Mixed Integer Programming

NYISO Proof of Concept Experience

Matthew Musto

Senior Project Manager

New York Independent System Operator

Muhammad Marwali

Manager, Energy Markets Products

New York Independent System Operator

FERC Technical Conference

June 24, 2013

Washington, D.C.

Overview

- Background and Project Genesis
- Multi-Phased Proof of Concept (POC)
- Iterative Development
- Enabling Prudent Risk Taking

Background

- In 2009, NYISO began looking at alternatives to Lagrangian Relaxation based Unit Commitment (UC)
- MIP quickly became a top contender, as it was already a *de facto* standard among ISO/RTOs
- NYISO uses the same commitment algorithm for both Day Ahead (SCUC) and Real-time (RTC)

First Proof of Concept - 2010

- Developed NYISO UC algorithm in AMPL for our first POC
- Initial results showed similar results to LR with several key issues identified
  - *Performance was comparable to LR with considerable variability[1]*
  - *MIP Gap tolerances large enough to allow timely execution could result in undesirable market outcomes[2]*
  - *SCUC (Day Ahead) and RTC/RTD (Real Time) markets would likely not be able to run in the required timeframes and solution tolerances*

1,2 - See Appendix for References

Second Proof of Concept - Coprocessor

- **Addressing performance was the primary concern stemming from the first POC**
  - ***Unable to migrate an integrated Energy Management System/Market Management System (MMS) to a new hardware platform***
  - ***MMS system ran on hardware which did not offer cutting edge CPU and memory performance[3]***
  - ***Employed a high performance Linux cluster into our MMS to offload computationally intensive tasks (E.g. Unit Commitment)***
  - ***Offloading calculations to x86 Linux servers resulted in >3x performance improvements[1]***

3,1 - See Appendix for References

Confident Enough to Commit

- The first POC indentified both solution quality and performance issues
- The second POC quelled fears of performance being insurmountable
- Two years of additional constraint modeling experience supplied confidence we could improve solution quality
- Late 2012 NYISO formally proposed a project to our market participants for a 2014 implementation

Iterative Development

- Desire to confirm early resolution of known issues
  - *Performance*
  - *Solution quality and consistency*
- MIP/LP solver
  - *Native co-processor solution (low cost, high reliability)*
  - *Comparable performance to other solvers on NYISO model*
  - *Consistently more optimal solutions*
- Modeling enhancements
  - *Constraint modeling improvements with performance as the primary goal*

First Code Drop Results

- **Performance**
  - ***Confirmed MIP performance is greatly improved with the co-processor[4]***
  - ***AMPL time is proving difficult to reduce but options exist***
- **Optimization Quality**
  - ***On average, MIP produces more optimal market solutions***
    - **>$3M a year improvement in total production cost**
    - **>5MW less system losses through optimal commitment of resources**
    - **Increased transparency to market operations**
  - ***Corner case scenarios still present but much better understood and solvable with specific model constraints***
- **Ongoing Efforts**
  - ***Providing necessary feedback to development so that subsequent builds and testing will be productive***

4 -See Appendix for Reference

Ability for Stretch Goals

- **Each POC iteration allowed us to isolate and take risks which we could not have been done under normal circumstances**
  - ***Co-processor architecture was new to NYISO***
  - ***Linux was previously not used internally***
  - ***Multiple MIP vendor evaluations took considerable time***
- **Taking our time allowed technology to mature and in some cases even exist**
  - ***Gurobi now offers a compute server product out of the box which saved significant custom work***
- **Ultimately, the process is providing a better solution for the NY marketplace**
  - ***Lower cost to develop and maintain***
  - ***Version '2.0' features and quality in the initial release***

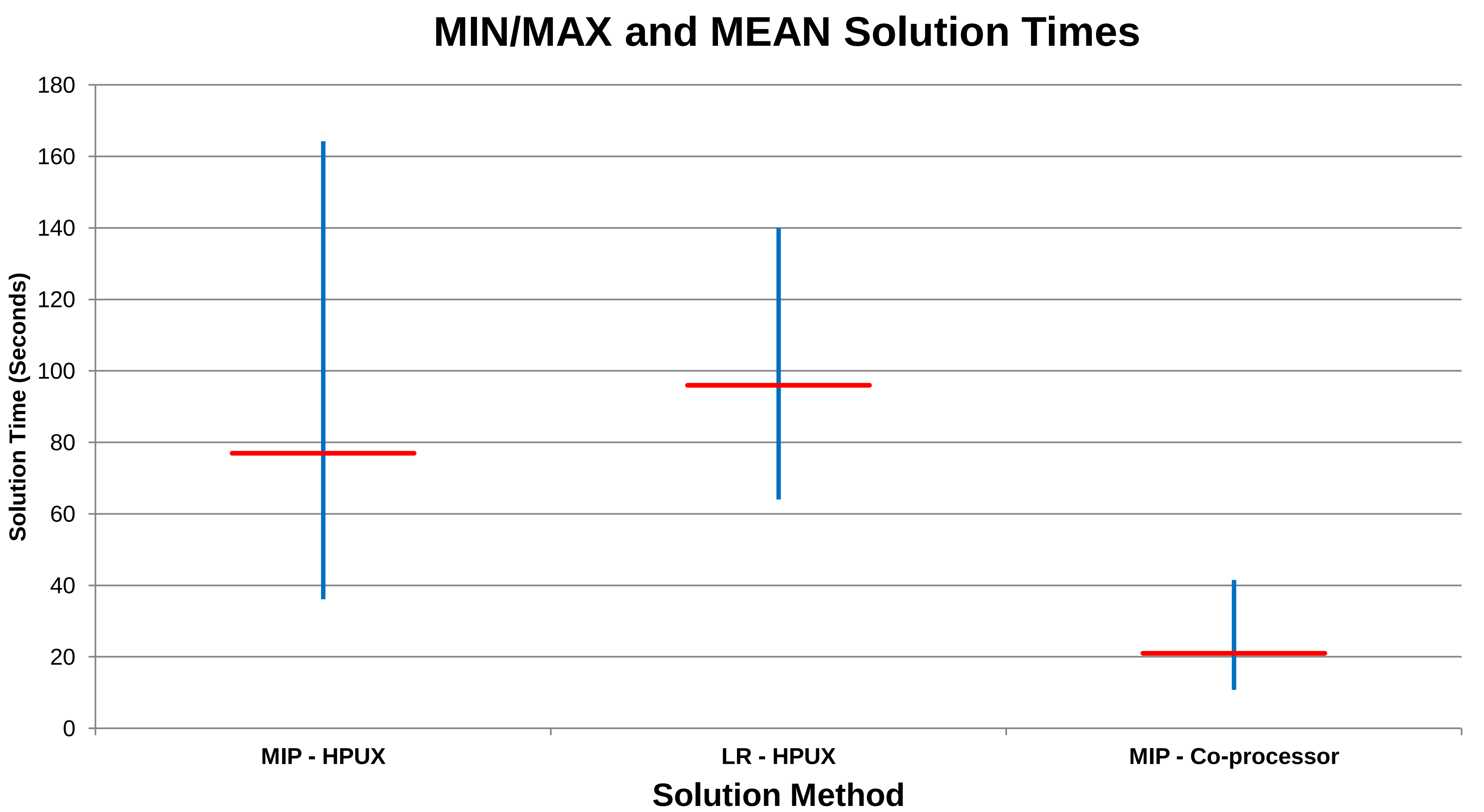
MIP - Opening New Doors

- **Allows faster prototyping of complex modeling and solution methodologies**
  - ***Combine Cycling Modeling***
  - ***Dynamic Reserve Modeling***
  - ***Storage Optimization***
  - ***Disaggregated Virtual Trading***
  - ***UC with Transmission Demand***
- **Plan to go live 2014**

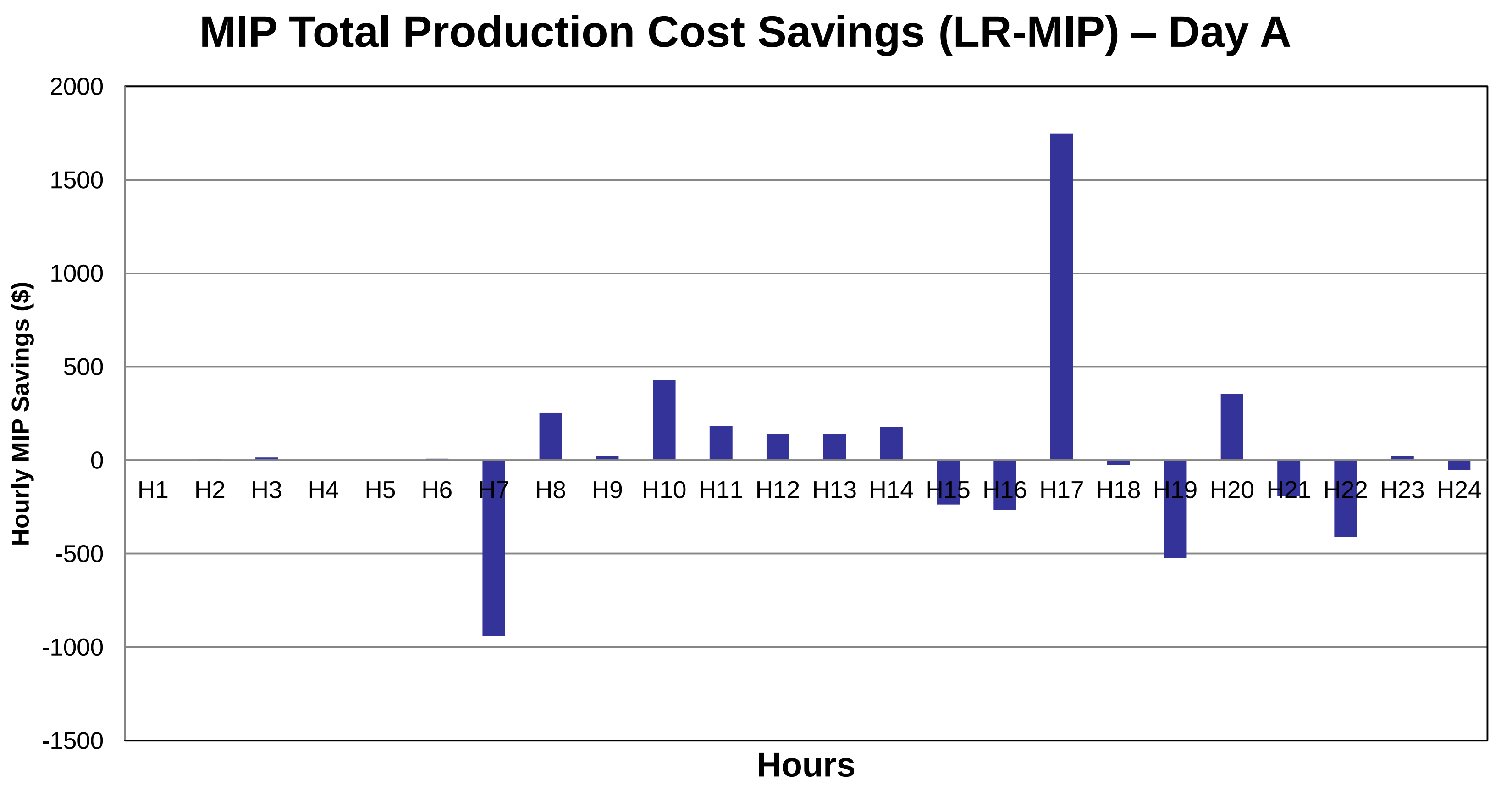
Appendix

References 1-4

Reference 1


MIN/MAX and MEAN Solution Times
Solution Time (Seconds)
180
160
140
120
100
80
60
40
20
0
MIP - HPUX
LR - HPUX
MIP - Co-processor
Solution Method

Reference 2



MIP Total Production Cost Savings (LR-MIP) – Day A
2000
1500
1000
500
0
-500
-1000
-1500
Hourly MIP Savings ($)
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13 H14 H15 H16 H17 H18 H19 H20 H21 H22 H23 H24
Hours

Reference 3

Itanium 9350 SPEC FP = 270 vs. Xeon E5-2690 = 507 (16 cores each)

– Sourced from www.spec.org

Reference 4

LR average is 1.5 minute.

Gurobi solve time is 30-45 seconds.

AMPL overhead is 70 seconds.

– Internal NYISO testing

The New York Independent System Operator (NYISO) is a not-for-profit corporation responsible for operating the state's bulk electricity grid, administering New York's competitive wholesale electricity markets, conducting comprehensive long-term planning for the state's electric power system, and advancing the technological infrastructure of the electric system serving the Empire State.

www.nyiso.com