Polymathian

Industrial Mathematics

Optimisation Simulation Analytics

Applied Mathematics

Resources Logistics Maritime

Industry Expertise

Hosted On-premise Consulting

Bespoke Solutions

Steven Donaldson
Jackson Richards

Content

- What does Polymathian do?
- The Polymathian tech stack and tool kit
- Example Projects

- Casual work and summer scholarships

Who is Polymathian?

1. Niche consulting and hosted software development company
2. Specialise in solving difficult numerical optimisation problems for industry
3. Specialise in cloud computing
   - Built a cloud based optimisation platform
   - Runs all of our deployments
4. Based in Brisbane (founded 2012)
   - 12 staff

Who are we?

- Jackson Richards
  - Polymathian Optimisation Consultant
  - Bachelor of Engineering, Mechanical Engineering, UQ
  - Bachelor of Science, Mathematics, UQ
- Steven Donaldson
  - Partner
  - Master of Science, Management Science, Operational Research, LSE
  - Bachelor of Mathematics, QUT
  - Bachelor of Information Technology, Software Architecture, QUT

What does Polymathian actually do?

- How do you schedule an airline for the next 3 months?
  - Maximise profit?
  - Minimise cost?
- You have a green field and information about what is underground, how do you mine it?
  - Maximise present value?
  - Maximise mine duration (capture price uncertainty)?
- Generate the team, location and referee schedule for the NFL
  - Just find any solution that satisfies all the rules?

Polymathian solves optimisation problems

- These are known as *optimisation* problems
- Characterised by an objective and set of possible decisions
  - The set of all possible decisions is prohibitively large
- Field of mathematics known as *operations research*
  - Originated during World War 2
- Polymathian develops web-hosted tools which solve these problems for industry

The Polymathian tech stack principles

1. Open source (where possible)
   - Leverage the work of other people
2. Free or subscription based
   - Collaboration (Atlassian, Slack)
   - Third party solvers
   - Hardware rental (Amazon AWS)
3. Heavily used with large community
4. Modern
   - Tech stacks date extremely quickly
   - No VBA!
5. Cross platform
   - Half staff use Windows, half Ubuntu
   - Deploy using Ubuntu

Programming languages

Web Servers / Business Logic Layer

Optimisation Engines

Client Side

Frameworks and libraries

Web Servers

Pyramid™
SQLAlchemy
C
@asynchronous_task

Optimisation Engines

COMPUTATIONAL INFRASTRUCTURE FOR OPERATIONS RESEARCH
COIN|OR
GUROBI
OPTIMIZATION
Σ
IBM
ILOG
Changing the rules of business™

Client Side

Knockout.
Bootstrap
GOOGLECHART
Leaflet
jQuery
write less, do more.

IDEs and source control

Python IDE

PyCharm

C++ IDE / Tools

Visual Studio

Source Control

Atlassian Bitbucket

mercurial

TortoiseHg

git

Atlassian SourceTree

Collaboration

File Sharing

Dropbox

Documentation / Bug Tracking

JIRA

Confluence

SPHINX
PYTHON DOCUMENTATION GENERATOR

Office Productivity / Project Management

slack

Trello

Deployment: hardware, software

amazon web services™

CloudWatch

SQS

SNS

ELB

KMS

EBS

VPC

EC2

RDS

S3

Alarm

Management Console

IAM

Devops

docker

SALTSTACK

Databases

SQLite

PostgreSQL

Tropofy is Polymathian’s custom framework

Tropofy

A Platform for Problem Solvers

www.tropofy.com

- Licensed Python toolkit for rapidly developing and deploying web applications
- Requires developer key to run (email us for one)
- Allows user to configure commercial grade hosted business applications without needing knowledge of web servers, databases, client side scripting, task synchronisation
- One of our key competitive advantages
- Can produce a fully functional online workflow in hours

Example Projects

Multiple Domains

We have experience applying mathematical optimisation in a range of domains

- Mining (Planning, Scheduling, Operations)
- Rail Operations (Rolling stock optimisation, Bulk, Freight and passenger crew scheduling and rostering)
- Port Operations Optimisation (Operational Planning)
- Transportation Logistics and Network Design (Air, Rail, Sea, Road)
- Manufacturing (Machine Scheduling and Operation)
- Traffic Management (Signalling and Routing)
- Telecommunications (Network Construction and Maintenance)
- Utilities (Power pricing, Water Network Management)
- Education (Timetabling, Class Construction, Teacher Transfer)
- Finance (Electronic Trading, Portfolio Optimisation)
- Sport (Draw Construction, Venue Scheduling)
- Politics (Market Segmentation)

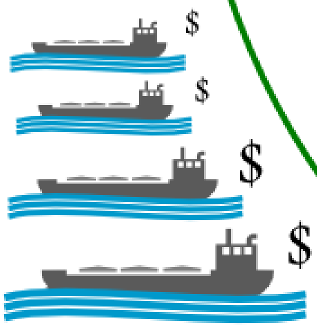
Example Time-Horizons

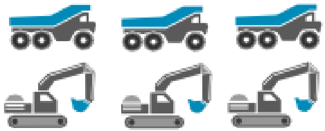
We have experience applying mathematical optimisation over a range of time horizons

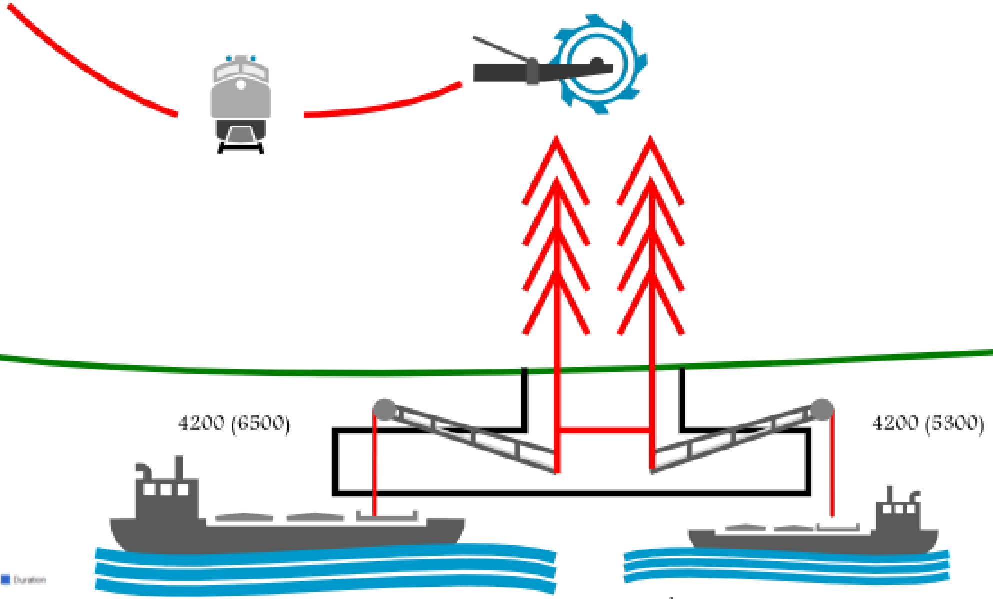
- Real-Time
  - Underground loader dispatch
- Short Term
  - Rail Schedules
  - Pit to Port Supply Chain Optimisation
  - Ship berthing and loading optimisation
- Medium/Long Terms
  - Pit to Port Supply Chain Optimisation medium term planning
- Strategic
  - NPM Optimisation (SLC, Bauxite)

Client example - Port operation scheduling

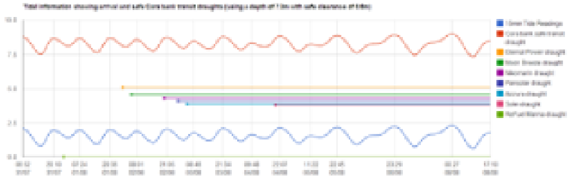
Simultaneously determine the best berthing sequence and loading strategy to minimise demurrage

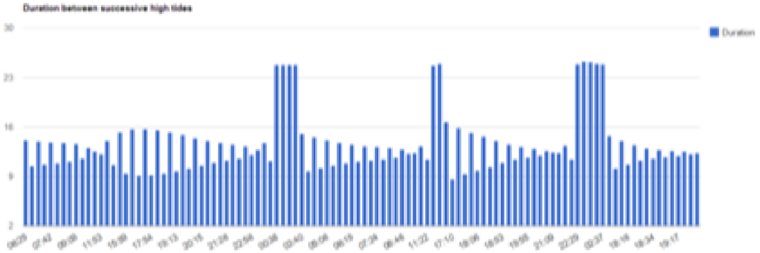






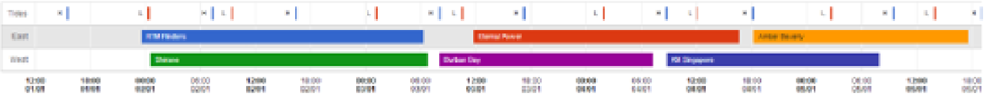
ROB $

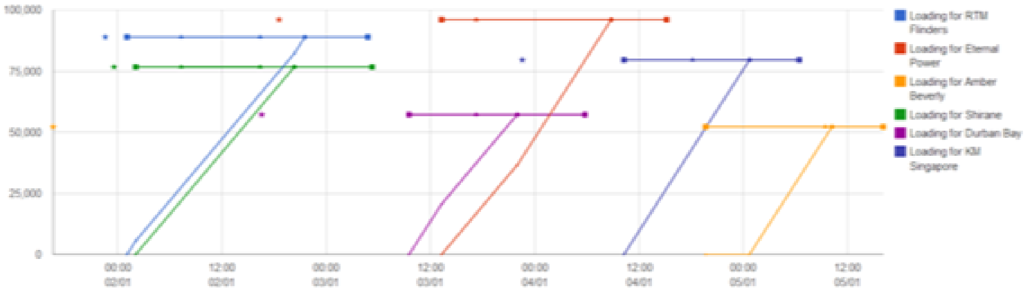




Ability to concurrent load

Vessel Separation, for 'move' types
Tidal Clearance
Turn time (demurrage grace)
Business Priority Vessels
High tide proximity
Other berth order requests





Closures
Reduced Rates
Flood Tide Berthing Only

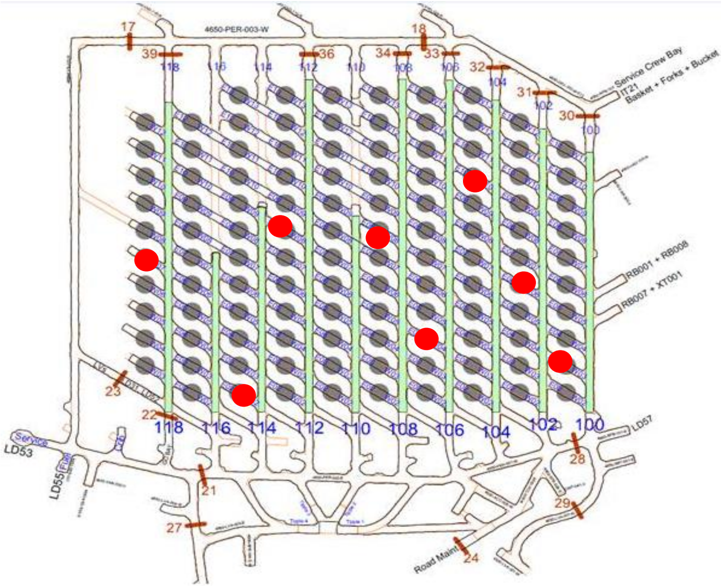
How did we solve the problem?

- Understand the problem
  - Extensive consultation with the customer to convert the real world rules into mathematics
- Convert the mathematics into code
  - Develop an optimisation engine (C++) which is able to solve the problem in a meaningful amount of time (minutes)
  - Utilise *mathematical programming* approach (a field of computational mathematics)
- Develop GUI iteratively with the end-user (possible with Tropofy framework)

The results

- Direct improvement of millions of dollars per month in reduced costs
- Indirect improvement of time saved which converts to more ship movements

Client example - Real-time underground fleet dispatch



The Problem

Objective (weighted combination of)

- Matching capacity of underground MHS using the fleet as efficiently as possible
- Ensuring smoothed progression towards monthly targets
- Grade smoothing

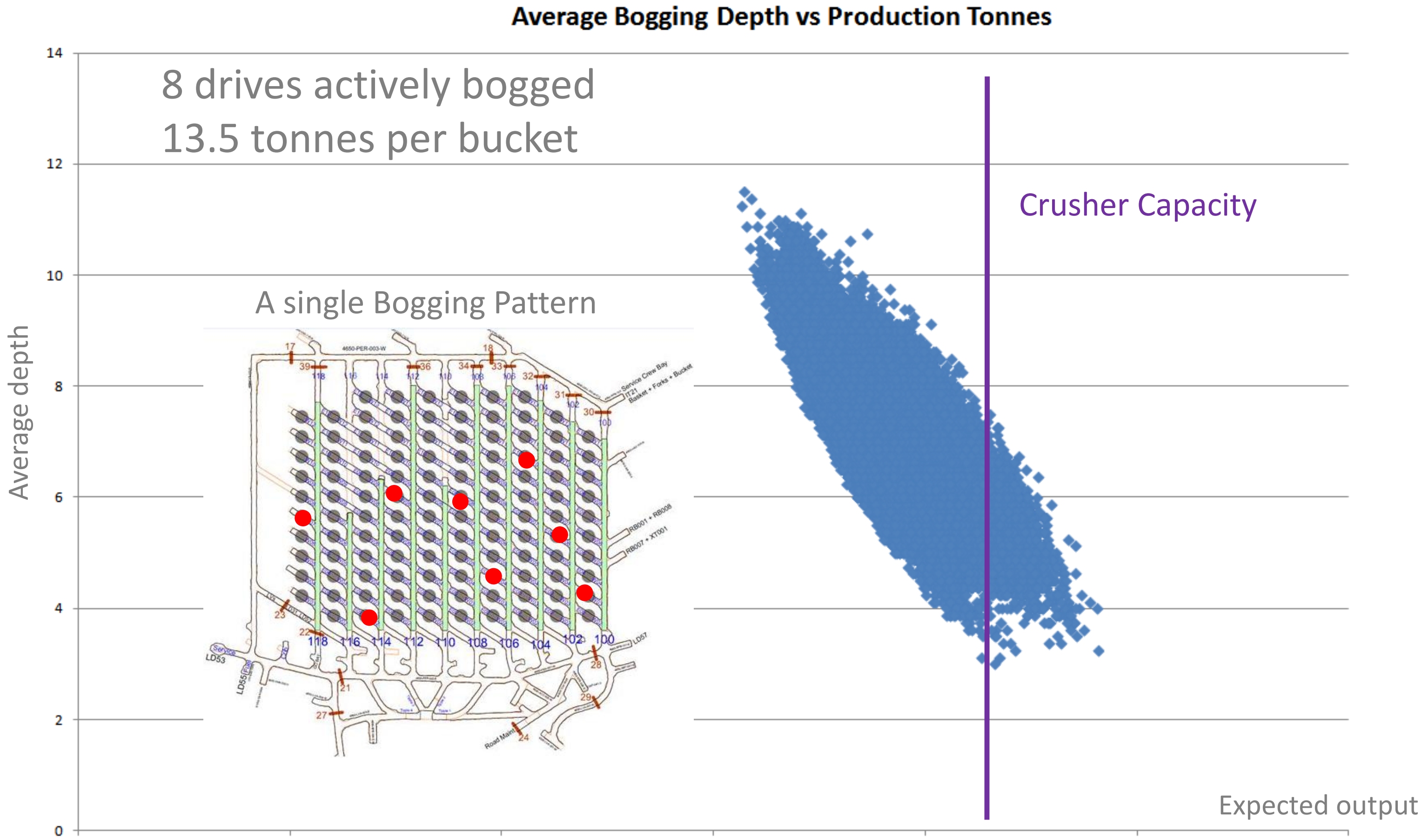
Decisions

- Bogging Patterns

Constraints

- Draw point constraints
- Available fleet
- Grade variance
- + more

Matching MHS



8 drives actively bogged
13.5 tonnes per bucket

8 drives bogged with 12 draw points active: 12^8 ~ 430,000,000 **bogging patterns**

How to handle the number of decisions?

How did we approach the problem?

- Shift-start tool
  - Start small – focus on the maths
  - Prove value-add
  - Delay IT integrations
- Real-time tool
  - IT Integrations
  - Simple interface
  - Radio communication
- Enhanced GUI’s
  - Multiple users (roles / views / etc)
  - Custom real-time data capture

ORB Demo

The results

- Direct improvement of 8% increase in tonnes (thousands of tonnes per day)
- Increased Compliance
- Reduced Radio Traffic (safety)
- Move to continuous planning (Changed mode of thinking)

Working at Polymathian

- Casual work – we are always looking for staff
  - Require at least 16 hours availability per week
  - Excellent communication and interpersonal skills are a must
  - Python, JS, C++ experience (in that order) will set you apart
  - Great place to work! (Ski trip last January)
- Summer scholarships
  - We have taken on summer scholars for the past 3 years
  - Previously through the maths department
  - Stay tuned
- Stay in contact with us
  - That’s how I ended up at Polymathian

What is a good workplace?

1. Friendly, highly skilled workmates
   - Being the smartest person in the room at 20 years old means you are in the wrong room
   - Learn skills from other people with experience
2. Freedom to solve problems as you want to
   - Avoid micromanagement
3. Find interesting work content (project based)
   - Avoid designing only door handles for 40 years
   - Project based work can be good as it is varied and will develop different skills
4. Learn transferrable skills
   - Becoming an expert in a dying language is borrowing time from your future!

Questions?

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