A SAT Based Scheduler for Interpreters and Student-Teacher Conferences

{ David Weinflash }@UC Santa Barbara

COMPUTER SCIENCE
UC SANTA BARBARA
Computing. ReInvented.

Objective and Goals

Twice a year, the Interdisciplinary Humanities Center at UC Santa Barbara matches volunteer interpreters with student-teacher conferences throughout the Goleta and Santa Barbara school districts. When pairing interpreters with conferences, the scheduling approach should be:

1. ***Objective-driven:*** A maximal number of student-teacher conferences include an interpreter.
2. ***Constraint-driven:*** Schedules are fair, convenient and practical for all interpreters and teachers.

Future Work

Once student-teacher conferences are no longer virtual, it will be necessary to introduce new transportation and convenience constraints. To limit transportation costs, interpreters with vehicles should be assigned to the most distant schools. Additionally, for convenience purposes, interpreters should not have to wait longer than 30 minutes between meetings.

Acknowledgments

This material uses annonymized data derived from students and faculty from UC Santa Barbara and elementary schools throughout Goleta and Santa Barbara, California. The utilized SAT solver is adopted from Google's open source software suite OR-Tools.

Challenges

- ***Supply & Demand:*** Scheduling is restricted to a limited number of interpreters and an increasing number of teacher meeting requests.
- ***Fairness:*** Interpreters are distributed fairly amongst schools, ensuring no one school is unfairly assigned a majority of interpreters and no one interpreter is unfairly assigned a disprortionate amount of meetings.
- ***Practicality:*** Based on predefined limits, each interpreter works at least X meetings per week and at most Y meetings per day.

Solution

Utilize a SAT solver and objective function to maximize the number of conferences that are assigned an interpreter.

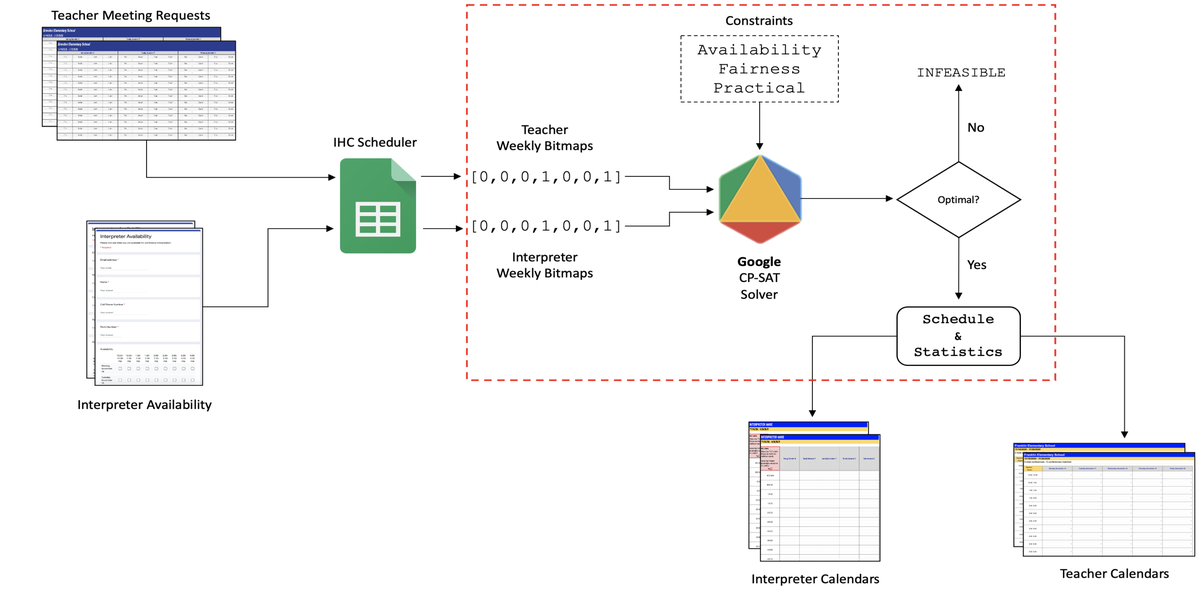
1. ***Data Structure:*** For each interpreter and each teacher, use a weekly bitmap to represent interpreter availability and teacher meeting requests, respectively.
2. ***Objective Function:*** Subject to formalized availability, fairness and practicality constraints, optimize the objective function to match a maximal number of interpreters with student-teacher conferences.

References

[1] Martins, Ruben and Justine Sherry. Lisbon Wedding: Seating arrangements using MaxSAT

[2] Zhang, Hantao, Dapeng Li and Haiou Shen. A SAT Based Scheduler for Tournament Schedules

Overview of Approach



Approach by Example

Shift Variables

```
# shifts[(i, t, d, s)]: interpreter 'i' paired with teacher 't' works shift 's' on day 'd'
shifts = {}
for i in all_interps:
    for t in all_teachers:
        for d in all_days:
            for s in all_shifts:
                shifts[(i, t, d, s)] = model.NewBoolVar('shift_i%it%id%is%i' % (i, t, d, s))
```

Constraints

```
# Interpreters work at most max_daily_mtgs per day
for i in all_interps:
    for d in all_days:
        model.Add(sum(shifts[(i, t, d, s)] for t in all_teachers for s in all_shifts) <= max_daily_mtgs)


# Interpreters work a fair amount of shifts
for i in all_interps:
    model.Add(sum(shifts[(i, t, d, s)] for t in all_teachers for d in all_days for s in all_shifts) >= num_weekly_mtgs)
    model.Add(sum(shifts[(i, t, d, s)] for t in all_teachers for d in all_days for s in all_shifts) <=
        max(num_weekly_mtgs+1, tot_mtg_reqs - (num_interps-1)*num_weekly_mtgs))


# Teachers get a fair amount of interpreters
for t in all_teachers:
    model.Add(sum(shifts[(i, t, d, s)] for i in all_interps for d in all_days for s in all_shifts) >= num_weekly_mtgs)
    model.Add(sum(shifts[(i, t, d, s)] for i in all_interps for d in all_days for s in all_shifts) <=
        max(num_weekly_mtgs+1, tot_mtg_reqs - (num_interps-1)*num_weekly_mtgs))
```

Objective Function

```
# Optimize the objective function
model.Maximize(
    sum(interp_avails[i][d][s] * mtg_reqs[t][d][s] * shifts[(i, t, d, s)] for i in all_interps
        for t in all_teachers for d in all_days for s in all_shifts))
```

Statistics & Schedule

```
Teachers: 45
Interpeters: 62

Total Meeting Requests: 279
Total Meetings Matched: 278

Min Weekly Meetings: 1
Max Daily Meetings:  2

Interpreter Weekly Meetings Table
 0 weekly meetings:  1
 1 weekly meetings:  2
 2 weekly meetings:  5
 3 weekly meetings:  8
 4 weekly meetings: 22
 5 weekly meetings:  5
 6 weekly meetings: 10
 7 weekly meetings:  4
 8 weekly meetings:  4
 9 weekly meetings:  1
10 weekly meetings:  0

Min Meetings per Interpreter: 0
Med Meetings per Interpreter: 4
Avg Meetings per Interpreter: 4.5
Max Meetings per Interpreter: 9

Interpreter:  1 Teacher: 15 Day:  2 Shift:  2
Interpreter:  1 Teacher:  6 Day:  2 Shift:  4
Interpreter:  1 Teacher:  6 Day:  3 Shift:  8
Interpreter:  1 Teacher:  3 Day:  3 Shift: 10
```