

Developments in Planning

Research report

By Nimish Sanghi

According to the AIMA book, most popular planning approaches are Partial Order planning, Fast Forward state-space search planner and GRAPHPLAN system based on planning graphs.

- 1) **Partial Order Planning:** It is an approach to automated planning where decisions about ordering or actions is left as open as possible. It exhibits the Principle of Least Commitment. Anthony Barret and Daniel Weld in their 1994 paper "Partial-order planning. Evaluating possible efficiency gains" have argued that partial-order planning is superior to total-order planning, as it is faster and thus more efficient.¹ Partial order planners dominated 20 years of research after introduction of NOAH planner (Sacerdoti, 1975, 1977). Chapman's work on TWEAK (Chapman, 1987) led to a complete straight forward description of a complete partial-order planner. This further led to very popular implementations of SNLP(systematic non-linear planner) and UCPOP (upward compatible partial order planner). While POP fell out of favor in 1990s as faster methods emerged. However, in 2001, Nguyen and Kambhampati argued that a reconsideration is merited. They show that with accurate heuristics derived from planning graphs, RePOP planners scale up better than GRAPHPLAN in parallelizable domains.²
- 2) **GRAPHPLAN:** Graphplan is an algorithm for automated planning developed by Avrim Blum and Merrick Furst in 1995. GRAPHPLAN was much faster than the Partial Order planning approaches in vogue during that time. This was the first planner to use planning graph techniques. GraphPlan's place in history is secured by the critical role it played in development of reachability heuristics i.e. heuristics aimed to estimate the cost of a plan from current state to goal state. Many subsequent planning systems have used ideas from it either directly as descendants of graphplan or by using the planning graph representations to improve problem definition like SAT-based planning.³
- 3) **Fast Forward state space searcher:** Fast forward (FF) automatic planner relies on forward search in state space guided by a heuristic which estimates goal distances by ignoring delete lists. It was described by Hoffmann in 2001 as a result of it being the most successful automatic planner in AIPS – 2001 planning systems competition.⁴

¹ Partial-order planning. Evaluating possible efficiency gains -

<https://iths.pure.elsevier.com/en/publications/partial-order-planning-evaluating-possible-efficiency-gains>

² Reviving Partial Order Planning - <http://rakaposhi.eas.asu.edu/ucpop-revive.pdf>

³ Fast planning through Planning graph analysis - <http://www.cs.cmu.edu/~avrim/Papers/graphplan.pdf>

⁴ FF: The Fast-Forward Planning System - <http://www.cs.toronto.edu/~sheila/2542/w06/readings/ffplan01.pdf>

As we can see, at different times different approaches have dominated the field of automated planning. Graphplan emerged from the desk of two theoreticians who took a different view to the approach. Apart from the work resulting into Graphplan, it also lead to many other approaches based on planning graph representation and it dominated from 1995 to 2001 when Nguyen and Kambhampati showed that for certain class of problems, partial order planning based on REPOP could beat Grpahplan. So we can see that different competing approaches continue to evolve and dominate the space for certain periods of time. Each time an old approach reemerges, it borrows the good ideas from the other dominant approaches to provide an overall improvement with higher theoretical understanding and more scalable practical algorithms.