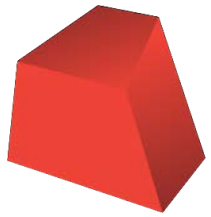


GUROBI OPTIMIZATION

end-to-end ANALYTICS

Welcome to the Webinar

Beyond an Optimal Answer

How Optimization Adds Unexpected Value to an Organization

Speaker Introduction

- Tracy Pesanelli
- Over 30 years of sales management experience in the high-tech industry, responsible for Gurobi's sales execution
- Prior to joining Gurobi, Ms. Pesanelli was a Sales Director at Permabit Technology Corporation and held multiple sales positions at ILOG, Inc.
- Ms. Pesanelli holds a Bachelor's of Science degree from the University of Massachusetts at Amherst.

Speaker Introduction

- Dr. Russell Halper
- Principal at End-to-End Analytics
- PhD in Applied Mathematics from the University of Maryland
- Both in-house and consulting experience
- Devoted his career to developing cutting-edge analytics solutions to problems in supply chain, manufacturing and marketing
- Passionate about connecting analytics to business problems to ensure pragmatic, measurable results

Gurobi Optimization
Who We Are

end-to-end *ANALYTICS*

GUROBI OPTIMIZATION

Outstanding Support
Direct access to PhD-level optimization experts

Performance Leader
Consistent public benchmark winner

GUROBI OPTIMIZATION

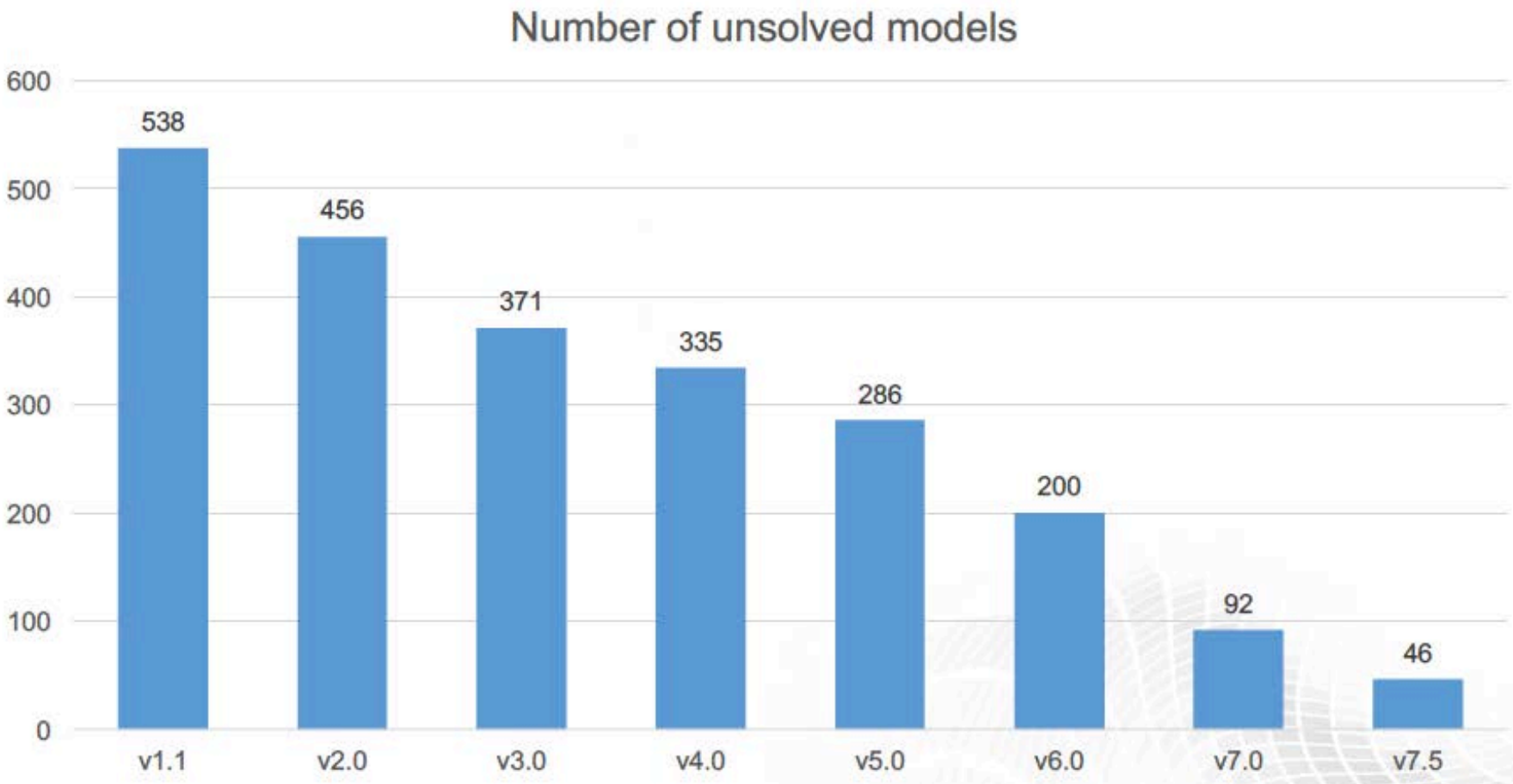
Continual Improvement
21X faster to solutions than four years ago

No surprises
Transparent pricing with flexible licensing

Gurobi Optimization
Continual Performance Improvements

end-to-end *ANALYTICS*

GUROBI OPTIMIZATION



Time limit: 10000 sec.
Intel Xeon CPU E3-1240 v3 @ 3.40GHz
4 cores, 8 hyper-threads
32 GB RAM

MIP test set has 3420 models:
- 217 discarded due to inconsistent answers
- 788 discarded that none of the versions can solve

End-to-End Analytics

Who We Are

We **partner** with our customers to solve **complex business challenges** bringing the right **balance** of management **consulting**, **analytics** and **technology**

Consulting

Management consulting focused on business strategy and process adoption

Analytics

Robust yet practical analytics to answer the hardest questions

Technology

Right sized technology tailored to enable your business needs

Company

Founded in 2005

Based in Palo Alto, CA

Team

50+ professional staff

17 Ph.D.'s from Major Universities

Resources in CA, MI, MA, Hong Kong, China, Peru, and Brazil

Work

Over 75 clients

More than 700 projects to date

30+ published articles

More than 15 patents

End-to-End Analytics

What We Do

end-to-end *ANALYTICS*

GUROBI OPTIMIZATION

Key Verticals

- Automotive
- High Tech
- Retail
- Consumer
- Financial Services
- Other

Analytics Maturity Model

end-to-end *ANALYTICS*

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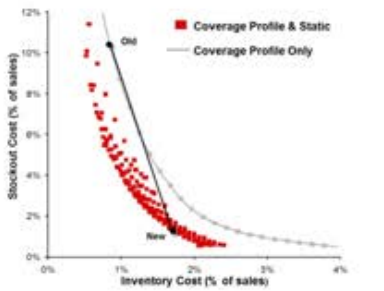
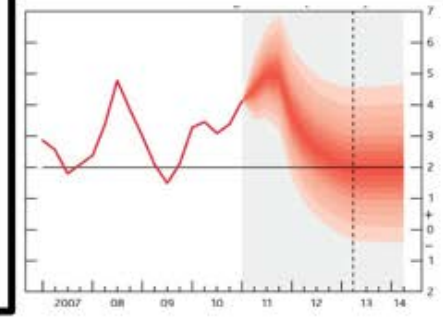
Prescriptive



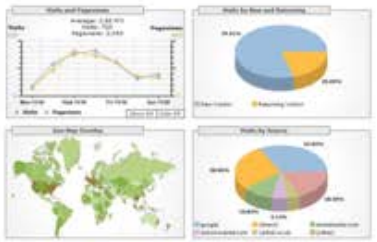
What should we do?

Predictive



What will happen?

Descriptive



What has happened?

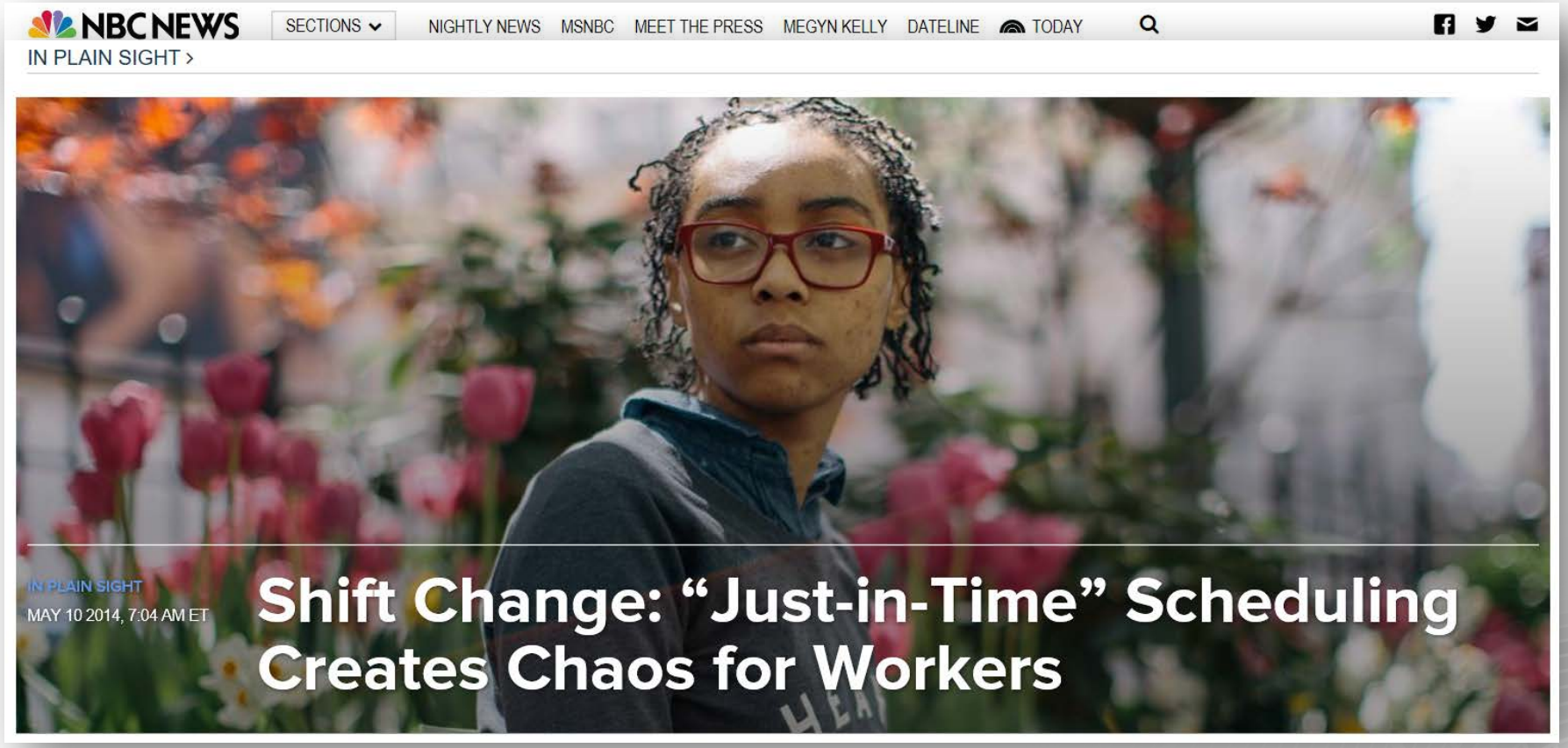
Agenda

1. How is optimization often perceived
   - Where to apply optimization
   - What value is it viewed as providing

2. How optimization provides value to an organization
   - Automating Workflow
   - Scenario Analysis
   - Flexibility
   - Can Address Long-standing Business Issues

3. Realizing this value in practice
   - Gurobi Functionality
   - 5-Point Framework for Realizing Impactful Optimization Opportunities

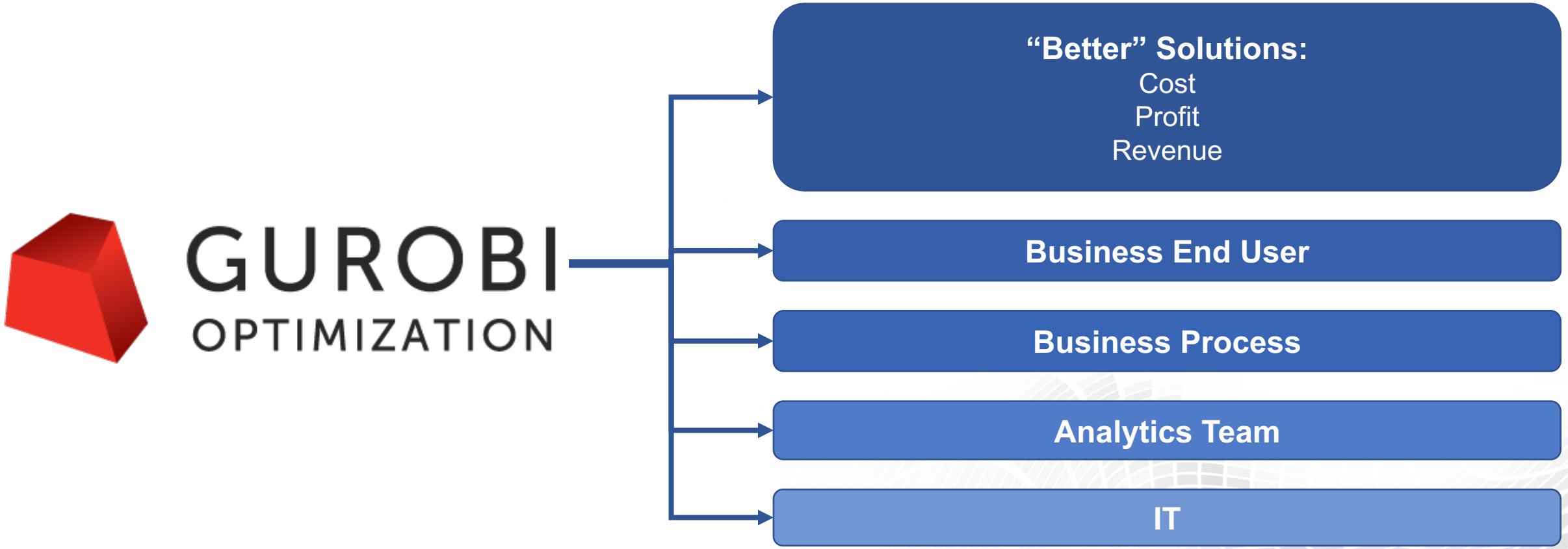
Prescriptive Analytics is About More than Cost or Revenue…



- Prescriptive analytics for determining schedule
- Desire to closely match schedule with demand
- At times little consideration of employee quality-of-life
  - Inconsistent hours each week
  - Varying work times
  - Family responsibilities
  - Retail employees sometimes have multiple jobs

http://www.nbcnews.com/feature/in-plain-sight/shift-change-just-time-scheduling-creates-chaos-workers-n95881

What types of “Value” can be generated by using optimization?



Getting Started with Analytics

Source: https://en.wikipedia.org/wiki/Analytics

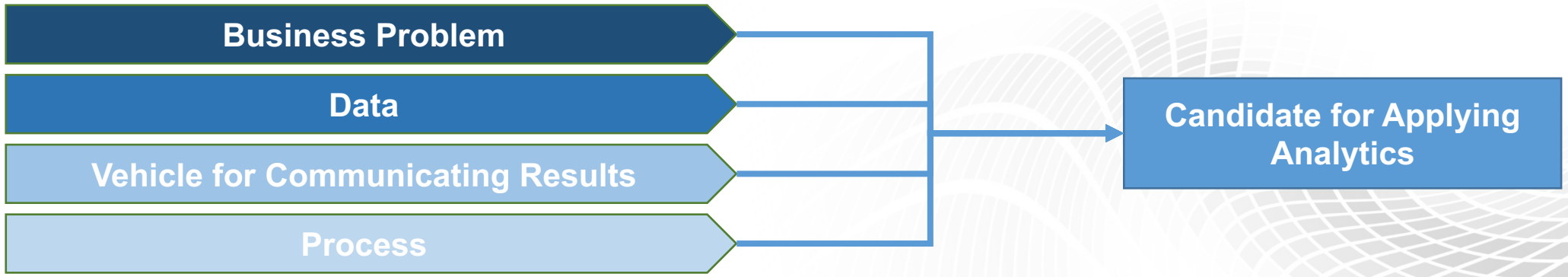
Analytics

From Wikipedia, the free encyclopedia

For the ice hockey term, see Analytics (ice hockey).

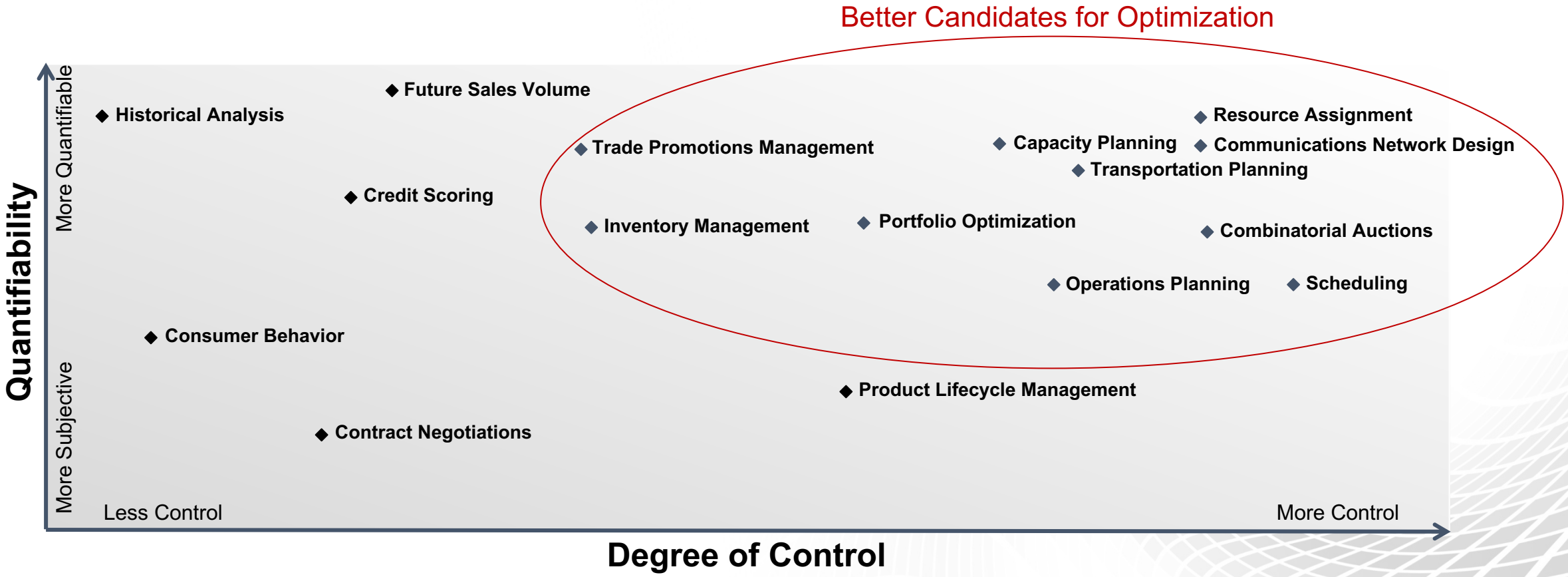
Analytics is the discovery, interpretation, and communication of meaningful patterns in data. Especially valuable in areas rich with recorded information, analytics relies on the simultaneous application of statistics, computer programming and operations research to quantify performance.

Organizations may apply analytics to business data to describe, predict, and improve business performance.



Identifying Opportunities for Optimization

Optimization can often be used when the business has a high degree of control over a reasonably quantifiable business problem.



Common Optimization Applications

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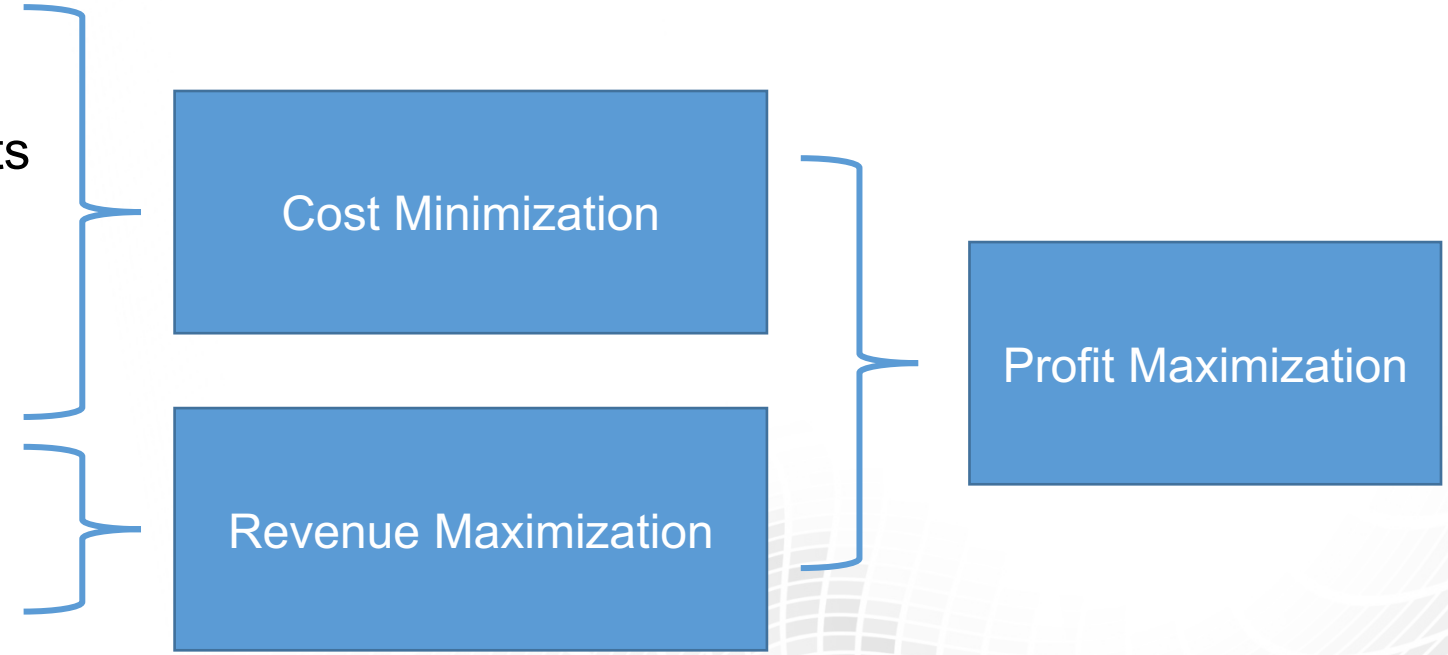
Common Optimization Problems

- Minimize Distribution Costs
- Minimize Infrastructure Investment Costs
- Minimize Production Costs
- Minimize Procurement Costs
- “Right-size” Inventory
- Maximize Trade Promotion Revenue
- Maximize Auction Revenue



Common Optimization Applications

Common Optimization Problems

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- Minimize Procurement Costs
- "Right-size" Inventory
- Maximize Trade Promotion Revenue
- Maximize Auction Revenue

In practice, Network Design problems seldom implement the least cost solution

Difficult-to-quantify constraints such as union contracts can influence solution choice

Companies often want to source from multiple strategic vendors

Trade Marketing strategies have many goals from maximizing ROI, volume, or revenue to supporting base volume, distribution, or shelf space

Agenda

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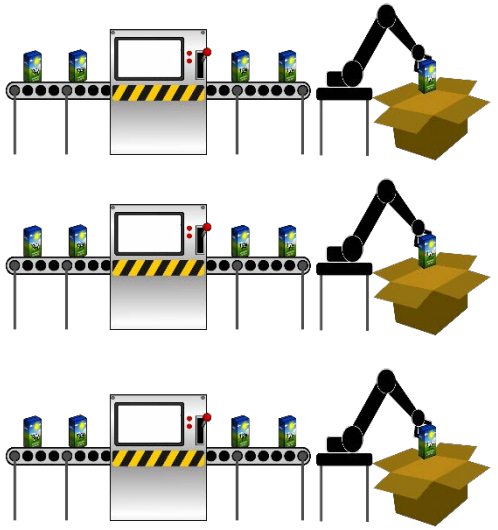
Conceptual Exercise: Factory Scheduling



How is accelerating the decision making process important in scheduling?

Complex production schedules can take significant amounts of time to create:

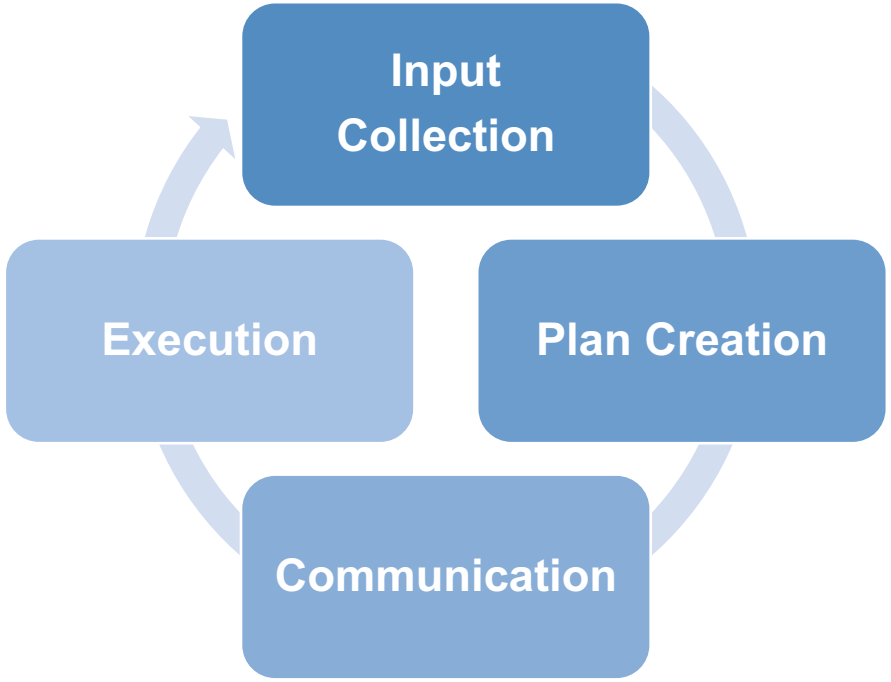
- Many individual decisions
- Complex & interactive constraints
  - labor, equipment capacity, storage, and materials
- Demand that can rapidly change
- WIP and Storage considerations in multi-stage manufacturing

This schedule is typically not optimal.

"Everyone has a good plan until they get punched in the mouth"
– Mike Tyson

Value of scheduling optimization is often not just the first schedule, but the ability to re-schedule as attainment deviates from the desired.

Automating Workflow & Accelerating The Decision Making Process



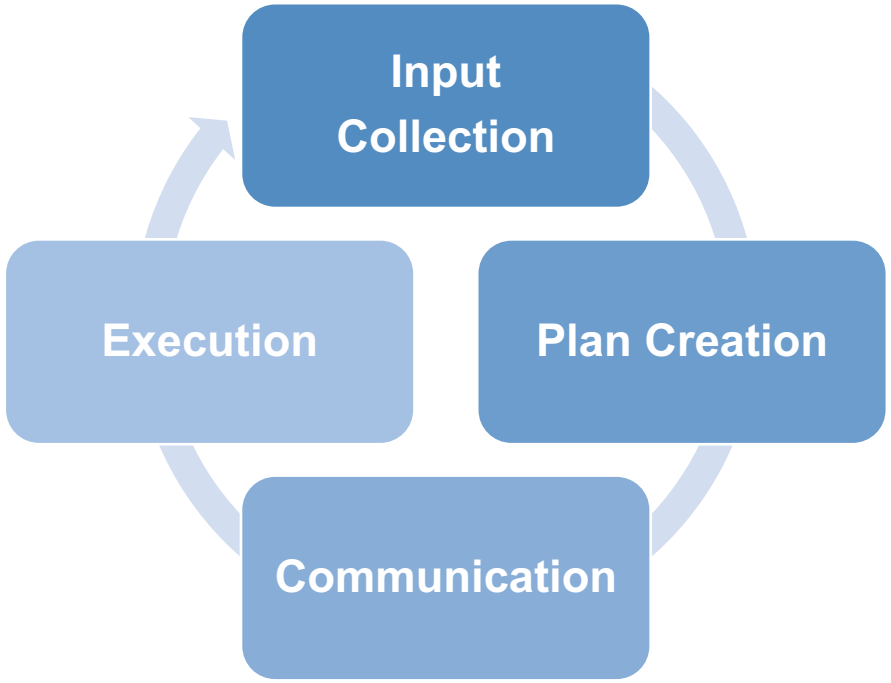
A Typical Planning Cycle

This planning cycle applies to a variety of situations

- Scheduler
- Supply Planner
- Transportation
- Resource management
- Inventory optimization

Mixed-integer Programming can act as a workforce multiplier by automating decision processes enabling time to be spent on higher value-added activities.

Automating Workflow & Accelerating The Decision Making Process



A Typical Planning Cycle

How does an optimization model affect each stage of the planning cycle:

Input Collection

- Optimization models of planning cycles typically require a well-structured set of inputs, which can be quickly collected.

Plan Creation

- A model can often generate a plan more quickly than a human and yield a better quality plan

Communication

- Outputs of a model enables standardized reporting and operational decisions to be easily supplied to the business

Execution

- A well-designed optimization model should provide a plan with characteristics that enable efficient execution.

Optimizing For Multiple Objectives

- Many optimization problems can have multiple goals (objectives).
- Gurobi has built-in features to solve models with multiple objectives.
- Two ways to handle multiple objectives
  - Hierarchical – The objectives are ranked. Gurobi will solve for each objective sequentially.
  - Weighted – All the objectives are combined to one composite objective by giving each objective a weight.

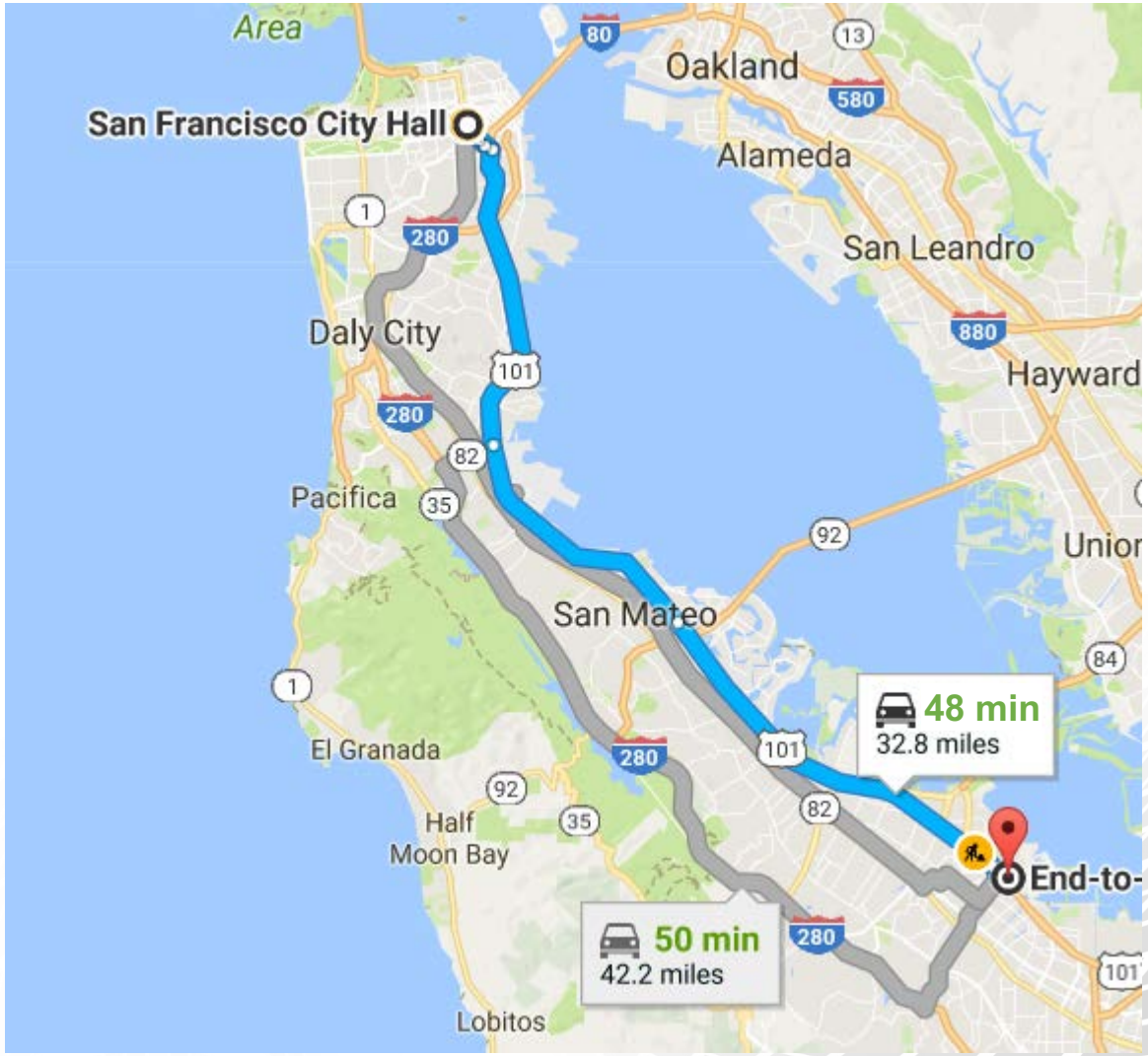
Scenario Analysis

Scenarios with data and constraints

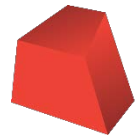
Understanding not just one solution, but what are the best K solution.

- Gurobi can find multiple solutions (Solution Pools).
- It typically stores feasible solutions that it finds on its way to the optimal solution.
- Gurobi can be configured to find the K best solutions.

The last decade has seen huge improvement in the performance of optimization solvers. This allows users to try out multiple scenarios before making a final decision.



Tips for Effective Scenario Analysis



Effective Data Management

- Easy way to create/configure scenarios
- Always store the output of all scenarios

Robust reporting/descriptive analytics for comparing results

- Visualizing results is often crucial to understanding a solution

Process to make key business decisions considering different scenarios

- Cost based
- Consensus
- Robustness
- Ease of Implementation

Utilize Gurobi functionality, such as Solution Pools, to save development time.

Exception-Based Decision Making

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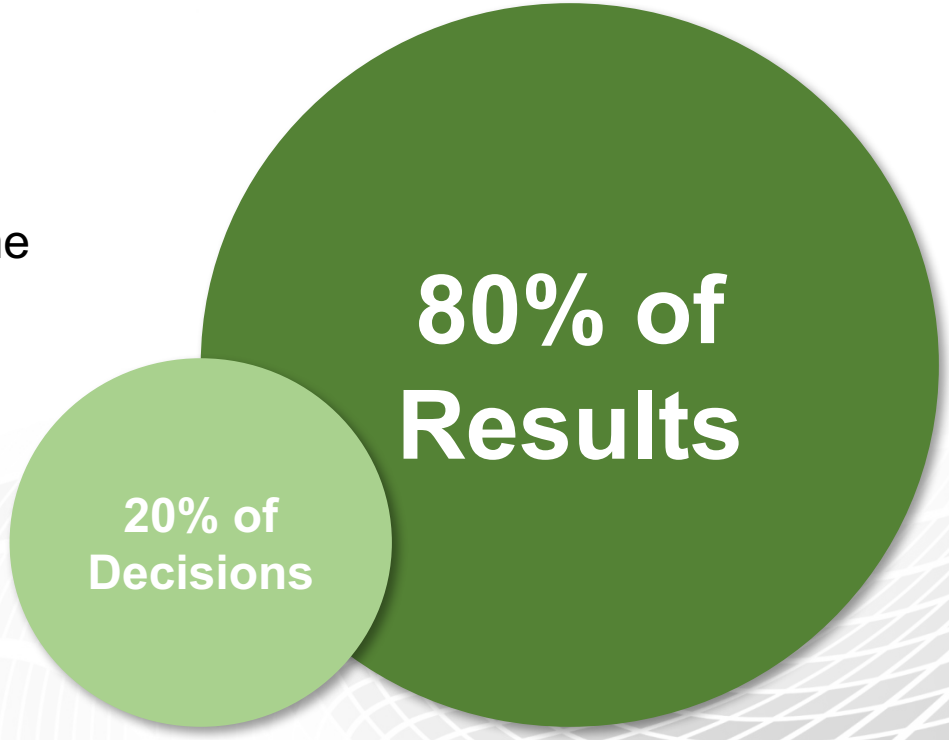
Automating Workflow → **Scenario Analysis** → **Exception Based Decision Making**

- In planning processes, many decisions yield low ROI vs the time required to create the plan.
- Automating “busy” work enables planners to increase the time spent on value added activities such as:
  - Planning
  - Communication
  - Execution
- What does the role of a planning in an organization become
  - Planner ➔ Planning Analyst
  - Skills sets needed may evolve



Pareto Principle

MIP Provides Flexibility

How quickly can your prescriptive analytics react to changes in business conditions?

Analytics Team

- Assured high level reliability/quality
- Can implement new considerations without having seen past results
- Better able to scale resource time
- Potentially less new code to deploy
- Sometimes better buy-in from IT

How does buy-in from the business change when analytics have a good foundation?

Higher degree of trust in the model

More willingness to implement the solution

More willingness to pursue future projects/expand scope

Business Results

- Better able to service market conditions
- Increased ROI from software and services
- May be more IT friendly
- Easier line-of-sight to implement and test changes

Implementing Optimization Can Help Address Operational Challenges

Challenge #1: Decisions made using rules of thumb rather than rigorous analysis

- Rules of thumb may have worked, but are slow to adapt to change
- Data available, but typically not processed or analyzed effectively as a result of training, data quality, or limited access, or poor systems

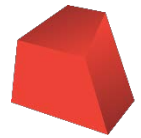
Challenge #2: Decisions made in isolation or in silos

- Lack of inter-department collaboration driven by conflicting objectives
  - Manufacturing: Minimize changeovers to reduce manufacturing costs
  - Supply Chain: Minimize inventory carrying costs
- Anecdotes defending particular points of view prevail because the data is too hard to assimilate

Challenge #3: Organization repeats mistakes

- Processes are not closed loop
- KPI's are calculated, but the issues are not tied back to root causes and the process and system do not enable continuous learning

Agenda



GUROBI OPTIMIZATION

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Why Gurobi is the Best Solver to Unlock this value

- Fastest Mixed Integer Optimization Solver
- Gurobi Instant Cloud (on AWS) - Quickly build and deploy optimization applications
- Superior Interfaces. Gurobi provides Application Programming Interfaces(API's) to many programming and modeling languages
- Advanced Modeling features such as:
  - Piecewise linear objectives
  - Logical Constraints

5-Point Framework for Identifying Impactful Optimization Opportunities

1. Business decision process:
   - A high degree of control
   - Reasonably quantifiable
   - Solid understanding of the “Levers” that can be pulled
2. Does data exist or can it be manufactured?
3. Can a set of decisions (solution) be quantified?
4. Define the value to the business
   - Cost/Profit/Revenue
   - Time savings
   - Scenario analysis
   - “Survival” – Decisions required considering all the facts
   - Flexibility
5. Methodology for engaging the business and implementing results

Thank you for joining us

- If you haven't already done so, please register for an account at www.gurobi.com
- Visit www.gurobi.com/downloads/get-anaconda to try Gurobi and Python for yourself
- For questions about Gurobi pricing contact sales@gurobi.com or sales@gurobi.de
- End-to-End is available to help evaluate or plan your Gurobi implementation
- For more information about End-to-End Analytics, please contact russell@e2eanalytics.com
- Please view our previous E2E/Gurobi joint webinar: Building the Business for Optimization at https://goo.gl/mwV7kY
- A recording of this webinar, including the slides, will be available in roughly one week