

ESIG Forecasting/Markets Workshop

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GUROBI
OPTIMIZATION

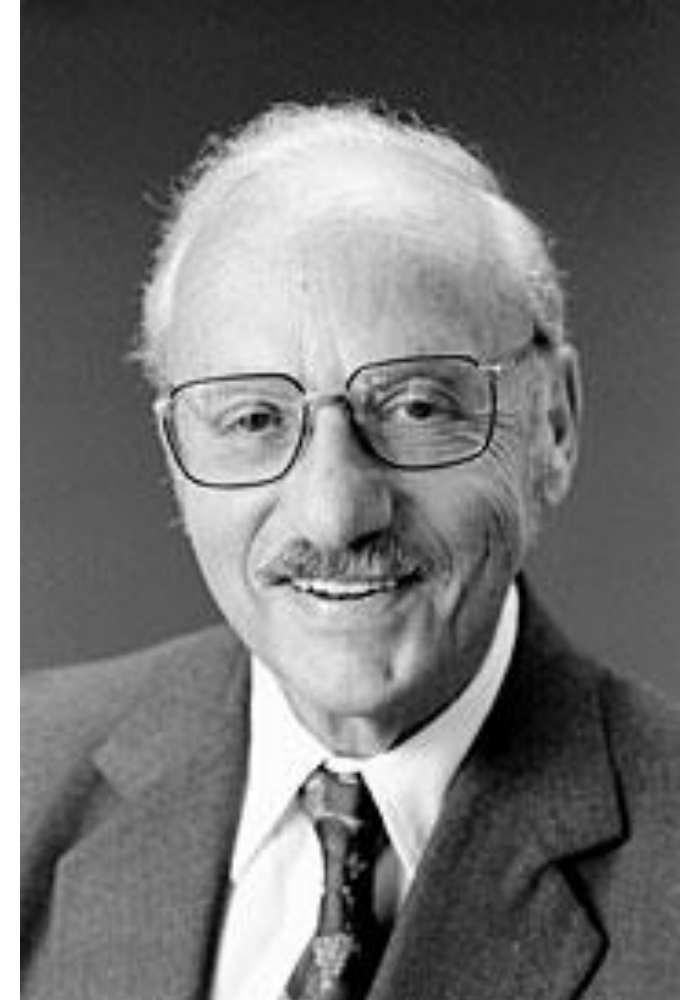
The World's Fastest Solver

Are You Solving the Right Model?

- **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

- **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

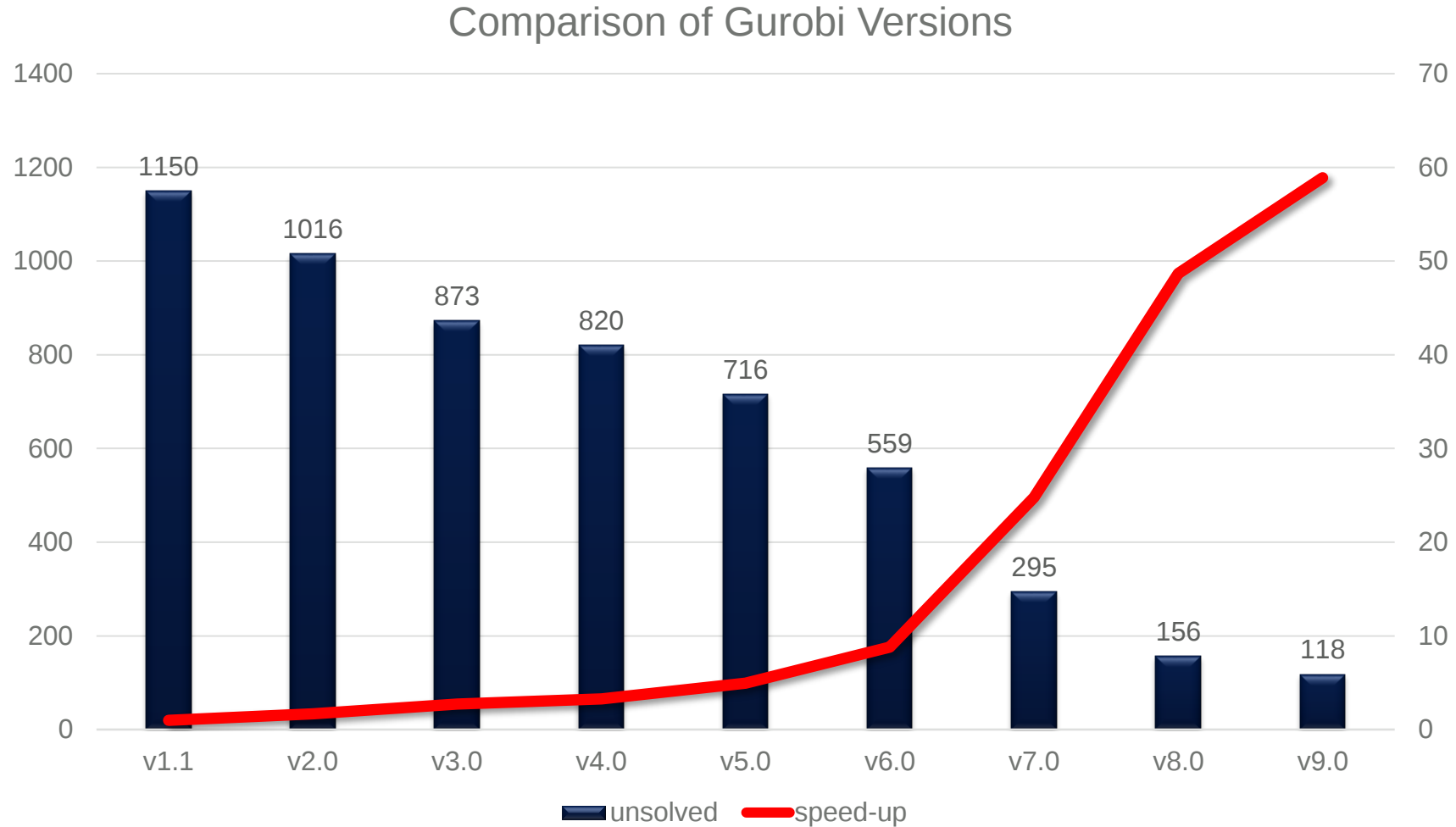
- **Supply chain**

- 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



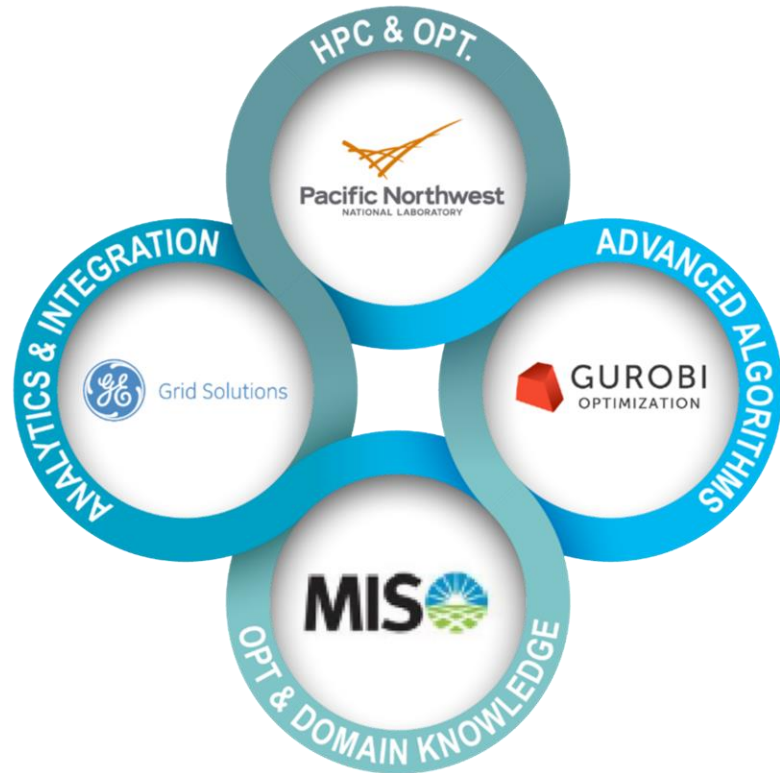
Improvements in Underlying Technology

- **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

- **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

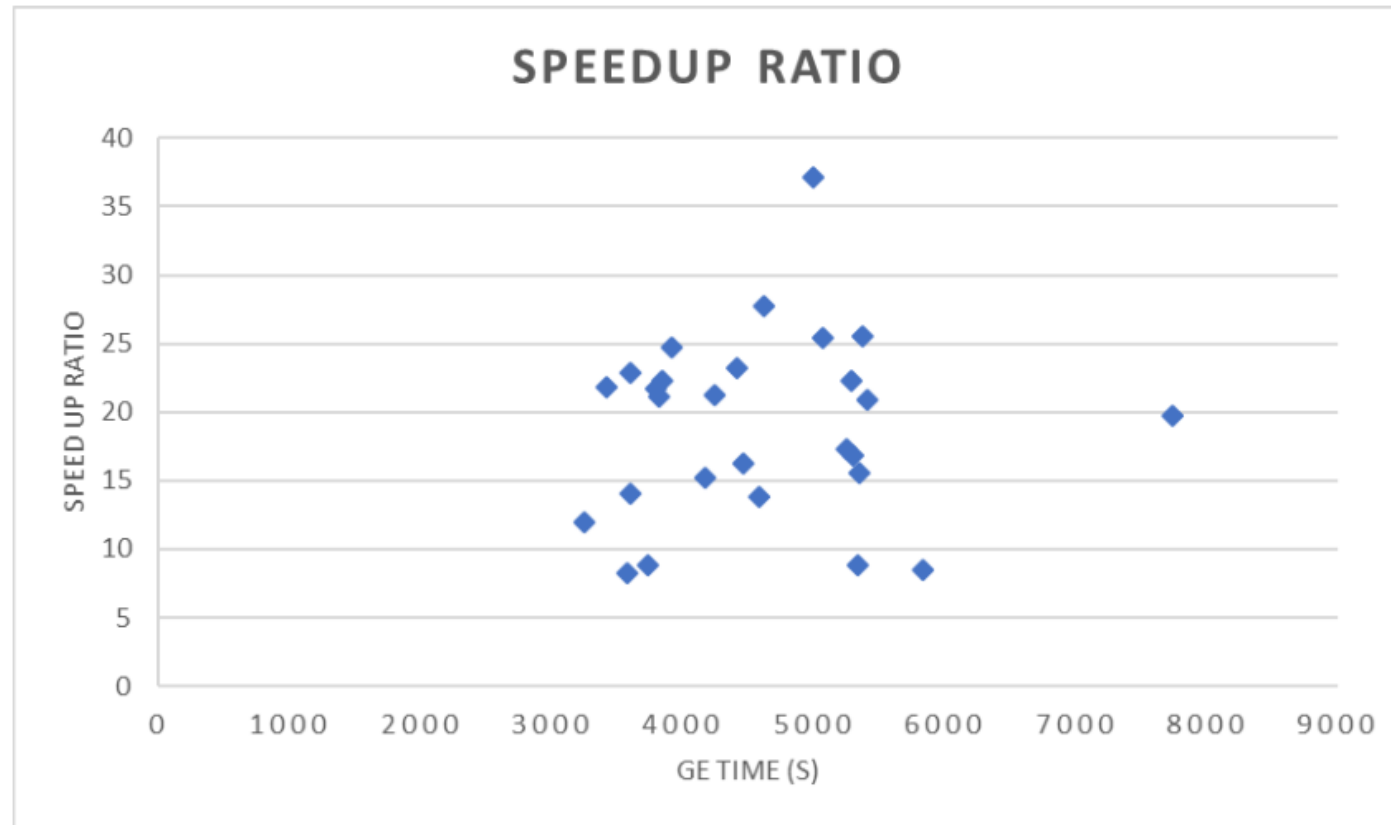


Example: SFT in Unit Commitment

- **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

