Natural Gas Adaptive Scheduling

for
Client Pipeline

Peak Energy Solutions, Inc.

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Solutions, Inc.

Overview

- Introduction to Peak Energy Solutions, Inc.
- What is Natural Gas Adaptive Scheduling (NGAS)?
- NGAS Implementation for Client Pipeline

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Highlights

- Provides fast-running, customized, gas scheduling software
- 26 years of experience in natural gas scheduling and process optimization
- Familiar with NAESB/FERC and a wide variety of pipeline business rules

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Current Customers

- Northwest Pipeline
- Kern River Gas Transmission Company
- Texas Gas Transmission
- Gulf South Pipeline
- Southern Star Central Gas Pipeline

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Principal Associates

- **Steve Hoyle, Ph.D. Stanford University**
  Mathematical Programming
  Used AMPL/CPLEX for large-scale transportation
  First used AMPL/CPLEX in natural gas scheduling in 1994
- **Deb Parker, M.S. Stanford University**
  Operations Research
  Experience in natural gas scheduling since 1997
- **Andrew Hoyle, B.S. University of Colorado**
  Computer Science & Engineering, and Music Education
  Experience in natural gas pools and mapping since 2011

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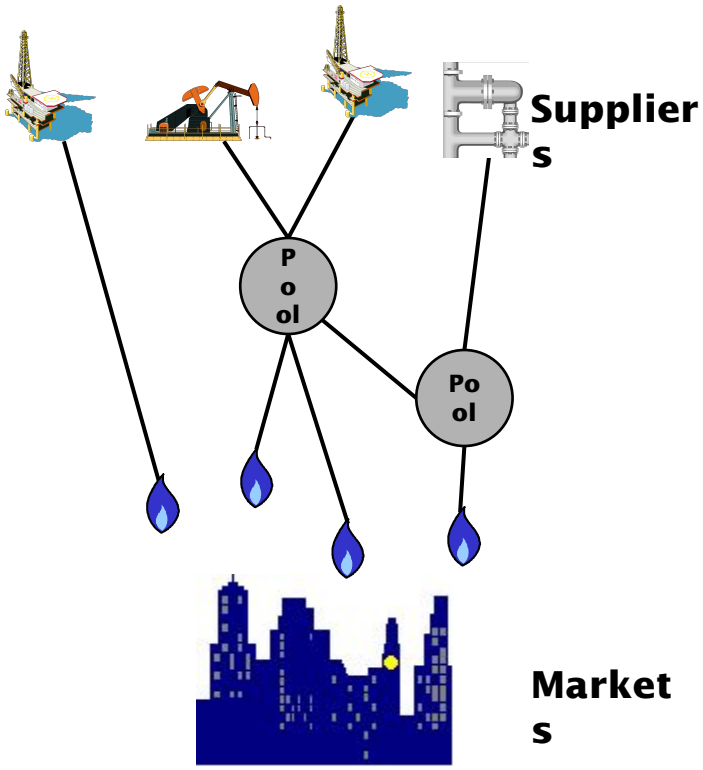
Natural Gas Networks

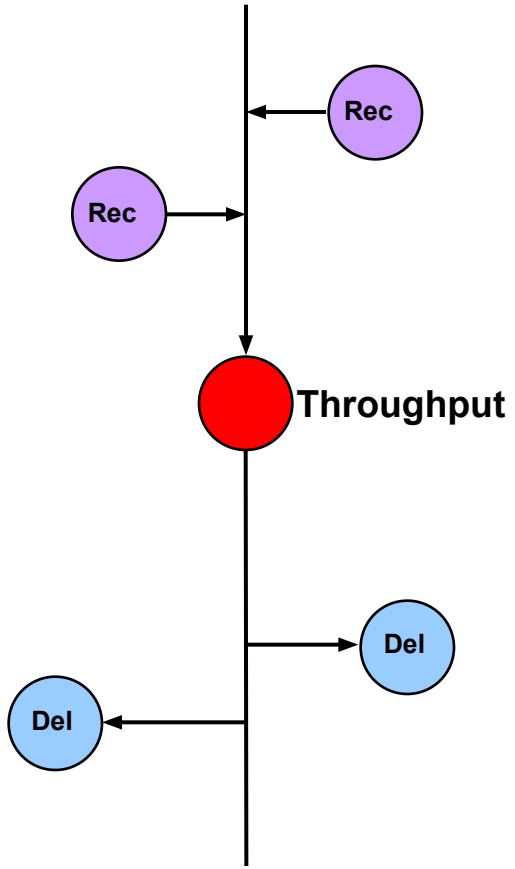
Ownership View

- Gas ownership transitions from upstream supplier, through pipeline (including pools), and to the downstream market.
- Total gas flow is determined by supply/ demand in accordance with tariffs, laws, regulations, and agreements.



Physical View

- Capacity limits at receipt, throughput, and delivery locations are enforced.



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What is NGAS?

- **N**atural **G**as **A**daptive **S**cheduling
- A scheduling engine that interfaces with your system to provide optimal scheduling solutions
- Uses state-of-the-art optimization methods
- Implemented with powerful AMPL/CPLEX linear programming software – essential for large, complicated pipelines
- Runs on PC or UNIX platforms (and on the Cloud)
- Most effective when used to perform all scheduling adjustments (cuts)

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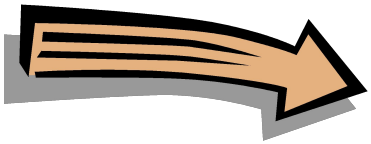
Advantages of Using NGAS

- **Outperforms industry running times: typical run times of seconds to a few minutes depending on pipeline complexity**
- **Cost effective: full-time AMPL/CPLEX developers are not needed**
- **Higher pipeline throughput via unique "reinstatement" optimization step**
- **Handles displacement automatically**
- **Many business rules are data-driven (such as Priority of Service for capacity cuts, number and length of cycles)**
- **Client Pipeline owns the customized code**

Traditional Scheduling

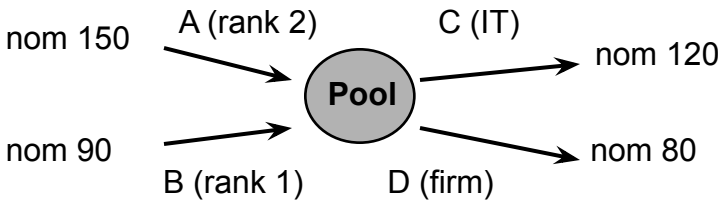
- "Double cuts" decrease throughput
  - Always occur when sequential cuts are made
  - Result from physical and ownership cuts
- Ineffective use of displacement gas decreases throughput



NGAS Increases Throughput

- Automatically uses displacement gas
- Detects slack in schedule created by earlier cuts
- Uses this slack to reinstate gas on double-cut noms/contracts without violating any constraints

NGAS Avoids "Double Cuts"



RULES

- **Pool Balance: Flow in equals flow out**
- **Operator: Physical or contractual**
- **Capacity: Physical limitation**

SEQUENTIAL APPROACH

		A	B	C	D
1.	Pool Balance: Cut A to 110	110	90	120	80
2.	Operator: D is above limit by 10 so cut it to 70 then also cut A by 10 more	100	90	120	70
3.	Capacity: B is over by 20 so cut to 70 and, since D is firm, cut C by 20	100	70	100	70

ADDITIONAL NGAS STEP

4.	By considering all constraints simultaneously, SE recognizes 'slack' created by double cuts and reinstates 20 to noms A and C	120	70	120	70

Traditional Results

170 Throughput

NGAS Results

190 Throughput

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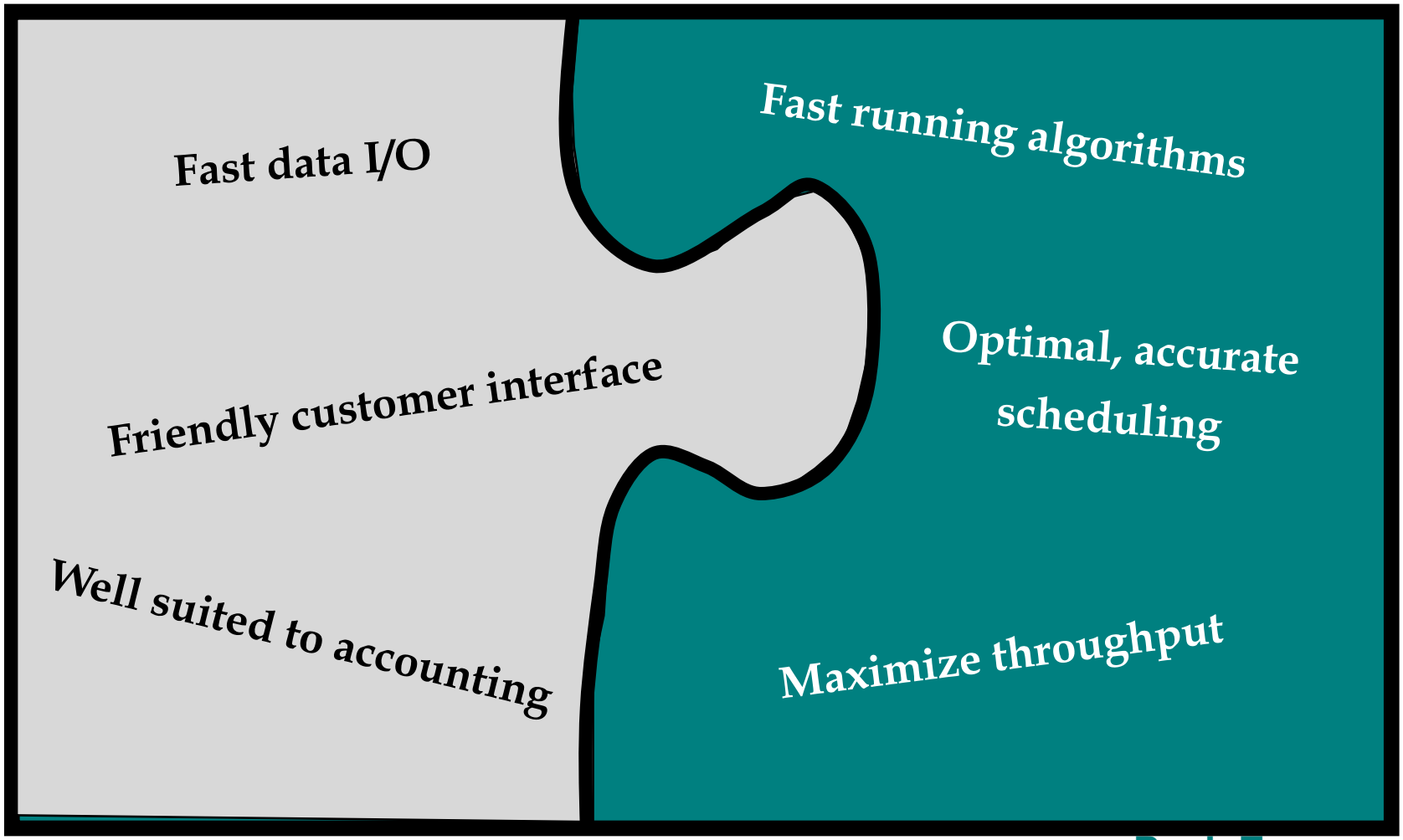
Client Pipeline and NGAS work together



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NGAS and Client Pipeline System Integration

- **Client Pipeline System**
  - Gathers and stores information (contract data, nominations, etc.)
  - Provides input data to **NGAS** using flat files or ODBC
- **NGAS sequentially determines and labels cuts with accurate reason codes**
  - Cuts are passed to database via **NGAS** output files
  - Reinstatement “cuts” are labeled as such
  - **NGAS** provides outputs (by nomination, contract, point, etc.)
- **Client Pipeline System uploads output files**
  - Updates database tables
  - Prepares outputs and reports for display to end-users

NGAS Implementation Highlights

- Several initial pool balancing and rebalancing methods available
- Modularity facilitates maintenance, such as changing the cut order
- Capacity techniques make verification and explanation of cuts much easier
- Previously scheduled amounts protected at contract or nomination level, or can be cut
- Implements complex, customized segmentation rules

Notional Implementation Sequence for Client Pipeline

- Develop software requirements
- Describe database/Cloud interface
- Build NGAS model
- Run test sets for verification of results
- Provide support as needed

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AMPL and CPLEX on the Cloud

(excerpt from AMPL)

PLATFORMS

Computers and Operating Systems Supported by AMPL

AMPL is available for many popular combinations of computer and operating system, as shown in the table below. Both 32-bit and 64-bit architectures are supported as appropriate. If a platform you want to use is not listed, let us know; we may be able to build you a version.

Platforms listed in bold are also supported for all solvers available directly from us. Please contact us for availability of these solvers on other listed platforms. Information on supported platforms for other available solvers is available from their listed developers or distributors.

Computer/Processor	Operating System
Apple Macintosh / Intel	**OS X all versions**
IBM Power Systems	AIX
IBM Power Systems	Linux
Intel Itanium	Linux
Intel x86/x64 or compatible	**Linux all versions**
Intel x86/x64 or compatible	Solaris
Intel x86/x64 or compatible	**Windows all versions**
Sun SPARC	Solaris

AMPL and CPLEX on the Cloud

The same licensing works in the cloud as in other situations, if the following machine characteristics (as seen by AMPL and CPLEX) do not change:

- hostname
- MAC address
- C drive label (Windows only)

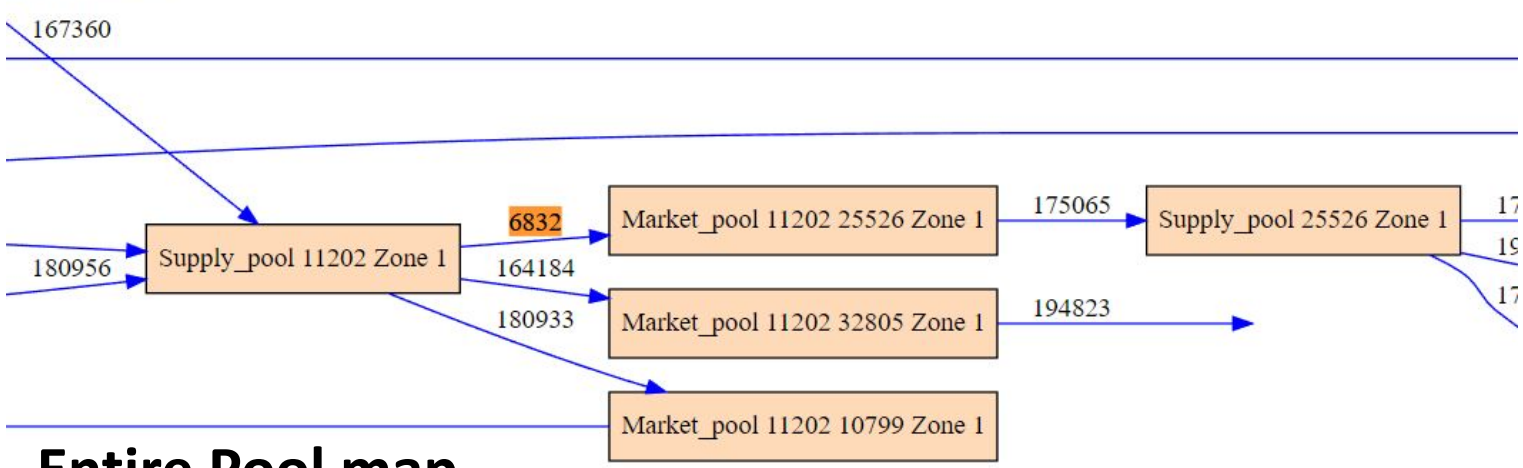
For example Google's cloud service offers fixed machine characteristics, and we have used it a number of times for testing.

If the observed machine characteristics will change frequently, then our sales team can offer other licensing possibilities. In this situation we have a lot of flexibility for AMPL, but will need to take greater care with CPLEX in order to stay within IBM's requirements."

- excerpt from AMPL

Mapping Examples

- Scalable Vector Graphics files using a 2-dimensional arc de-confliction routine built on the Cloud (herokuapp.com but can be hosted elsewhere)



- Entire Pool map

- Receipt location cut with alternate flow

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Summary

- **Peak Energy Solutions, Inc. has been providing highly customized gas scheduling software and personalized support for 26 years**
- **We not only implement our customers' requirements; our expertise allows us to help customers define/refine requirements**
- **NGAS provides fast, optimized scheduling solutions that maximize pipeline throughput while meeting all your business rules**

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