Scheduling Reach Mahjong Tournaments using Pseudoboolean Constraints

Martin Lester

University of Reading

SAT, 8th July 2021

Reach Mahjong

- **Mahjong**: A gambling game for 4 players.
  - **Each player competes individually.**
- **Reach** mahjong: variant most popular in Japan.
- Also played in amateur tournaments across Europe.

Tournament Scheduling

- How to construct a tournament schedule satisfying various constraints?
  - Use **Pseudoboolean** encoding.
  - **Monolithic** encoding, followed by **tuning** phase.
- Tool **CoMaToSe** available.
  - Used successfully for UK tournaments.

Table	**1**				**2**				**3**				**4**				**5**				**6**			
Session	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*
1	1	3	2	4	7	8	5	6	11	12	10	9	14	13	15	16	17	20	18	19	24	22	23	21
2	9	23	7	17	3	19	10	15	16	6	24	2	8	18	21	12	22	5	1	14	20	11	4	13
3	11	18	14	24	21	1	13	17	20	7	3	22	10	4	6	23	2	15	9	8	12	16	19	5
4	15	21	6	20	4	22	16	9	19	23	8	14	2	17	11	5	3	24	12	13	18	10	1	7
5	13	8	22	10	23	2	20	12	5	15	4	18	19	9	24	1	7	16	21	11	6	14	17	3

Primary constraint: Socialisation

- Tournament is a **partial round robin**.
  - Common sizes: 4-9 sessions, 16-68 players.
  - European championship 2016: 10 sessions, 128 players.
- Every player plays in every round, facing opponents at most once.
  - Well-known **Social Golfer Problem**.

Table	1				2				3				4				5				6			
Session	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*
1	1	3	2	4	7	8	5	6	11	12	10	9	14	13	15	16	17	20	18	19	24	22	23	21
2	9	23	7	17	3	19	10	15	16	6	24	2	8	18	21	12	22	5	1	14	20	11	4	13
3	11	18	14	24	21	1	13	17	20	7	3	22	10	4	6	23	2	15	9	8	12	16	19	5
4	15	21	6	20	4	22	16	9	19	23	8	14	2	17	11	5	3	24	12	13	18	10	1	7
5	13	8	22	10	23	2	20	12	5	15	4	18	19	9	24	1	7	16	21	11	6	14	17	3

Existing SGP solution methods

- Heuristic-guided **local search**:
  - Best automated method for hard SGP instances.
  - Hard to add other constraints.
- **SAT** encodings:
  - Best SAT encodings don't scale to large numbers of players.
- **Pseudoboolean** encoding:
  - Original encoding of SGP!
  - Scales well and easy to add other constraints.

Secondary constraint: Seat allocation

- Each player has a **seat** at the table.
  - Seats named after winds: **E**ast, **S**outh, **W**est, **N**orth.
  - Allocating seats in tournament schedule saves time.
- Seat position can have big impact:
  - Being dealer gives a bonus.
  - Dealer position rotates during game.
  - Tournament games played to time limit.
  - If you start as West or North, less likely to get a second turn as dealer.
- Players want equal number of allocations of each seat in tournament schedule.
  - Easy to add constraints in PB formulation.

Tuning seat allocation

- Solver for monolithic encoding doesn't always find perfect balance of seat positions.
- In this case, **tune using separate encoding** that only adjusts seat allocation.
- Perfect balance usually possible with tuning.

Table	**1**				**2**				**3**				**4**				**5**				**6**			
Session	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*	*N*
1	1	3	2	4	7	8	5	6	11	12	10	9	14	13	15	16	17	20	18	19	24	22	23	21
2	9	23	7	17	3	19	10	15	16	6	24	2	8	18	21	12	22	5	1	14	20	11	4	13
3	11	18	14	24	21	1	13	17	20	7	3	22	10	4	6	23	2	15	9	8	12	16	19	5
4	15	21	6	20	4	22	16	9	19	23	8	14	2	17	11	5	3	24	12	13	18	10	1	7
5	13	8	22	10	23	2	20	12	5	15	4	18	19	9	24	1	7	16	21	11	6	14	17	3

Secondary constraint: Tournament graph

- Consider tournament as a mechanism for transfer of points between players.
- For players who don't play each other in the tournament:
  - Maximise opportunities for indirect points transfer.
  - So add constraints:
    - **at least *d* paths of length 2 between them**.
- Mainly a concern for larger tournaments.

Conclusion

- **Pseudoboolean** constraints are a convenient and effective way of encoding problems.
- For our encoding, **clasp** worked well as a PB solver.
- **Monolithic** encoding didn't always find optimal solution.
  - A separate **tuning** phase often improved upon this.
- Local search still far better for **pure SGP**.

Thanks for listening