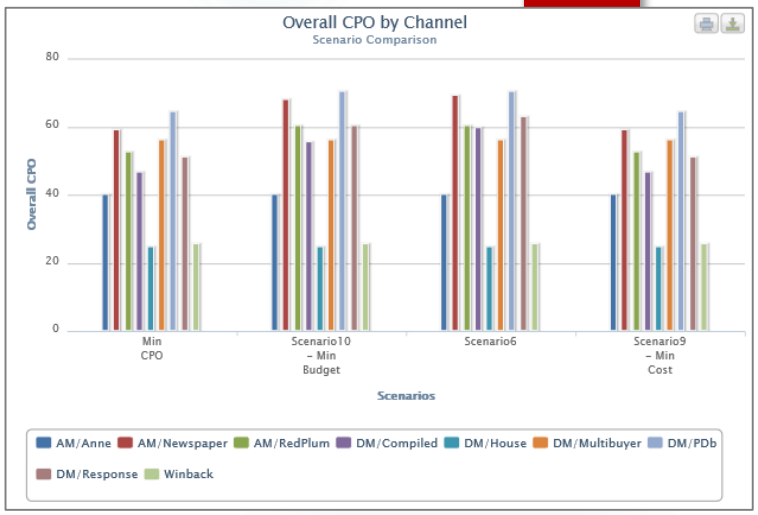


Output

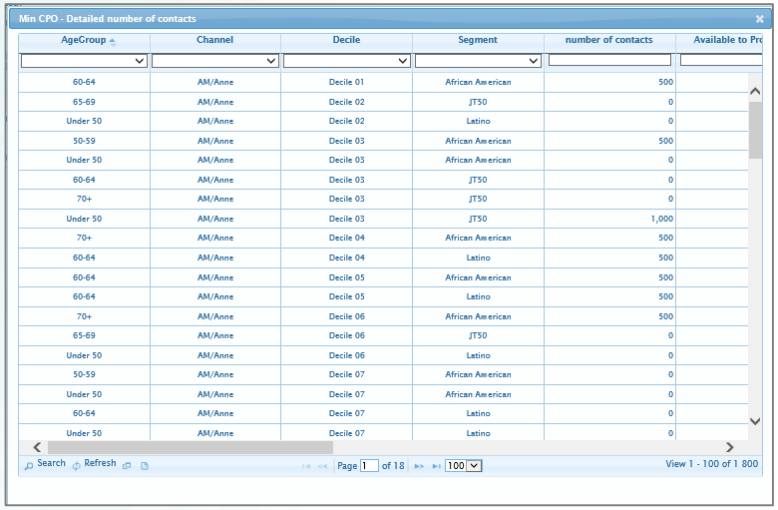
- Compare multiple optimization scenarios looking at multiple objectives by multiple dimensions

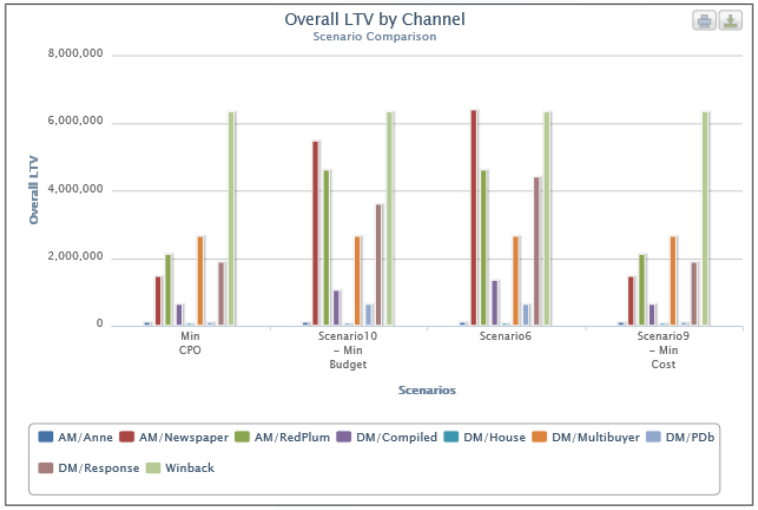
  Example: What channel delivers the lowest CPO under different optimization scenarios?

  Example: What channel delivers the highest LTV under different optimization scenarios?



- After identifying the optimal scenario, output the criteria needed to execute it.





Lityx

Key Terms

- **Scenario** – a business problem and optimized solution from a fully defined constrained optimization setup. Included in a scenario are:
  - **Terminology & Problem Definition** – a name to be used by LityxIQ to create a variable that will be determined in order to solve the optimization problem.
    - The objective is to optimize *Contacts* across different *Dimensions*
  - **Dimension** – categorical divisions of interest and difference
    - Age
    - Segment
    - Channel
    - Model Decile
  - **Level** – a sub unit within a dimension
    - 18-34, 35-49, 50-64, 65+ (4)
    - AA, Hisp, Other (3)
    - DM, EM, SEO (3)
    - 1,2,3,4,5,6,7,8,9,10 (10)

Key Terms cont.

- **Attribute** – a characteristic about a portion of the levels
  - NY Office, Chicago Office (2)

NY Office | CHICAGO Office

	18-34									35-49									50-64									65+								
	AA			Hisp			Other			AA			Hisp			Other			AA			Hisp			Other			AA			Hisp			Other		
	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO	DM	EM	SEO
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
2	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
3	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
4	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
5	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
6	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
7	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252
8	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288
9	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
10	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360

This example full matrix has 4 x 3 x 3 x 10 = 360 unique combinations

- **Data Element** – raw or calculated information used to provide details to the scenario that can be adjusted on the fly.
  - Cost Per Piece
  - Life Time Value
  - Response Rate
  - Potential Responders
  - Cost

Key Terms cont.

- **Summary Metrics & Objective Functions** – solution derived variables that define what you are seeking to achieve or control for.
  - Overall Cost-per-Order
  - Overall LTV
  - Potential Contacts
  - Total Cost
  - Total Recommended Contacts
  - Total Responders

Let's Look At OptimizeIQ Then Come Back Here

See the layout, what and where information is needed

Optimization Example Problem

Sales Rep Optimization:

Client has to determine the optimal use of their sales reps over the next two months with many options available including:

- *What product to sell?*
- *Which customer segments to target?*
- *How to allocate calls across months?*

Meta Data - Dimensions

What are the dimensions of this problem and what are their levels?

Example – 3 Dimensions:

Products, Periods, Segments

Products

Levels
Product A
Product B
Product C

Periods

Levels
Month 1
Month 2

Customer Segments

Levels
Segment 1
Segment 2

The optimization is performed at the combination of all levels and their dimensions.

Meta Data – Attributes and Data Elements

Each combination of dimensions and their levels can be assigned any number of attributes and data elements.

Dimensions Attribute Data Elements

Products	Periods	Segments	Sales Rep	Response Rate	Avg Sale Size
Product A	Month 1	Segment 1	Jane	.025	$146
Product A	Month 1	Segment 2	Jane	.043	$77
Product A	Month 2	Segment 1	Joe	.011	$143
Product A	Month 2	Segment 2	Jane	.025	$29
Product B	Month 1	Segment 1	Joe	.026	$102
Product B	Month 1	Segment 2	Jane	.047	$44
Product B	Month 2	Segment 1	Josh	.033	$93
Product B	Month 2	Segment 2	Jane	.022	$68
Product C	Month 1	Segment 1	Josh	.044	$106
Product C	Month 1	Segment 2	Joe	.023	$75
Product C	Month 2	Segment 1	Joe	.074	$84
Product C	Month 2	Segment 2	Josh	.004	$36

Meta Data – Optimization Variable

The variable to be optimized is defined. The optimization routine will determine its optimal value for each combination of dimension levels.

Optimization Variable

Products	Periods	Segments	Sales Rep	Response Rate	Avg Sale Size	Calls to Make
Product A	Month 1	Segment 1	Jane	.025	$146	?
Product A	Month 1	Segment 2	Jane	.043	$77	?
Product A	Month 2	Segment 1	Joe	.011	$143	?
Product A	Month 2	Segment 2	Jane	.025	$29	?
Product B	Month 1	Segment 1	Joe	.026	$102	?
Product B	Month 1	Segment 2	Jane	.047	$44	?
Product B	Month 2	Segment 1	Josh	.033	$93	?
Product B	Month 2	Segment 2	Jane	.022	$68	?
Product C	Month 1	Segment 1	Josh	.044	$106	?
Product C	Month 1	Segment 2	Joe	.023	$75	?
Product C	Month 2	Segment 1	Joe	.074	$84	?
Product C	Month 2	Segment 2	Josh	.004	$36	?

Meta Data – Summary Metrics

Now we define any number of key summary metrics in which we are interested. We will use these to define our optimization criteria and business constraints.

Products	Periods	Segments	Sales Rep	Response Rate	Avg Sale Size	Calls to Make
Product A	Month 1	Segment 1	Jane	.025	$146	?
Product A	Month 1	Segment 2	Jane	.043	$77	?
etc						

Summary Metrics

Metric	Definition
Total Calls	Sum (Calls To Make)
Total Responses	Sum (Calls To Make * Response Rate)
Total Sales	Sum (Calls To Make * Response Rate * Avg Sale Size)
Overall Response Rate	Total Responses / Total Calls
Overall Sales per Call	Total Sales / Total Calls

Some are based on aggregations of our data elements (including the unknown optimization variable) **"Simple"**

Others are based on previously defined metrics. **"Complex"**

Business Objectives and Constraints

Now we decide which summary metric we want to maximize (or minimize) and what business constraints we want to put on the problem.

Objective: Maximize Overall Response Rate

Constraint	Definition
Limit total number of calls	Total Calls <= 5000
Minimum # calls for each rep	Total Calls >= 50 (separately for each Sales Rep)
Focus on Segment 1	Percent Total Calls to Segment 1 >= 65
Force minimum total sales	Total Sales >= $1000
Distribute effort over each month	Percent Total Calls >= 45 (separately for each Period)

Execute and Evaluate Results

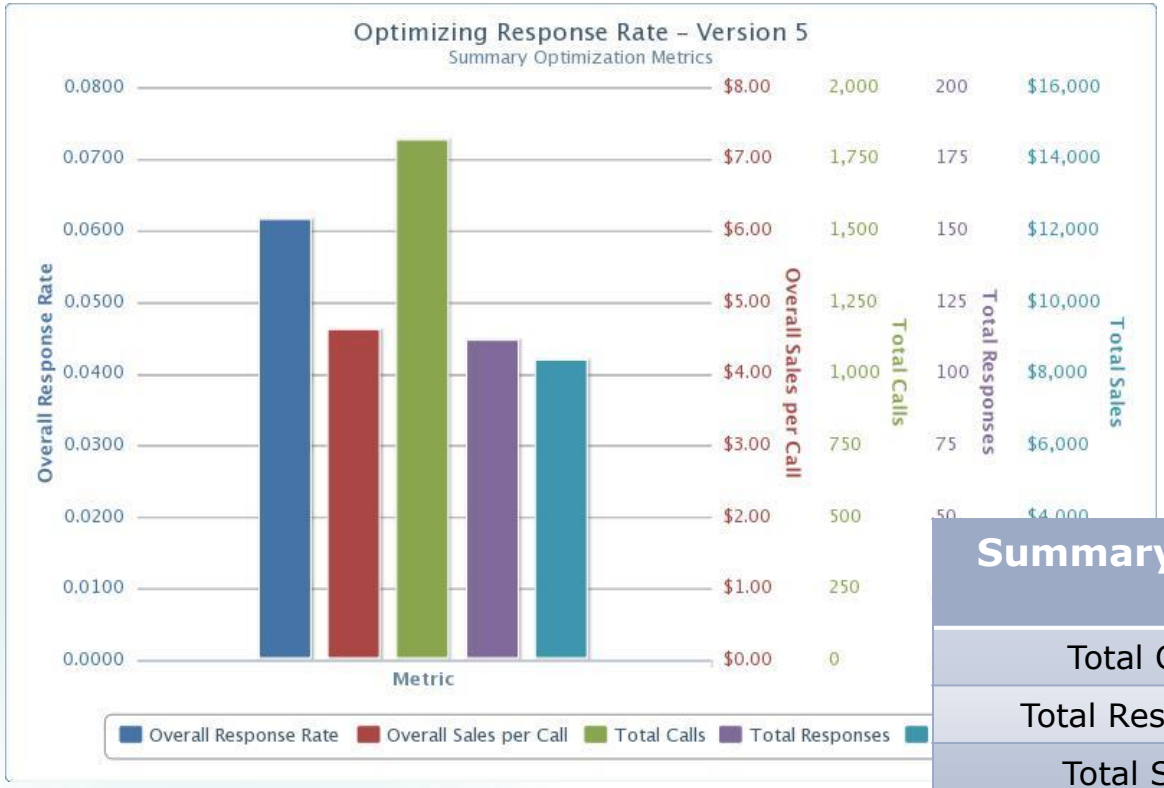
Now execute the optimization problem. Detailed results are the optimal values for each combination of dimensions and levels.

Products	Periods	Segments	Sales Rep	Response Rate	Avg Sale Size	Calls to Make
Product A	Month 1	Segment 1	Jane	.025	$146	0
Product A	Month 1	Segment 2	Jane	.043	$77	0
Product A	Month 2	Segment 1	Joe	.011	$143	0
Product A	Month 2	Segment 2	Jane	.025	$29	0
Product B	Month 1	Segment 1	Joe	.026	$102	0
Product B	Month 1	Segment 2	Jane	.047	$44	636
Product B	Month 2	Segment 1	Josh	.033	$93	0
Product B	Month 2	Segment 2	Jane	.022	$68	0
Product C	Month 1	Segment 1	Josh	.044	$106	182
Product C	Month 1	Segment 2	Joe	.023	$75	0
Product C	Month 2	Segment 1	Joe	.074	$84	1000
Product C	Month 2	Segment 2	Josh	.004	$36	0

Detailed Optimized Results

Summary Results

- We also receive and analyze the summary results.



Summary Metric	Optimized Result
Total Calls	1,818
Total Responses	112
Total Sales	$ 8,380
Overall Response Rate	6.16%
Overall Sales per Call	$ 4.61

Over to OptimizeIQ

Let's See This in Action!

APPENDIX

Setup - Scenarios

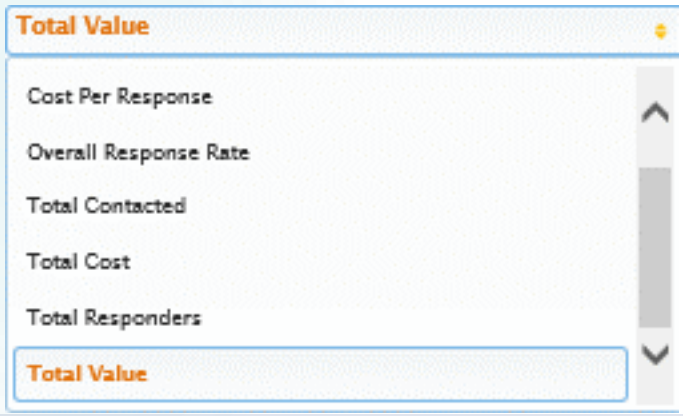
It helps to think about the solution in reverse. What do you want to see, then what data is going to be needed? In OptimizeIQ the metadata is where you define the data that get used in the construction of scenarios.

OptimizeIQ Scenario

1. **Objective**

Min/Max: Maximize

Objective Function: Total Value



The only two choices are to minimize something or maximize something.

The choices here get defined in the Metadata under **Summary Metrics & Objective Functions**

Setup – Scenarios *cont.*

OptimizeIQ Scenario

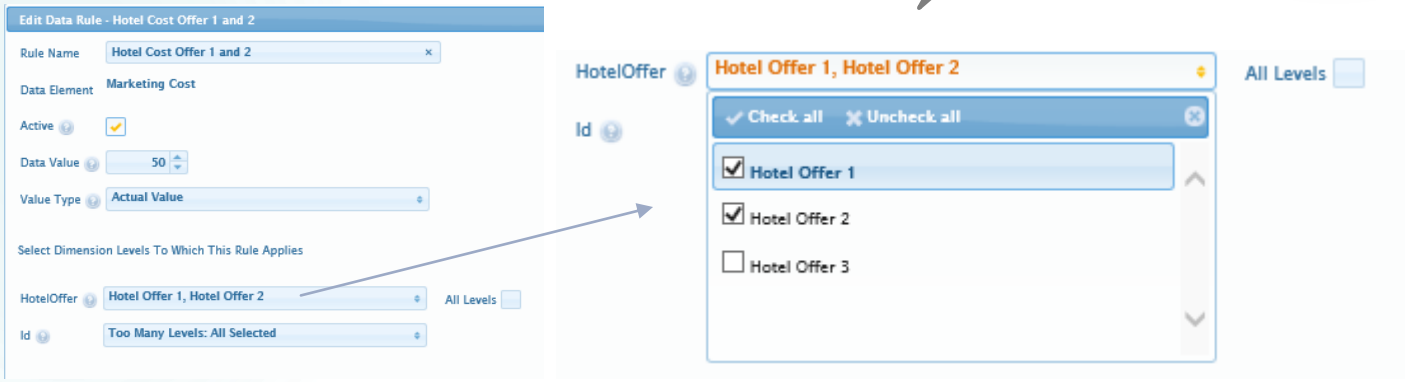
2. Additional Data Rules

The rules created here allow for easy change of key drivers on the fly when running scenarios.

The selection options are setup in the metadata under **Data Elements**

For example this rule is defined as a Marketing Cost and assigns $50 to Hotel Offer 1 and 2. The setup for the dimensions is in the metadata under **Dimensions and Levels**

Example



Setup – Scenarios *cont.*

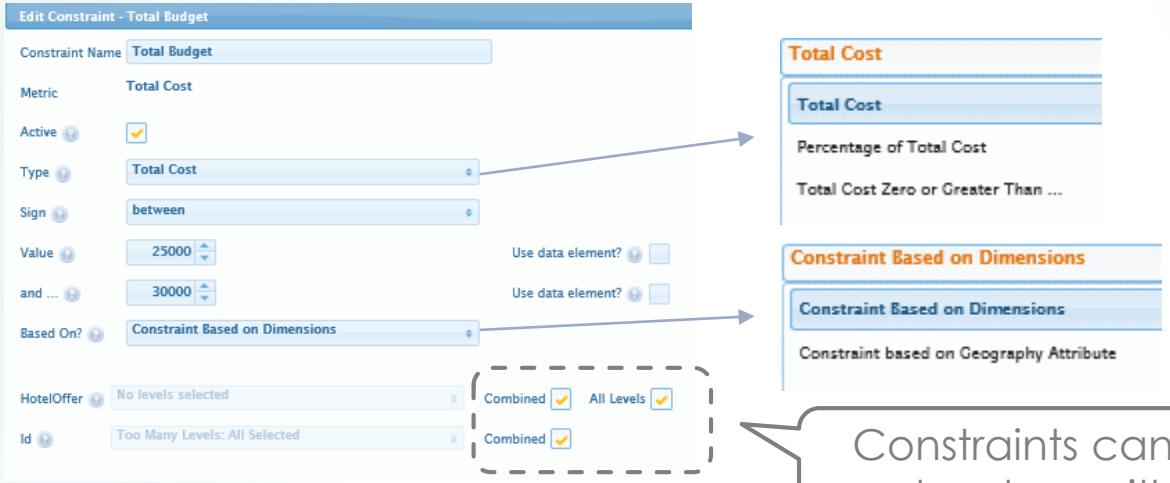
OptimizeIQ Scenario

3. Constraints

The choices here get defined in the Metadata under **Summary Metrics & Objective Functions**

Total Cost is selected as a constraint and set between $25k-$30k

Example

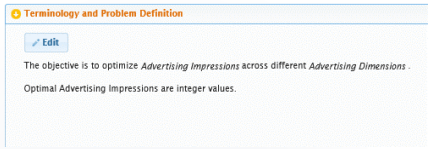


Constraints can be across levels or within level

Setup – Metadata

Metadata is information about the data to be analyzed and is necessary for OptimizeIQ to understand what is being solved for and the data available.

- **Terminology and Problem Definition**.
  The objective is to optimize _____ across different _____



- **Attributes**

Attribute	DefaultValue
Geography	Default

- **Dimensions and levels of the data**

Dimension	No. Levels	Levels
AgeGroup	5	50-59, 60-64, 65-69, 70+, Under 50
Channel	9	AM/Anne, AM/Newspaper, AM/RedPlum, DM/Compiled, DM/House ...
Decile	10	Decile 01, Decile 02, Decile 03, Decile 04, Decile 05 ...
Segment	4	African American, General Market, JT50, Latino

- **The data elements**

Data Element Name	Type/Formula
Available to Promote	Special Universe Size Data
Cost Per Piece	Basic
Response Rate	Basic

- **Summary metrics and objective functions**

Metric Name	Type	Formula
Overall CPO	Complex	Total Cost / Total Responders
Total Cost	Simple	SUM(contacts * Cost Per Piece)
Total Responders	Simple	SUM(contacts * Response Rate)

Summary of Setup

Define the Metadata	Link to Scenario Setup
	Used In . . .
▶ Terminology & Problem Definition - *The decision to be made* - *Number of contacts or impressions etc.*	1. Objective 2. 3. Constraints
▶ Dimensions and Levels - *Segments, Channels, Creative etc* - *Information on your file to examine separately or treat differently.*	1. Objective 2. 3. Constraints
▶ Attributes - *Qualitative characteristic on partial levels*	1. 2. Additional Data Rules 3.
▶ Data Elements - *Creative cost-per-piece, channel response rate etc.* - *Things you want to be able to change on the fly*	1. 2. Additional Data Rules 3.
▶ Summary Metrics and Objective Functions - *Key performance metrics*	1. Objective 2. 3. Constraints

Simple Example

Client has many options for their acquisition marketing efforts and would like to look at various optimization solutions.

Dataset

Type: Rolled-up
Records: 1,800

Dimensions:
- Channel (9)
- Decile (10)
- Segment (4)
- Age Group (5)

Metrics:
- # of Prospects
- Cost per Piece (CPP)
- Response Rate
- Life-Time Value (LTV)

For every combination of the dimensions, each of the metrics are given.

Scenarios

Scenario	Objective	Constraints	Additional Data Rules
1	Minimize cost-per-response (CPR)	Total responders >= 100,000 combined across all dimensions.	None
2	Maximize responders	Total cost <= $9MM combined across all dimensions	None

Simple Example – Define Metadata

Define the Metadata	Create Scenarios
	Used In . . .
▶ Terminology & Problem Definition (Stated) - *Number of Contacts*	1. Objective 2. 3. Constraints
▶ Dimensions and Levels (Read In) - *Age Group, Channel, Decile, Segment*	1. Objective 2. 3. Constraints
▶ Attributes	None
▶ Data Elements - *# of prospects* (Read In) - *CPP* - *LTV* - *Response Rate (RR)* - *Cost (# of prospects x cpp)* (Calc) - *Potential responders (# pspcts x RR)*	1. 2. Additional Data Rules 3.
▶ Summary Metrics and Objective Functions (Derived) - *Overall CPR (total cost / total response)* - *Total Responders (contacts x RR)*	1. Objective 2. 3. Constraints

Simple Example – Create Scenarios

Define the Metadata	Create Scenarios
▶ Terminology & Problem Definition (Stated) - *Number of Contacts*	1. Objective 2. 3. Constraints Used to define Overall CPR, Total Cost, Total Responders used in Objective and Constraints. Also output field to execute optimal solution.
▶ Dimensions and Levels (Read In) - *Age Group, Channel, Decile, Segment*	1. Objective 2. 3. Constraints Used to perform optimization by, run constraints across and recommend number of contacts by.
▶ Attributes	
▶ Data Elements (Read In / Calc) - *# of prospects* - *CPP* - *LTV* - *Response Rate (RR)* - *Cost (# of prospects x cpp)* - *Potential responders (# pspcts x RR)*	1. 2. Additional Data Rules 3. None.
▶ Summary Metrics and Objective Functions (Derived in Opt) - *Overall CPR (total cost / total response)* - *Total Responders (contacts x RR)*	1. Objective - ***Scenario1*** *Minimize overall CPR* - ***Scenario 2*** *Maximize total responders* 2. 3. Constraints - ***Scenario 1*** *Total Responders >= 100k* - ***Scenario 2*** *Total Cost <= $90M*

Lityx