Quantum Applications
Transportation and Manufacturing

Yianni Gamvros - Global Enablement Leader, Data Science

Twitter: @YGamvros
Linkedin: linkedin.com/gamvros
December, 2017
## Strategic vs Operational

<table>
<thead>
<tr>
<th>Integration</th>
<th>Manual I/O</th>
<th>Tight Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>Easy to make assumptions</td>
<td>Hard to define all exceptions</td>
</tr>
<tr>
<td>Interaction</td>
<td>Scenarios / What-if</td>
<td>Manual Editing / Schedule Repair</td>
</tr>
<tr>
<td>Solution</td>
<td>Optimality</td>
<td>Feasibility</td>
</tr>
<tr>
<td>User</td>
<td>Business Expert</td>
<td>Operations</td>
</tr>
<tr>
<td>Performance</td>
<td>&gt; Hours</td>
<td>&lt; Seconds</td>
</tr>
</tbody>
</table>

**Strategic Planning**

**Operational Scheduling**

Opportunity for Quantum
Airline Operations
Key Challenges in Travel and Transportation

- Irregular Operations (IROPs)
- Low customer satisfaction
- Variable fuel prices
- Increasing volume of traffic
- Complex regulations
Challenges: Irregular Operations (IROPSES)

Controllable causes
- Plane changes
- Maintenance delays
- Passenger misconnects
- Flight ops delays
- Airport ops delays
- Onboard delays

Uncontrollable causes
- Weather
- ATC
- Security
- Medical

Recoverability Opportunities
~$15-$22 billion USD / Year

- Estimated cost of airline disruptions: 2-3% of revenue
- Total industry revenue: $736B in 2016
- Disruption cost range: $15B-$22B

Source: IATA
Airline Operations

Strategic Problems (Years)
- Schedule / Network Design
- Crew Scheduling

Tactical Problems (Months - Weeks)
- Fleet Planning
- Heavy Maintenance
- Light Maintenance
- Tail Allocation
- Ground Operations

Operational Problems (Real-time)
- Gate / Crew Dispatching
- Routing / Diversions
- Rebooking
- Overnight Maintenance

Irregular Operations
- Equipment
- Crew / Ground
- Maintenance
Light Maintenance and Tail Allocation

Operational Inputs:
- Landing Cycles, Flight Time/Miles, Routing
- List of A Checks
- Hanger and bay availability and capacity
- Locations where a check can be performed
- Skills requirements and availability
- Manpower and Parts availability

Business Decisions:
- Where and when to perform maintenance
- Updated Maintenance Requirements

Operational Inputs
- Maintenance Requirements
- Segment Schedule
- Connection requirements
- Ground times per flight/pair of flights, airport

Business Decisions:
- Updating Routing
**Diversion Management**

**Weather Impact on Airport**
- Reduction in landing capacity

**Business Decisions**
- Divert some of the incoming flights
- Delay some of the incoming flights
- Hold some of the incoming flights

**Operational Inputs**
- Expected reduction in take-off and landing capacity
- Scheduled take-offs and landings
- Remaining flight times and fuel
- Alternative airports
- Hold pattern options
Gate Assignments

24 Hours Ahead Assignment
Gate-Flight Assignments

Operational Inputs
• Flight schedule
• Gate availability
• Gate-Equipment Capabilities
• Proximity constraints
• Gate-Flight preferences

Irregular Operations (IRROPS)
Business Decisions:
• Updated Gate assignment

Considerations:
• Minimize idling time on ground
• Number of gate changes
• Gate changes < 1 hour
• Proximity of new and old gates
Operational Crew Pairing and Scheduling

Flight → One day → Pairing → Monthly

One day schedule

Requirements
- Single Crew
- Equipment-Crew requirements
- Connections
- Rest at the end

Pairing schedule

Requirements
- Start / End at crew home base
- Pair up one-day schedules
- Max layover
- Min rest

Monthly schedule

Requirements
- Monthly limits
- Crew preferences
- Vacation
- Seniority

Scheduled Flights
Equipment

Irregular Operations
Other Transportation Problems

- **Logistics**
  - Routing

- **Rail**
  - Scheduling
  - Routing
  - Configuration

- **Ocean Freight**
  - Container Repositioning
Manufacturing (Discrete and Process)

Strategic Problems (Years)
- Network Design
- Warehouse / Manufacturing Locations
- Product Changes

Tactical Problems (Months - Weeks)
- Inventory Optimization
- Capacity Planning
- Sales and Operations Planning
- Line Balancing

Operational Problems (Real-time)
- Workforce Scheduling
- Detailed Scheduling
- Maintenance and Repair
Detailed Scheduling

Operational Requirements
- Order due dates
- Expedited orders
- Recipes and routings
- Raw material available
- WIP inventory

Key Decisions
- Start and end time for each task
- Worker-task assignment
- Workstation-task assignment

Schedule Generation
- Setup times / Changeovers
- Clean up times
- Workstation availability
- Workstation capabilities
- Worker skills and availability

Schedule Repair

Objectives
- Deliver on time (BTO / BTS)
Key Challenges in Scheduling

- **Detailed Capacity Considerations**
  - Hard to consider major tradeoffs: Shifts, Equipment, Certifications, Orders and Customers

- **Reliance on schedulers**
  - Decisions based on “experience” and “tradition”
  - Hard to create and hard to repair schedules

- **Complex dependencies**
  - Resource routings / Setup times / Cleaning times
  - WIP Synchronization

- **Dynamic Operations**
  - New orders / Inventory targets / Unplanned maintenance / quality assurance
Scheduling Across Manufacturing Industries

- **Automotive**
  - Car sequencing through stations

- **Electronics**
  - Scheduling of batches through stations

- **Aerospace**
  - Large scale assembly

- **Consumer Products**
  - Size and timings for batch operations
Thank you!

Yianni Gamvros - Global Enablement Leader, Data Science

Twitter: @YGamvros
Linkedin: linkedin.com/gamvros
December, 2017
• © IBM Corporation 2017. All Rights Reserved.
• The information contained in this publication is provided for informational purposes only. While efforts were made to verify the completeness and accuracy of the information contained in this publication, it is provided AS IS without warranty of any kind, express or implied. In addition, this information is based on IBM’s current product plans and strategy, which are subject to change by IBM without notice. IBM shall not be responsible for any damages arising out of the use of, or otherwise related to, this publication or any other materials. Nothing contained in this publication is intended to, nor shall have the effect of, creating any warranties or representations from IBM or its suppliers or licensors, or altering the terms and conditions of the applicable license agreement governing the use of IBM software.
• References in this presentation to IBM products, programs, or services do not imply that they will be available in all countries in which IBM operates. Product release dates and/or capabilities referenced in this presentation may change at any time at IBM’s sole discretion based on market opportunities or other factors, and are not intended to be a commitment to future product or feature availability in any way. Nothing contained in these materials is intended to, nor shall have the effect of, stating or implying that any activities undertaken by you will result in any specific sales, revenue growth or other results.
• All customer examples described are presented as illustrations of how those customers have used IBM products and the results they may have achieved. Actual environmental costs and performance characteristics may vary by customer.