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Network Flow Relaxations for Batched Transportation Models

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Network Flow Relaxations for Batched Transportation Models

- Description
- Application
- Research
- Implementation
- Conclusion

Batched Transportation Models (BTM)

- One focus of the thesis from my Master’s program – Batched Transportation Management
- Think traditional transportation model
- Additional Restrictions
  - Supply capacity is volumetric.
  - Assignments are by batched volume.
- Generalized Assignment Problem (GAP) is a special case of BTM.

Application- Water Disposal

- Disposal facilities have large capacity – limited resource.
- Production locations have small inventory capacity.
- Trucked transportation used to deliver water.

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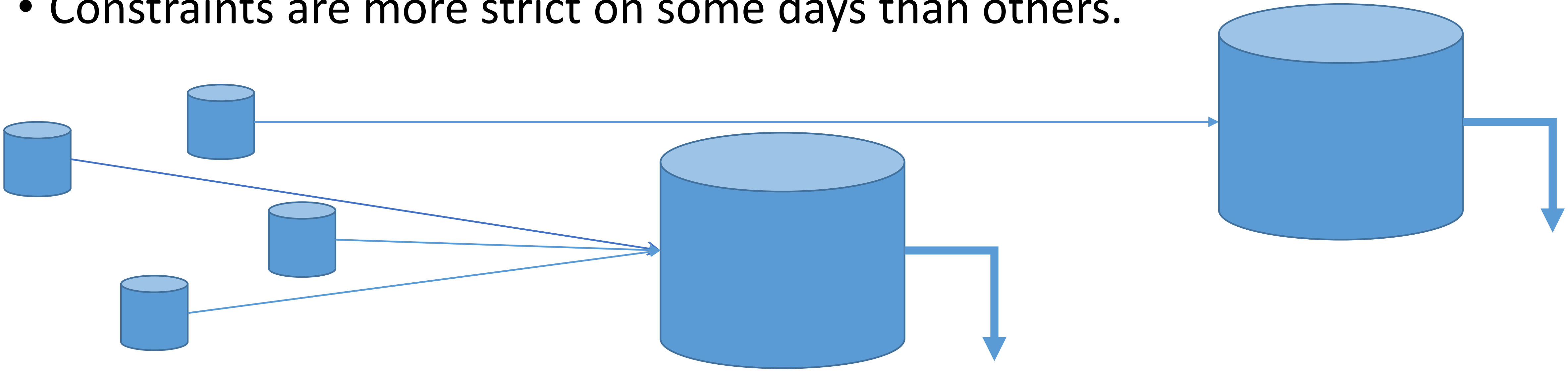
Application- Water Disposal

- Process requires quick decision, despite execution the next day.
- Hauling resources are contracted.
- Site inventories highly stochastic.
- Constraints are more strict on some days than others.



Possible Solution Methods

- Goal Programming
  - Adjust capacity constraints to make problem immediately feasible.
  - Seek lower objective through penalized constraint padding.
- Network Flows
  - Meets performance requirement.
  - Doesn’t handle assignment and capacity constraints at the same time.
- LP Relaxation
  - Meets performance requirement.
  - Rounding is messy.

Network Flow Relaxation

- Small violations of capacity constraints can be ok.
- Has quick execution.
- Network flows with relaxed capacity constraints gives the right combination.
- Treat all loads as the same size.
- Sum all added volume, then increase capacity constraints by this amount.

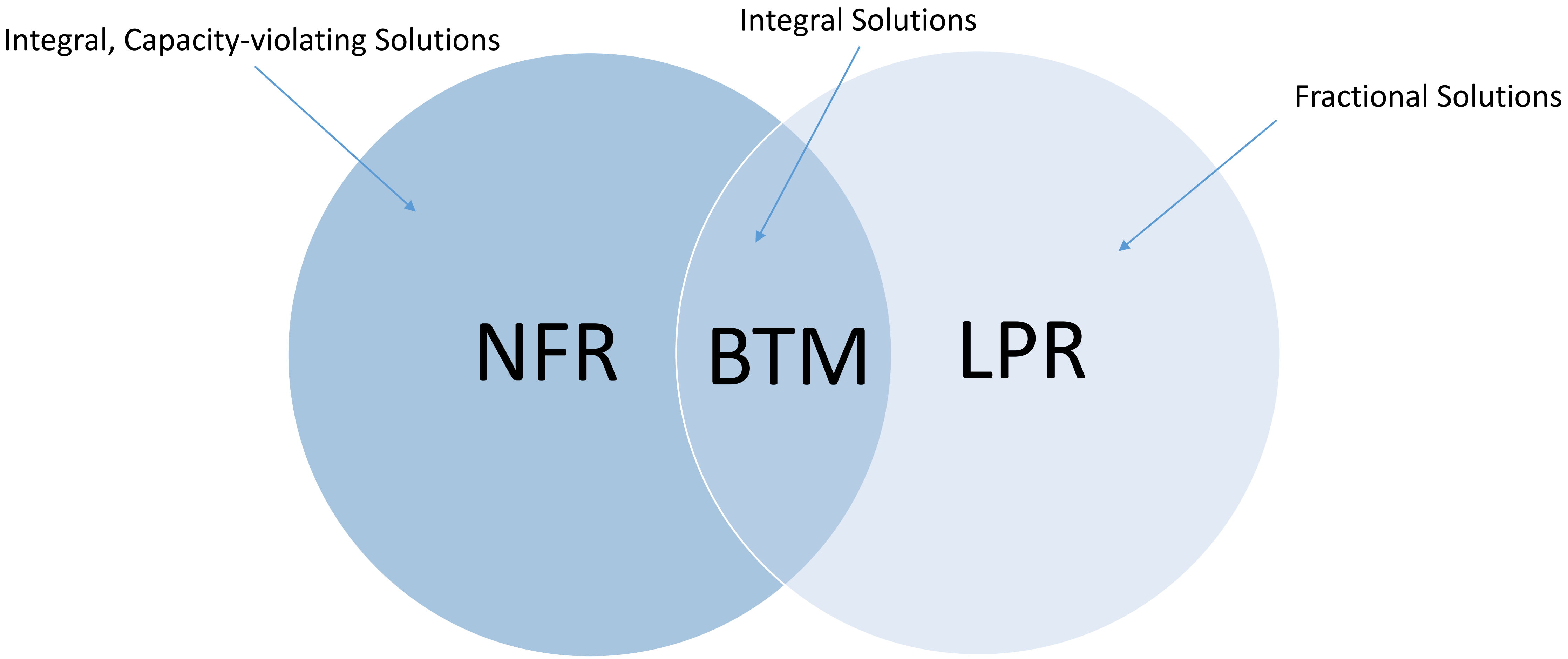
Transform BTM to NFR

$$
\begin{aligned}
\underset{x,z}{\text{minimize}} \quad & \sum_{i\in B}\sum_{j\in C}\sum_{k\in D} c_{ijk} z_{ijk} & \\
\text{subject to} \quad & \sum_{i\in B}\sum_{j\in C} x_{ijk} \le u_k & \forall k \in D \\
& \sum_{j\in C}\sum_{k\in D} x_{ijk} = r_i s_i & \forall i \in B \\
& z_{ijk} s_i = x_{ijk} & \forall i \in B, j \in C, k \in D \\
& z_{ijk} \text{ integer} & \forall i \in B, j \in C, k \in D
\end{aligned}
$$

$\Rightarrow$

$$
\begin{aligned}
\underset{z}{\text{minimize}} \quad & \sum_{i\in B}\sum_{j\in C}\sum_{k\in D} c_{ijk} z_{ijk} & \\
& \sum_{j\in C}\sum_{k\in D} z_{ijk} = r_i & \forall i \in B \\
& \sum_{i\in B}\sum_{j\in C} z_{ijk} \le \frac{u_k + \sum_{i\in B} \delta_i r_i}{\hat{s}} & \forall k \in D \\
& z_{ijk} \text{ integer} & \forall i \in B, j \in C, k \in D
\end{aligned}
$$

Solution Diagram



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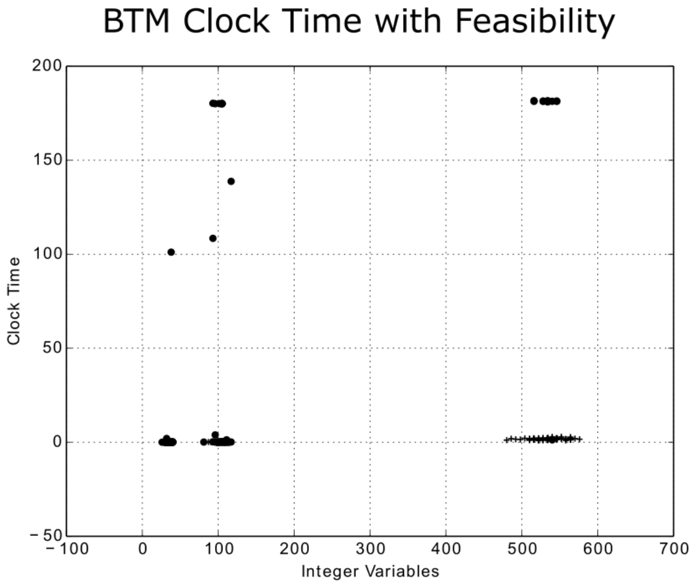
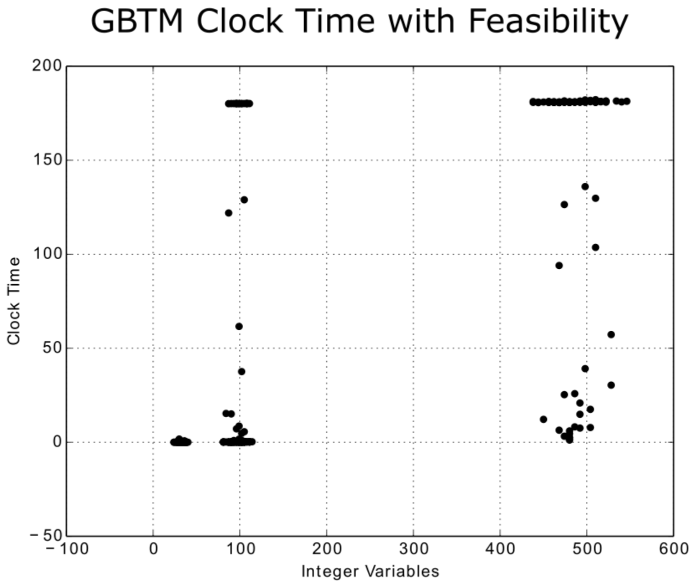
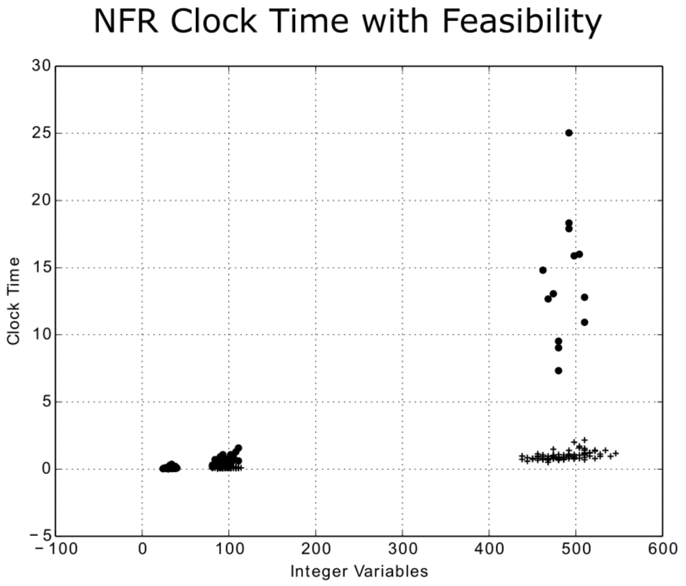
Instance Results- Execution and Variables by Model







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Implementation

- Operator in DJ Basin, Colorado
- 4000+ Producing Locations
- Seven to Eight Disposal Locations
- Iterative approach to the problem started with defining metrics around costs and objective; led to implementing an optimization tool that increased operational efficiency.

NFR Conclusions

- High performance option to work a difficult problem.
- Wide variety of steps to narrow solution space.
- Optimization tool wasn’t the only contribution that helped operations.

Thank you!

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