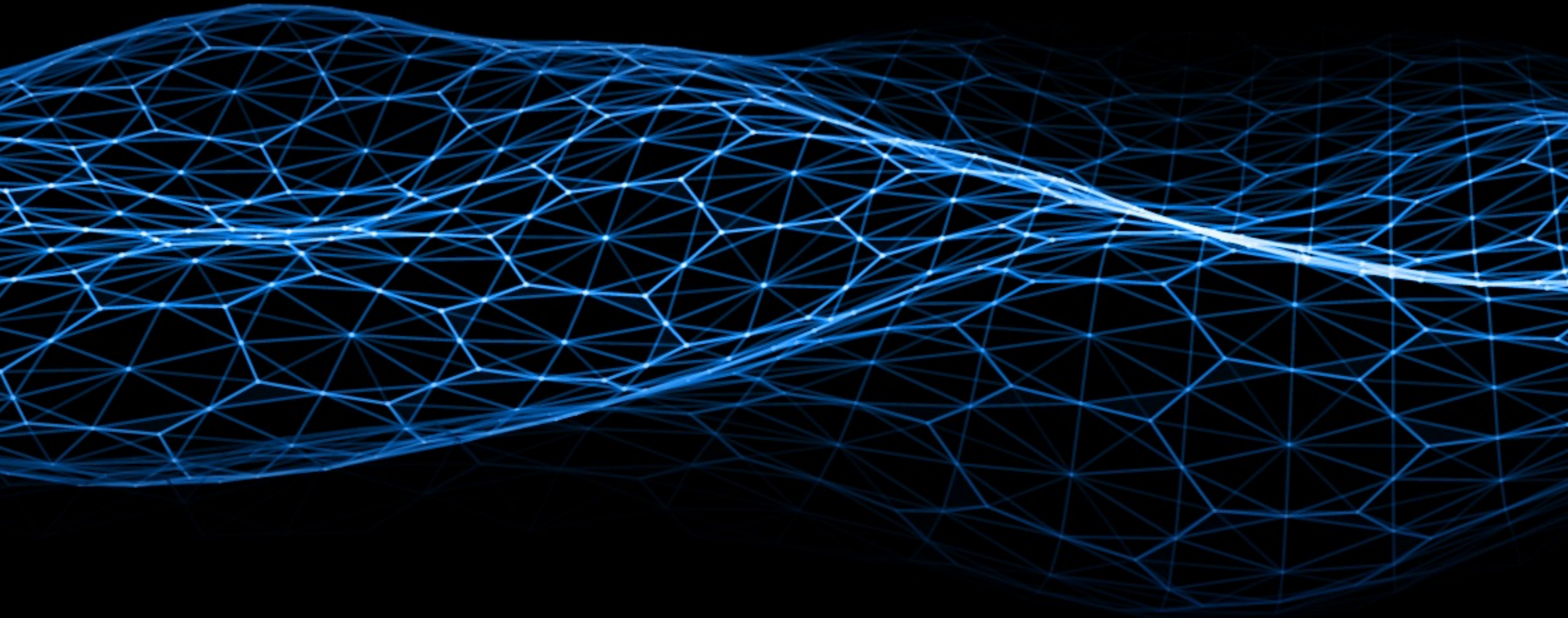


Modern Constraint Programming Education: Lessons for the Future



The Georgia Tech CP Course




The Georgia Tech CP Course



The Georgia Tech CP Course

- ▶ Basics of CP
- ▶ Elements of CP
 - Reification
 - Optimization
- ▶ Global Constraints
- ▶ Modeling in CP
 - Symmetry breaking
 - Redundant constraints
- ▶ Search in CP
- ▶ Scheduling
 - Interval vars
 - Sequence vars
 - Cumulative constraints
- ▶ Advanced Topics
 - Routing
 - Scripting
 - CP in Python
 - MiniCP

CONSTRAINT Scene Allocation **PROGRAMMIN**

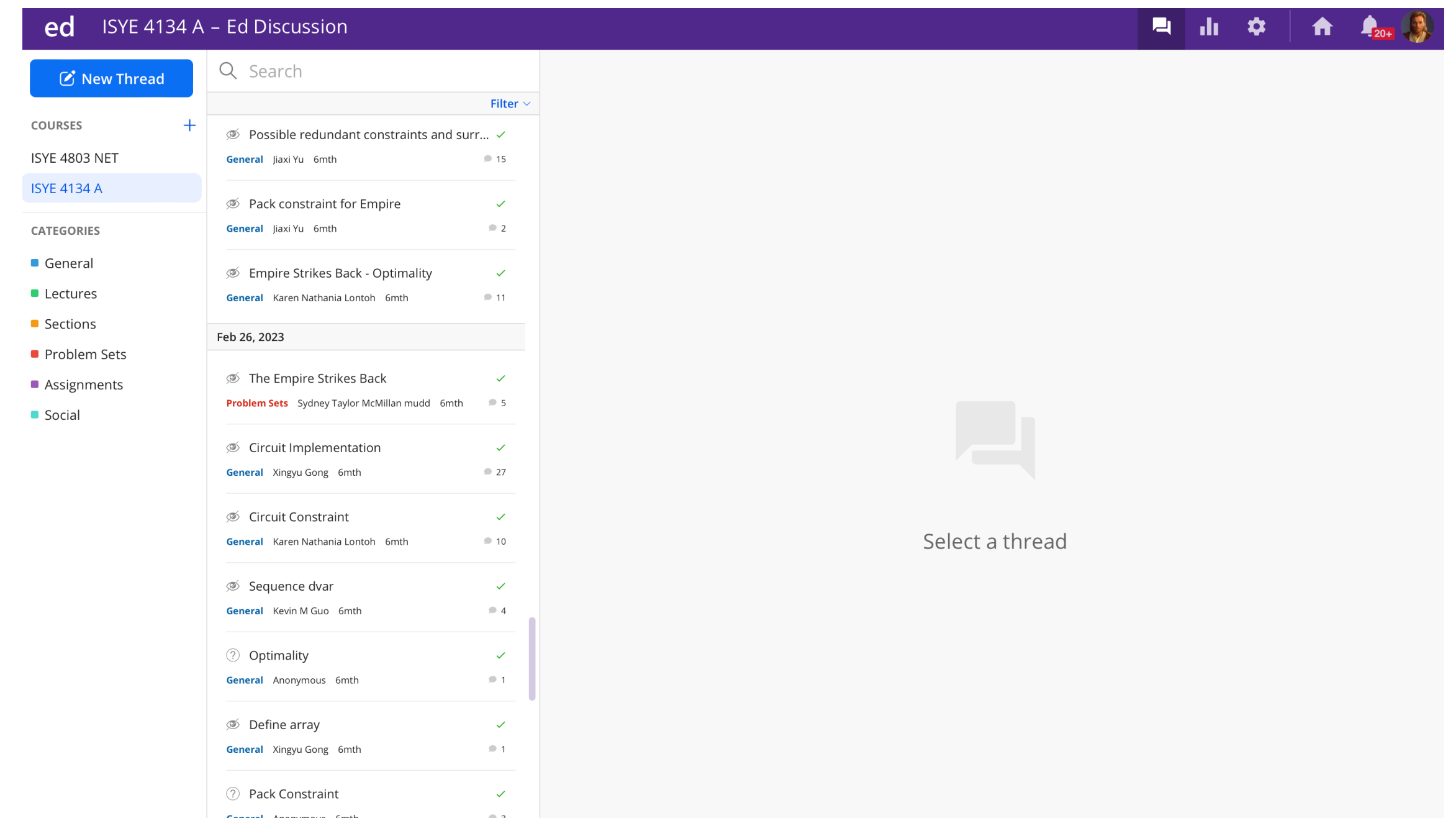


- ▶ Shooting scenes for a movie
 - an actor plays in some, but not all, of the scenes
 - at most k scenes can be shot per day
 - each actor is paid by the day
- ▶ Objective
 - minimize the total cost

Pascal Van Hentenryck, Copyright 2020 Introduction to Constraint Programming

Play stop 0:06 / 14:41

Interactive Sessions and Discussion Forums



ed ISYE 4134 A - Ed Discussion

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- Assignments
- Social

Possible redundant constraints and surr...
General Jiaxi Yu 6mth 15

Pack constraint for Empire
General Jiaxi Yu 6mth 2

Empire Strikes Back - Optimality
General Karen Nathania Lontoh 6mth 11

Feb 26, 2023

The Empire Strikes Back
Problem Sets Sydney Taylor McMillan mudd 6mth 5

Circuit Implementation
General Xingyu Gong 6mth 27

Circuit Constraint
General Karen Nathania Lontoh 6mth 10

Sequence dvar
General Kevin M Guo 6mth 4

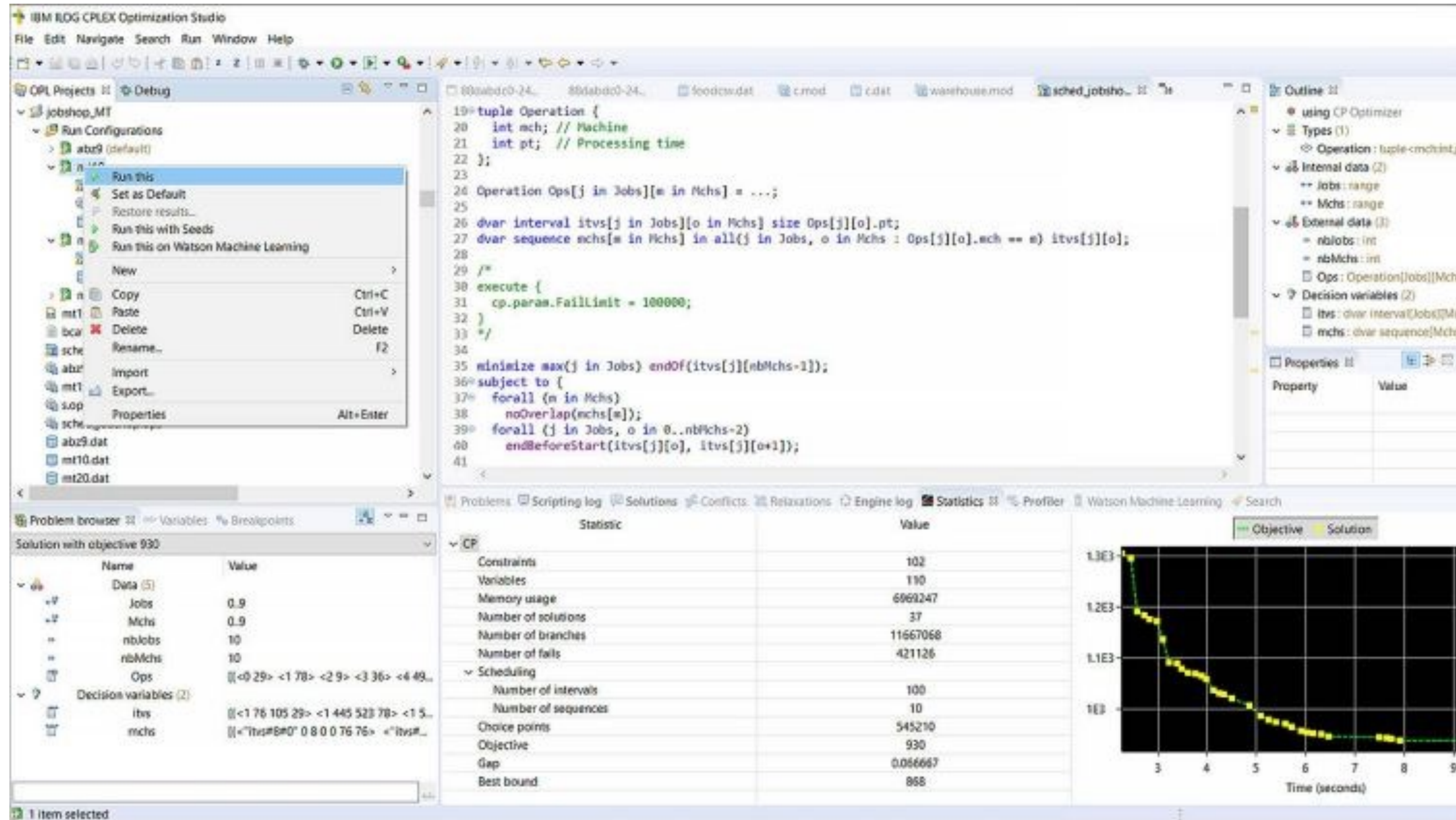
Optimality
General Anonymous 6mth 1

Define array
General Xingyu Gong 6mth 1

Pack Constraint
General Anonymous 6mth 3

Select a thread

Assignments



The screenshot displays the IBM ILOG CPLEX Optimization Studio interface. The main window shows the CPLEX model for a job shop scheduling problem. The model includes a tuple for operations, decision variables for intervals and sequences, and constraints for no-overlap and start-time ordering. The objective is to minimize the maximum completion time.

```
19 tuple Operation {
20   int mch; // Machine
21   int pt; // Processing time
22 };
23
24 Operation Ops[j in Jobs][m in Mchs] = ...;
25
26 dvar interval itvs[j in Jobs][o in Mchs] size Ops[j][o].pt;
27 dvar sequence mchs[m in Mchs] in all(j in Jobs, o in Mchs : Ops[j][o].mch == m) itvs[j][o];
28
29 /*
30 execute {
31   cp.param.FailLimit = 100000;
32 }
33 */
34
35 minimize max(j in Jobs) endOf(itvs[j][nbMchs-1]);
36 subject to {
37   forall (m in Mchs)
38     noOverlap(mchs[m]);
39   forall (j in Jobs, o in 0..nbMchs-2)
40     endBeforeStart(itvs[j][o], itvs[j][o+1]);
41 }
```

The bottom-left pane shows the solution with an objective value of 930. The decision variables are:

Name	Value
Jobs	0.9
Mchs	0.9
nbJobs	10
nbMchs	10
Ops	[[<0 29> <1 78> <2 9> <3 36> <4 49...]]
itvs	[[<1 76 105 29> <1 445 523 78> <1 5...]]
mchs	[[<"itvs#0" 0 8 0 0 76 76> <"itvs#...]]

The bottom-right pane shows the solution statistics:

Statistic	Value
Constraints	102
Variables	110
Memory usage	6969247
Number of solutions	37
Number of branches	11667068
Number of fails	421126
Scheduling	
Number of intervals	100
Number of sequences	10
Choice points	545210
Objective	930
Gap	0.066667
Best bound	868

The bottom-right pane also contains a graph showing the Objective value (green line) and Solution value (yellow line) over Time (seconds). The Objective value starts at approximately 1.3E3 and decreases to about 1E3 over 9 seconds.

Star Wars Theme



Student Engagement

■ **Figure 2** Average weekly student interaction with the course material over the semester



Student Reception

■ **Table 1** Enrollment for past iterations of the Georgia Tech CP course

Semester	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Spring 2023
Enrollment	26	41	94	100	183	30

■ **Table 2** Survey ratings for past iterations of the Georgia Tech CP course

Semester	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Spring 2023
Number of Respondents	15	82	93	153	26
Amount Learned	4.9	4.8	4.5	4.4	4.6
Instructor stimulates interest	4.9	4.95	4.8	4.6	4.8
Instructor effectiveness	5	4.97	4.9	4.7	4.7
Course effectiveness	4.9	4.92	4.8	4.3	4.6



Teaching to Undergraduate and Engineering Students



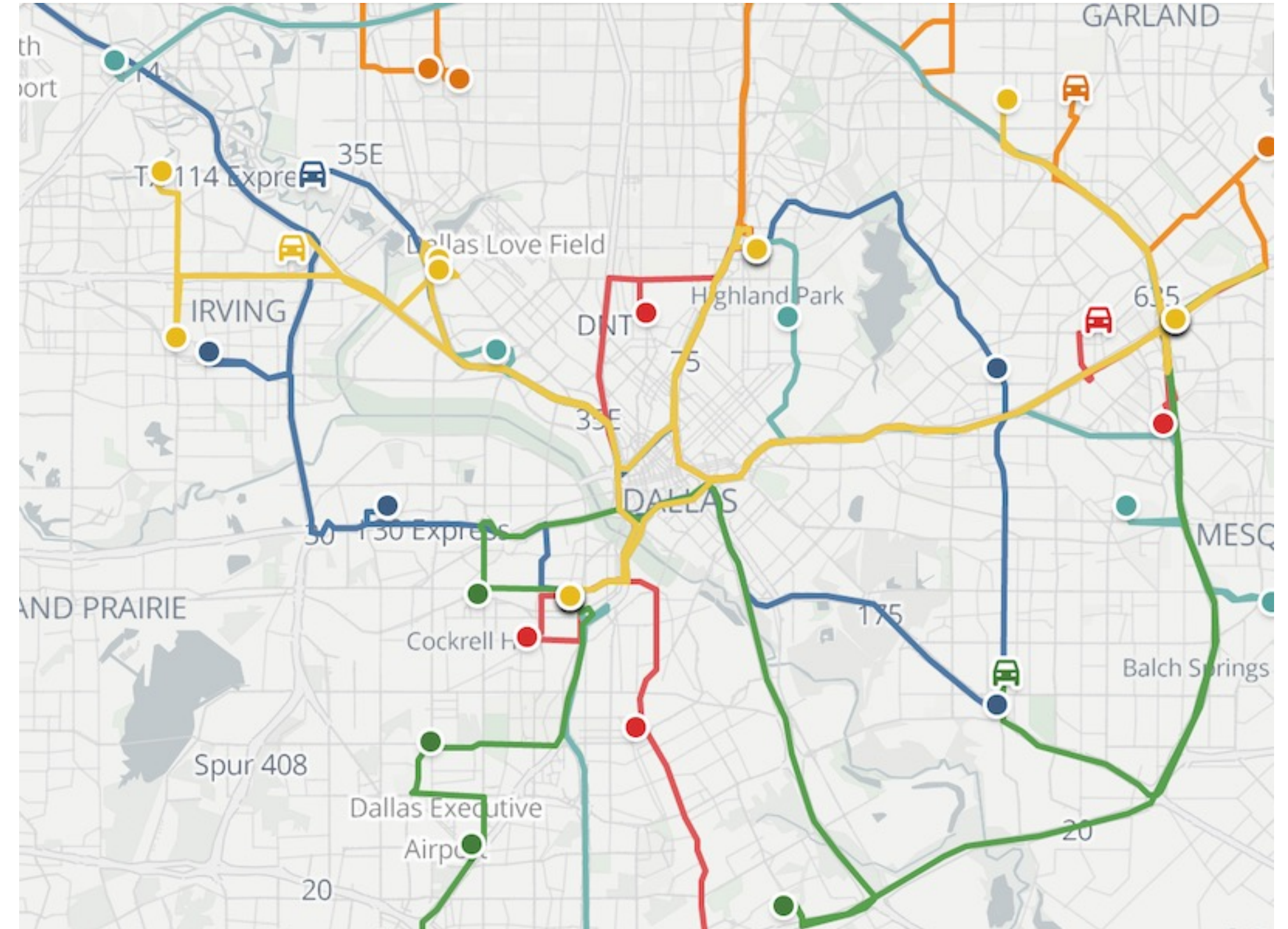
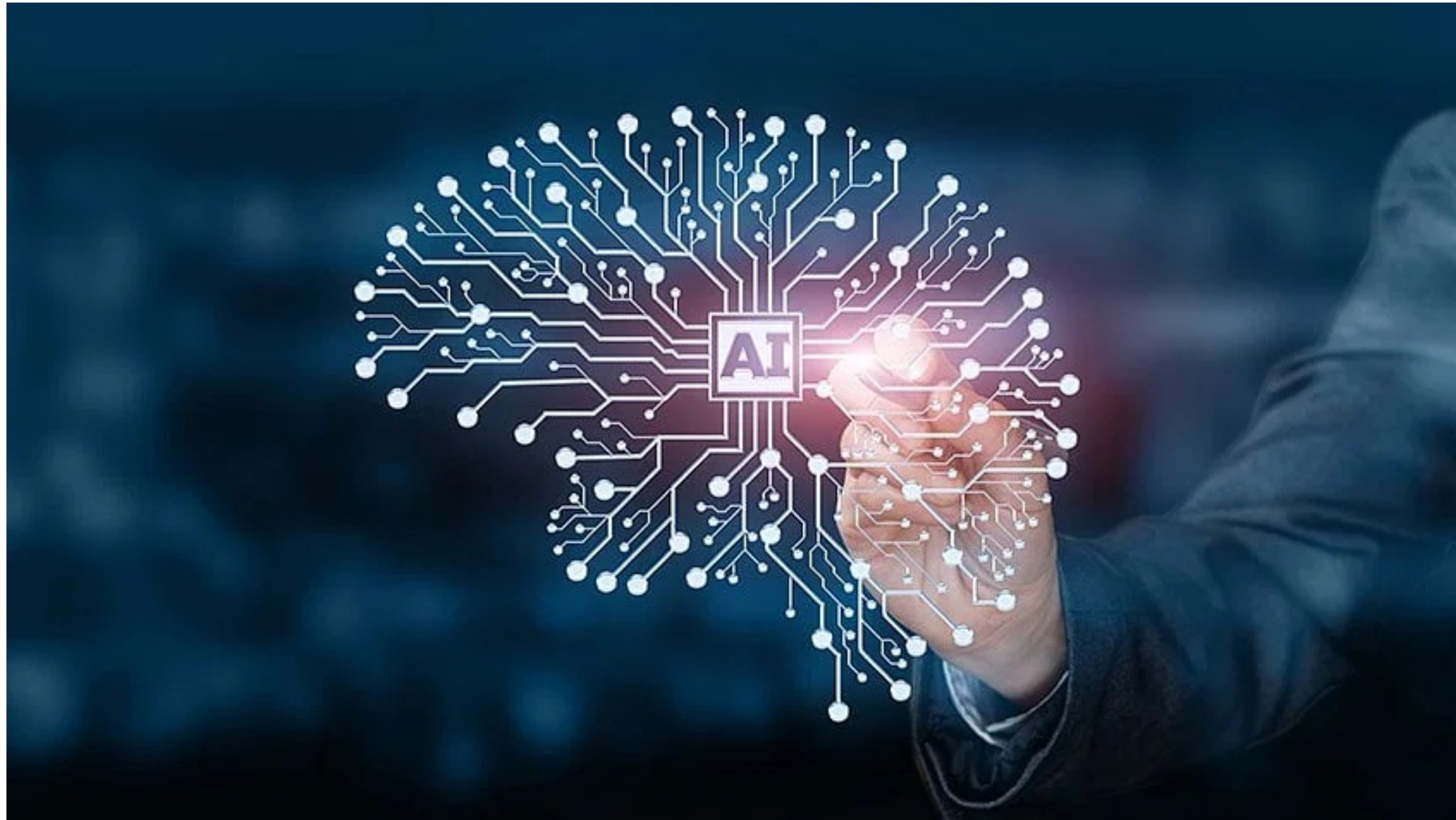
Modeling-Focused Teaching and Autograders

```
transp4.mod ✕
59
60 execute SETTINGS {
61   settings.displayComponentName = true;
62   settings.displayWidth = 40;
63   writeln("Routes: ", Routes);
64 }
65
66 execute DISPLAY {
67   function printRoute(r) {
68     write(" ", r.p, ":");
69     writeln(r.e.o, "->", r.e.d);
70   }
71
72   writeln("Routes:");
73   for (var r in Routes) {
74     printRoute(r);
75   }
76 }
77 {string} Orig[p in Products] = { c.o | <p,c> in Routes };
78 {string} Dest[p in Products] = { c.d | <p,c> in Routes };
79
80 {connection} CPs[p in Products] = { c | <p,c> in Routes };
81
```

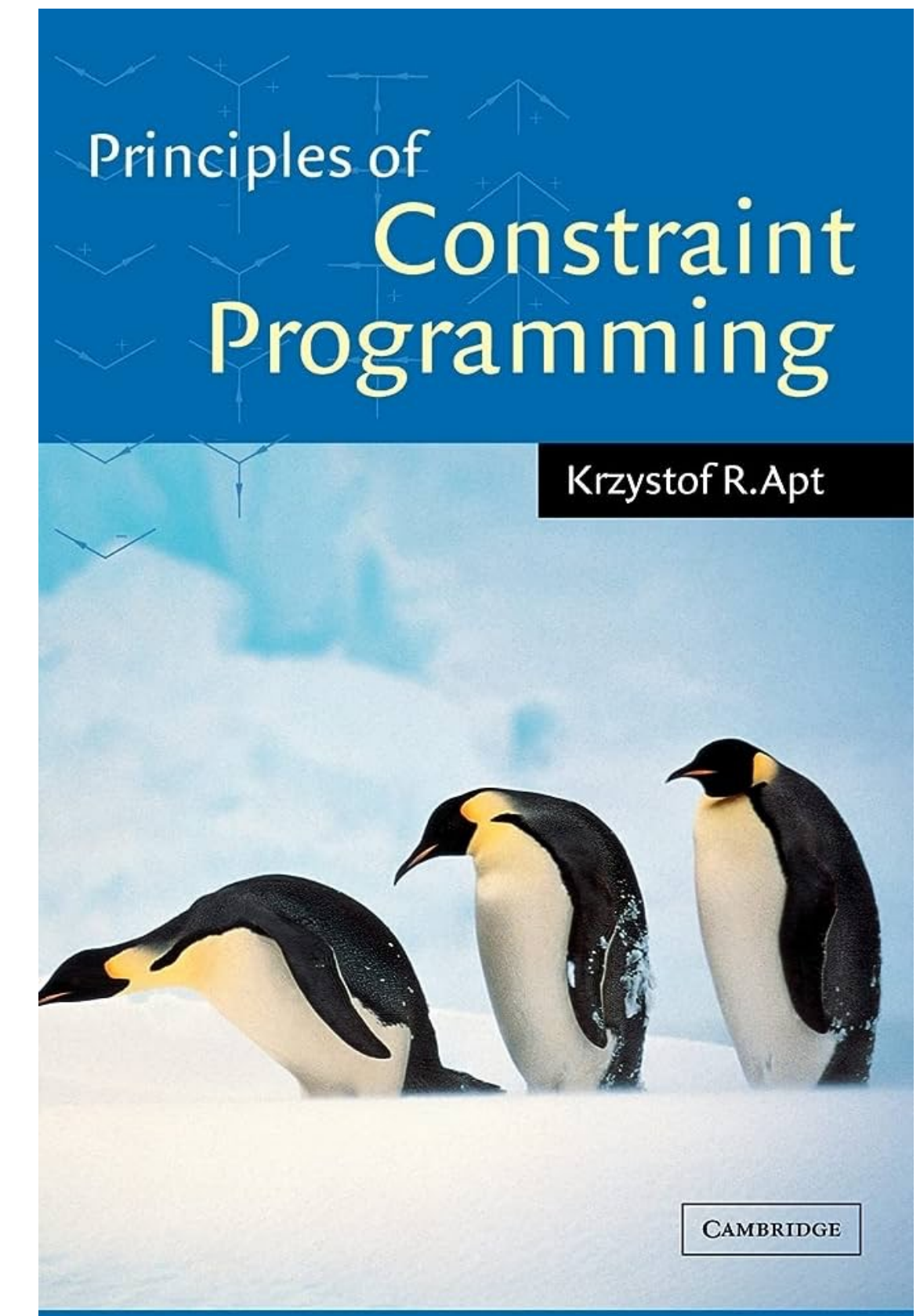
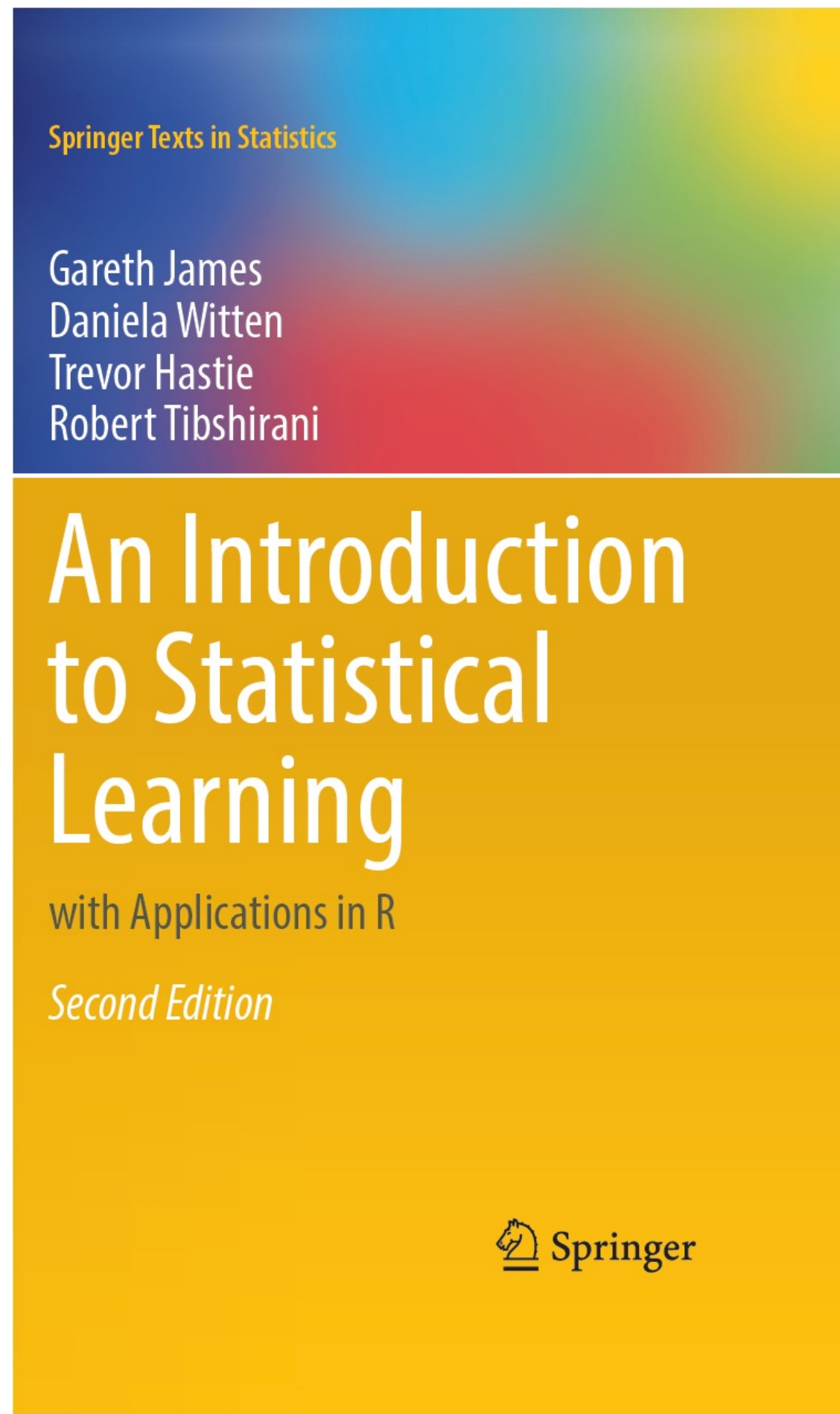
Distance Learning



Promotion of CP



Introductory Resources and Availability



Impact of LLMs

```
less Copy code  
  
// Sets and parameters  
int n = ...; // number of legions  
range Legions = 1..n;  
  
// Decision variables  
int s[Legions]; // position of each legion  
  
// Constraints  
subject to {  
  forall (i in Legions, j in Legions: i != j) {  
    s[i] != s[j]; // each legion must be positioned at a unique site  
  }  
  
  forall (i in Legions: i < n) {  
    forall (j in Legions: j > i) {  
      |s[j] - s[i]| != j - i; // distances between legions must be distinct  
    }  
  }  
}
```

[Regenerate response](#)

Thank you!

