# Machine Learning For Space Communications Service Management Tasks

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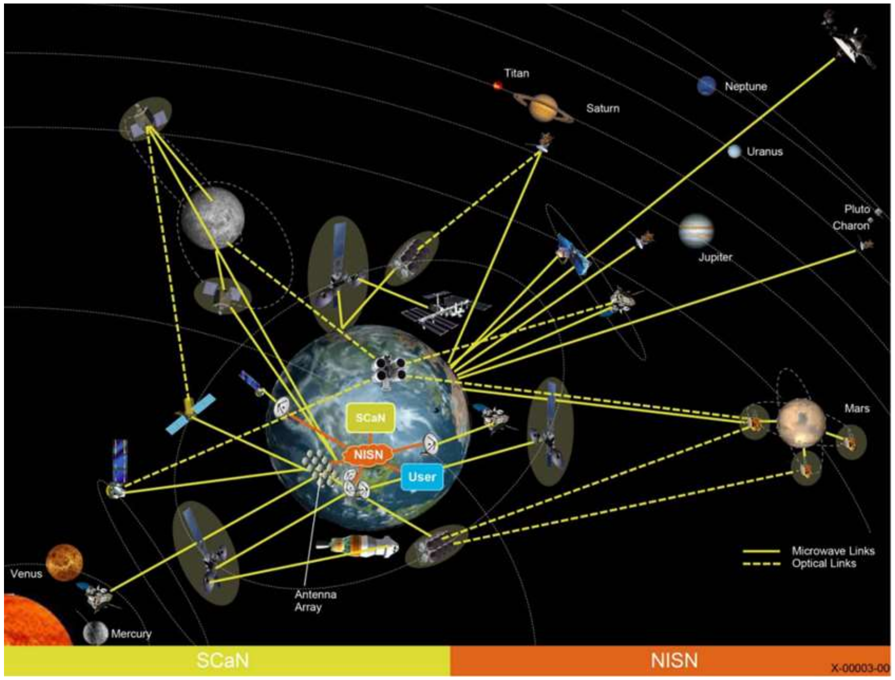
# Outline

- Motivation
- Challenges In Future Network Service Management
- Application of Machine Learning
- Current Status
- Conclusions and Future Work

# Motivations

- What is service management?
- SCaN has a diverse catalog of user services and provide coverage for:
  - Space Network (SN)
  - Near Earth Network (NEN)
  - Deep Space Network (DSN)
- All of the SCaN elements rely on significant human involvement.
  - Past DSN work indicated 30 people were needed to schedule for 61 missions.




**Takeaway: NASA networks heavily rely on human involvement to be properly scheduled.**

# Motivations

- Future impacts on service management:
  - Space Internetworking
  - Cognitive Communications

- Incorporate artificial intelligence (AI) and machine learning (ML) technology to extend networked services

**Goal: To develop intelligent routing for future space networks, in order to meet internetworking and other service management challenges.**

# Future Challenges

- Prevent SCaN staffing growth

- SCaN expansions:
  - Higher order modulations
  - Additional coding options
  - Space Link Extension ground interfaces
  - IP and DTN space internetworking services

- New resource constraints will add possible uncertainties into the scheduling problems.

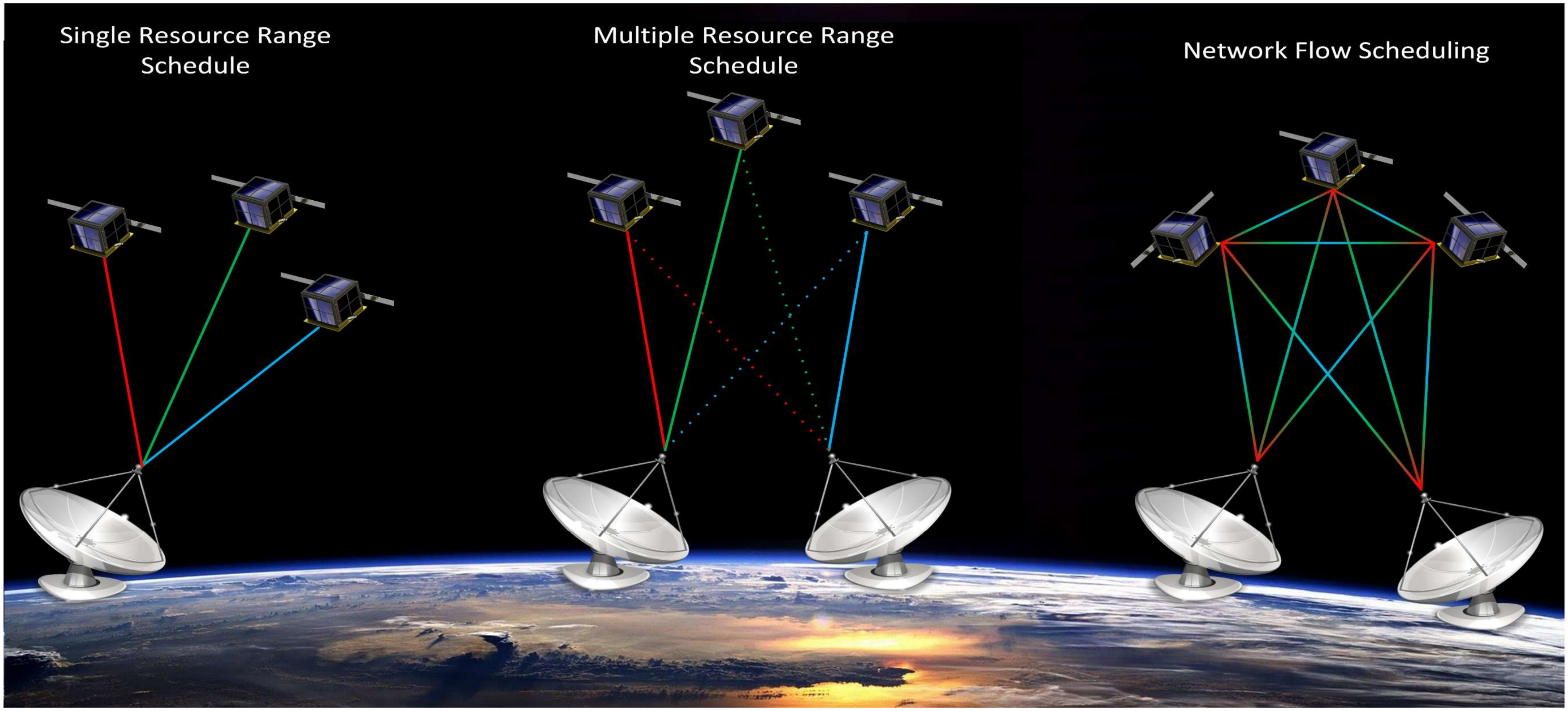
**Takeaway: New technologies will test the current scheduling methods.**

# Network Flow Scheduling

- The Air Force Satellite Control Network (AFSCN) has defined two forms of scheduling problems:
  - Single Resource Range Scheduling (SiRRS)
  - Multiple Resource Range Scheduling (MuRRS)
- We can further abstract MuRRS requests to encompass network wide scheduling requests or Network Resource Range Scheduling (NeRRS)
  - Simplify the user created request
- Scheduling technology needs to be flexible while remaining accurate

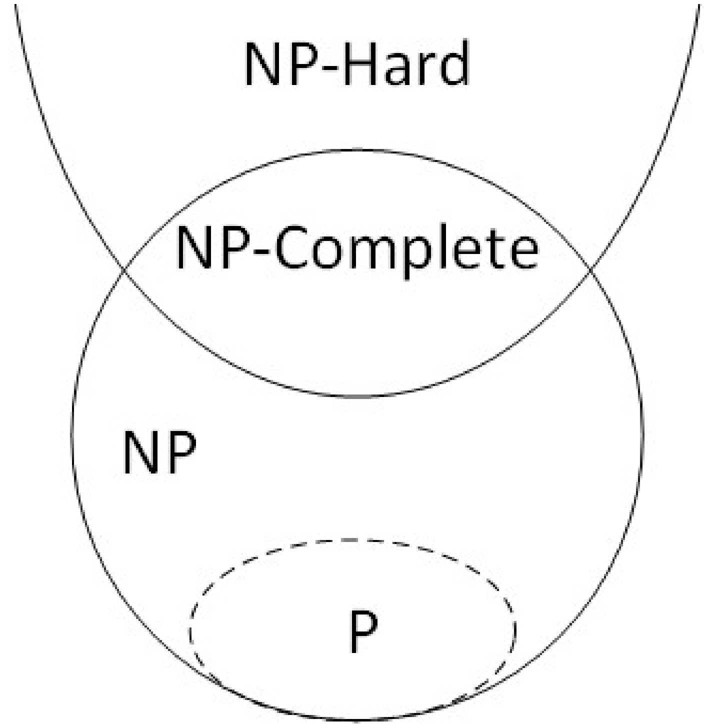
**Takeaway: A new approach must be taken to perform network flow level scheduling.**

# Progression of Scheduling Algorithms



# Applying Cognitive Technology

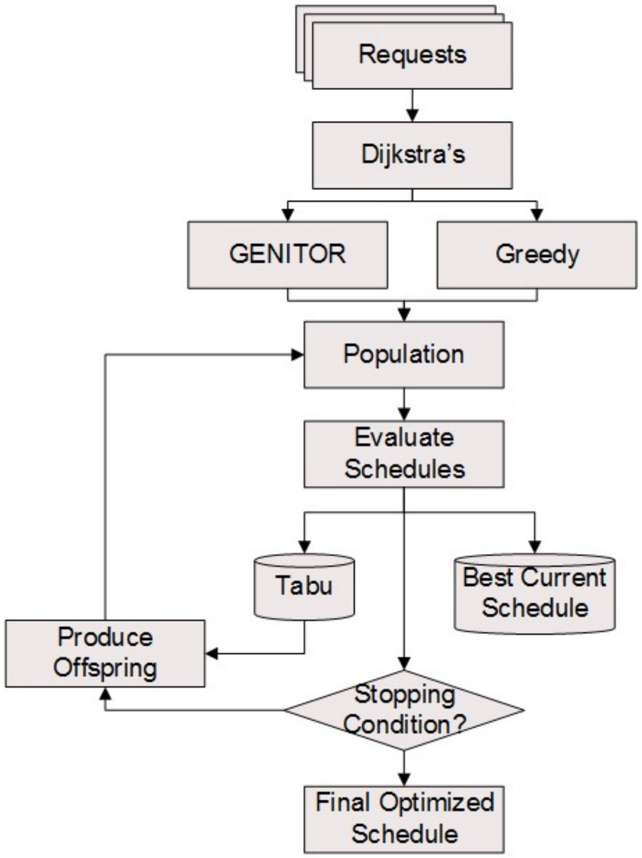
- The general problem of range scheduling is NP-complete
- Metaheuristics algorithms are beneficial when:
  - The solution space is large
  - The evaluation function is noisy or varies with time



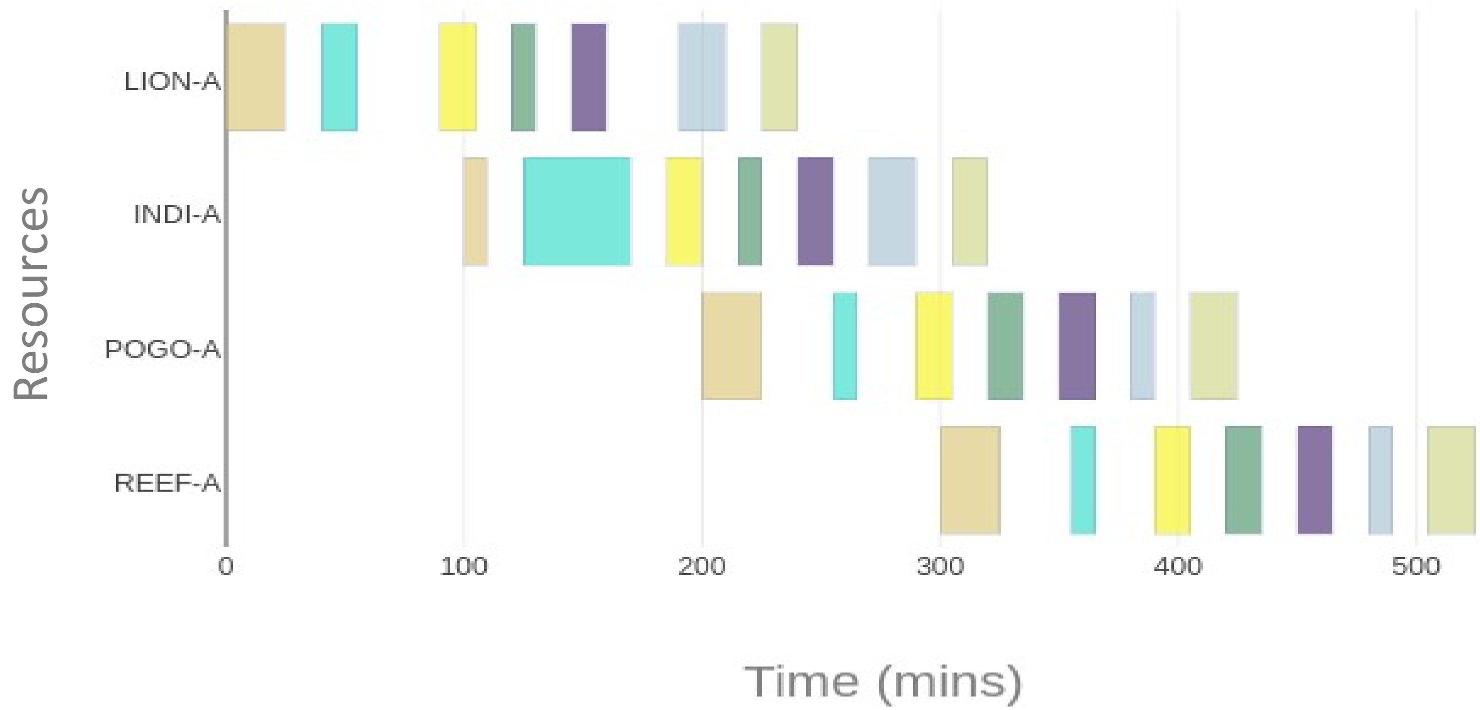

**Takeaway: By searching for near optimal solutions, metaheuristic algorithms can actually sift through the solution space.**

# Algorithm Prototype

- Translating the requests
- Major underlying sub-algorithms:
  - GENITOR (University of Colorado)
  - Greedy Algorithm
  - Dijkstra's Algorithm
- Evaluate the population
- Store the genotypes of the least desirable schedules in a tabu list.
- Produce offspring via mating the current best schedules.

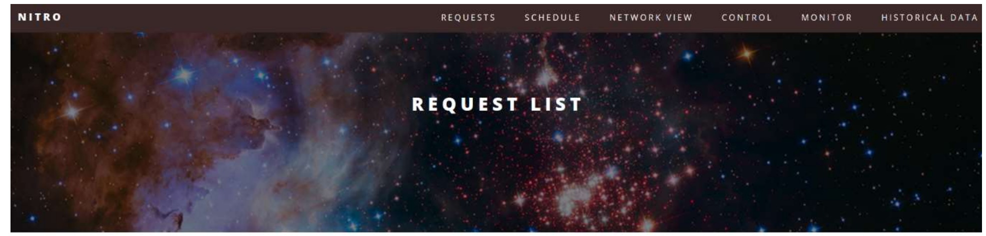


# Visualizing Network Flows



# Current Status

- The algorithm has shown expected results AFIT datasets for SiRRS and MuRRS
- We have developed an algorithm for producing example network scheduling request sets.
- The entire system has a web-based interface that has proven to be useful in testing/ debugging.




| Request ID | Asset ID | Start Time | Stop Time | Duration | Turnaround | Orbit Information |
|---|---|---|---|---|---|---|
| 1 | LION-A | 15 | 60 | 15 | 15 | 979400000 |
| 2 | LION-A | 25 | 50 | 25 | 15 | 944600000 |
| 4 | LION-A | 30 | 53 | 23 | 15 | 936600000 |
| 5 | LION-A | 35 | 70 | 35 | 15 | 783700000 |
| 6 | LION-A | 45 | 480 | 435 | 15 | 503700000 |
| 8 | LION-A | 51 | 61 | 10 | 15 | 495500000 |
| 9 | LION-A | 60 | 360 | 300 | 15 | 503700000 |
| 146 | LION-A | 1365 | 1400 | 5 | 15 | 403500000 |
| 147 | LION-A | 1380 | 1460 | 20 | 15 | 212400000 |
| 148 | LION-A | 1380 | 1430 | 20 | 15 | 503700000 |
| 149 | LION-A | 1380 | 1450 | 10 | 15 | 639200000 |
| 150 | LION-A | 1380 | 1440 | 15 | 15 | 978300000 |
| 151 | LION-A | 1385 | 1440 | 35 | 15 | 601200000 |
| 152 | LION-A | 1410 | 1460 | 20 | 15 | 577500000 |
| 153 | LION-A | 1410 | 1440 | 10 | 15 | 731000000 |
| 154 | LION-A | 1415 | 1460 | 20 | 15 | 532900000 |
| 155 | LION-A | 1423 | 1433 | 10 | 15 | 484500000 |

ADD REQUEST | ADD ASSET | GENERATE SCHEDULE

# Future Work

- Extend our technology beyond MuRRS by computing network flow schedules.
  - 100+ unique user requests for complex networks
- Implement a learning aspect to the fitness function
- Giving the user more network monitoring options
- Optimize codebase through LISP partial solution techniques.

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