# ESIG Forecasting/Markets Workshop

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GUROBI
OPTIMIZATION

The World's Fastest Solver

# Are You Solving the Right Model?

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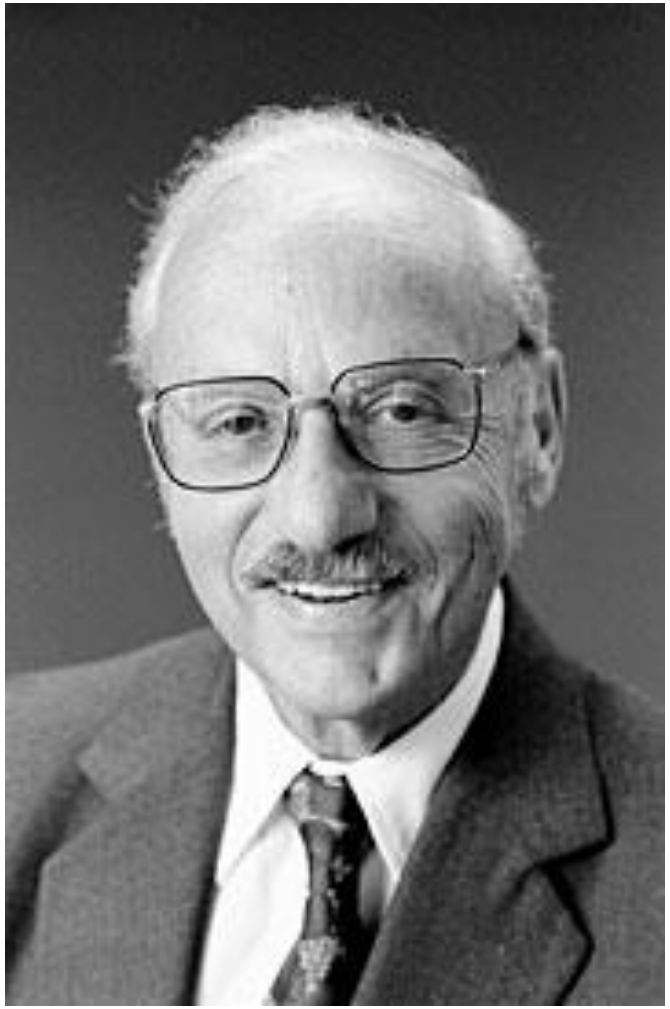
- Rare for optimization model to solve the ‘right’ problem
  - Always some simplifications
- Important to periodically step back and consider the current context

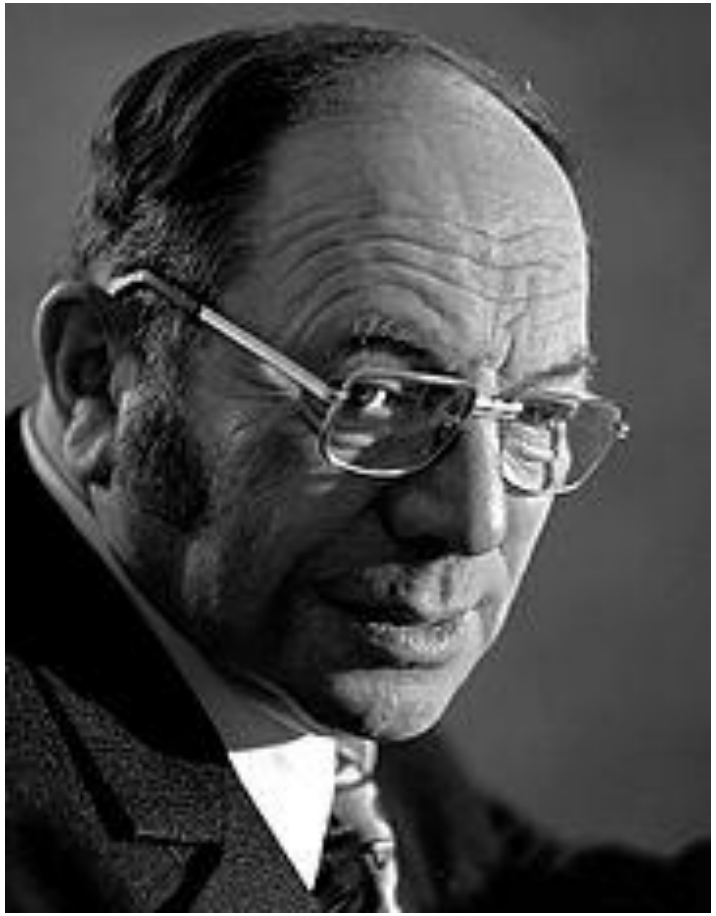
# Choosing the Appropriate Optimization Grain

- George Dantzig – inventor of the simplex method (1946)
- *"At a little bull session at the Pentagon with the Bureau of Labor's input/output team, Marvin Hoffenberg suggested we test [the newly proposed simplex method] on Jerry Cornfield's diet problem. Jerry said that he had worked on the problem several years earlier for the Army who wanted a low cost diet that would meet the nutritional needs of a GI soldier."*



# Choosing the Appropriate Optimization Grain

- Leonid Kantorovich – inventor of linear programming (1939)
- *The Mathematical Method of Production Planning and Organization* (1939)
- *The Best Uses of Economic Resources* (1959)



# Perpetual Push-Pull In Nearly Every Industry

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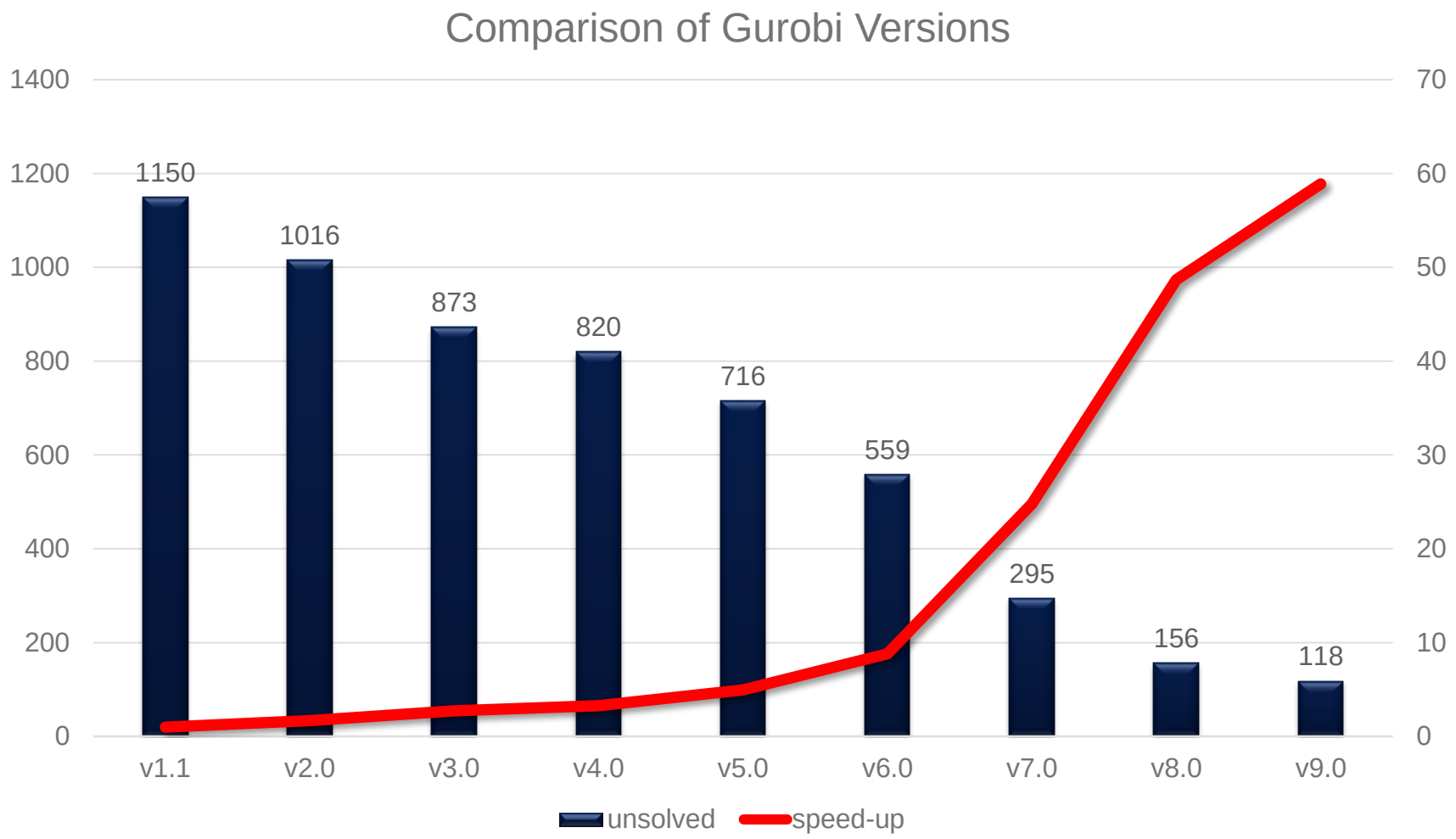
- **Airlines**
  - Split aircraft scheduling from crew scheduling
  - Split maintenance scheduling from aircraft scheduling
  - Split schedule creation from aircraft scheduling
  - Split gate assignment from schedule creation
- **Supply chain**
  - Split production planning from logistics
  - Split production planning from inventory management
  - Limited upstream/downstream visibility
    - The *bullwhip effect*

# Sources of Increasing Demand

- **More detail**
  - Capture complex, detailed behavior
    - Combined-cycle plans
- **More precision**
  - Capture behavior at finer time scales
    - 15-minute dispatch intervals
- **Broader scope**
  - Tighter integration of power and gas markets
- **Uncertainty**

# Improvements in Underlying Technology



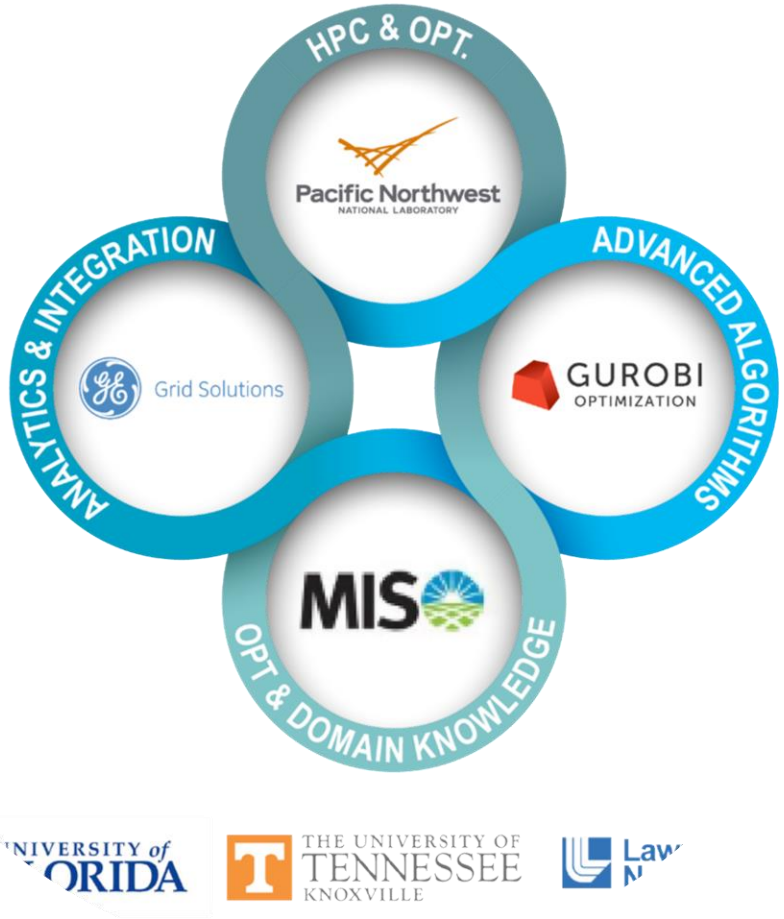
# Improvements in Underlying Technology

- **On 70 MISO test models**
  - Real MISO SCUC datasets
  - 39% average performance improvement in the last year

# Increasing Demand – 15-Minute Dispatch

- Move from 60-minute dispatch interval in SCUC to 15-minute interval
- Roughly 4X increase in problem size
- Growth in runtime?
  - 26X increase in root relaxation solve time
  - 11X increase in time to proven 0.1% optimality gap

# HIPPO Project




- ARPA-E funded project
- A solution framework for day-ahead SCUC based on parallel and concurrent optimization

# Decomposition Approaches

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- **Parallelism opens up a new dimension**
- **Decomposition an 'obvious' source of parallelism**
  - Bender's decomposition
  - ADMM (Alternating Direction Method of Multipliers)
- **Extensive experimentation**

# Decomposition Approaches

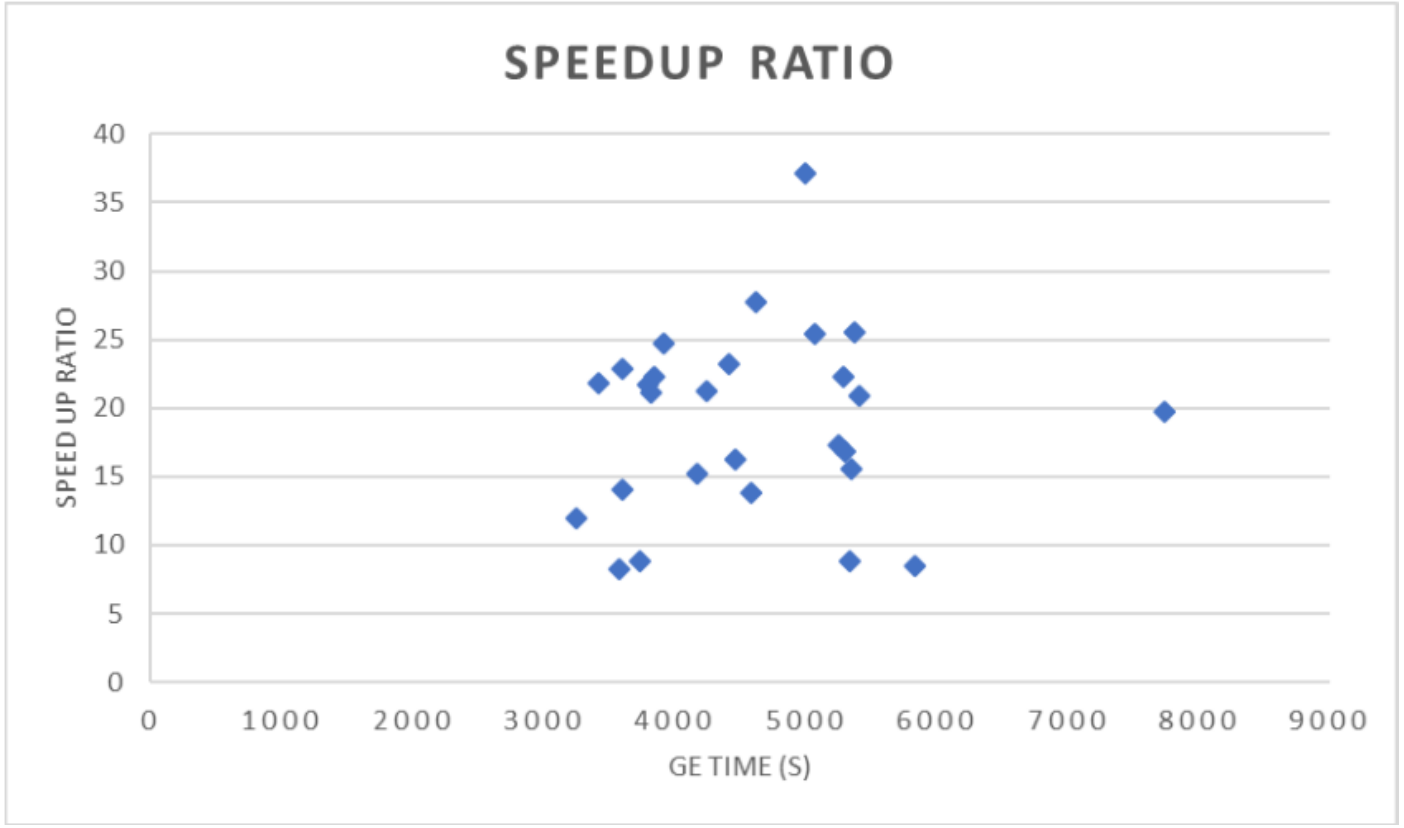
- You have to be an artist
- One clear tradeoff: solution accuracy
  - Traditional tolerance in optimization: 1e-6
  - Challenging tolerance for decomposition: 1e-2
- Decoupling in solution technique must match decoupling in the underlying problem

# Example: SFT in Unit Commitment

- **Simple decoupling**
  - Solve MIP with a subset of transmission constraints
  - Add transmission constraints violated by new solution
  - Repeat

# HIPPO Project – Tighter Integration

- **Undo decoupling (while exploiting parallelism):**
  - ~10X improvement in overall solution time



# HIPPO Project - Heuristics

- Solving the ‘right’ problem?
- Optimization as a toolkit for building domain-specific heuristics