This review summarizes the important historical developments in AI planning and search for fully observable, deterministic, static environments with single agent.

If we mark the first half of 1970s as 'the beginnings', the most prominent approach to planning at the time was so called '**linear planning**', the sequential execution of actions to get to the goal state. This seems to make an intuitive sense - as Sacerdoti (1975) put it, 'We usually think of plans as linear sequences of actions. This is because plans are usually executed one step at a time. But plans themselves are not constrained by limitation s of linearity.' Namely, sometimes the most optimal plan requires to execute actions that initially take you further away from goal state and linear planning would fail to find an optimal solution to even simple problems that required this. Hence, by mid-1970s, a new approach, named **partial planning**, came into prominence. It represented plans as 'partially ordered structures: a plan is a set of actions and a set of constraints of the form *Before*(a_i, a_j) saying that one action occurs before another'[1], i.e. it would create sub-plans for each sub-goal of the problem and then would try to combine the sub-plans into a plan by ordering the actions of the sub-plans in a way that no preconditions and effects conflict with each other. Under this approach there was no explicit representation of a problem state, only of actions with preconditions and effects, which made some computations a difficult task[2]. In addition, although this approach was better than linear planning in finding optimal solutions under conditions described earlier, it could not tackle problems of a large scale particularly efficiently. Nevertheless, this was the dominant approach to solving planning problems until mid 1990s, when a number of new ideas have shaken the field. Firstly, the proponents of **state space planning** successfully challenged the dominance of partial planning in the field. Under state space planning approach, there is a formal representation of a problem state and each action can only be executed if its preconditions are met in the current state and, once executed, it updates the state based on the action's effects. To find a solution to a problem, one can either start from initial state and search through possible state spaces until goal state is reached (forward search) or start with a goal state and search backwards until a list of actions leading to the goal state is identified (backward search). For complex problems, state spaces can be very large and hence an effective heuristic needs to be used to reduce the search space. As McDermott (1995) summarizes this approach, 'Keep search states simple, just sequences of actions, and try harder to find feasible and relevant actions to add'. State space planners have proven to show a better performance than partial planning on a number of planning problems.

Another big idea that came nearly at the same time was the **planning graph**. A planning graph is a layer by layer representation of all the actions that can be executed and states reached from a particular starting state. Actions and states that are mutually exclusive are marked as such in the planning graph. Once two consecutive state are identical, the planning graph is said to have 'levelled off' and its construction is halted. A wealth of information can be extracted from a planning graph. For example, the state level at which each sub-goal of the problem is reached or a level at which all sub-goals first appear in a single level without being mutually exclusive. If that can't be achieved, we know that the problem can't be solved. As Blum and Furst (1995) put it, 'A Planning Graph encodes the planning problem in such a way that many useful constraints inherent in the problem become explicitly available to reduce the amount of search needed.' In their paper, that introduced the GRAPHPLAN algorithm, they demonstrated that GRAPHPLAN outperformed both partial planner and state space planner in a number of different problems, showing particularly outstanding results for high complexity problems where other algorithms fail. This has brought a lot of excitement to the field and the planning graphs have become widely adopted for solving complex planning problems.

The field of planning and search is still actively developing and a number of new ideas on ways to tackle planning problems are introduced (e.g. binary decision diagrams or situation calculus), but none has yet caused comparable paradigm shifts in the adoption as the techniques described above. Time will show if further advances in automated planning performance can be achieved.

1 p.390, *Artificial Intelligence: A Modern Approach* by Norvig and Russell

2 p.391, *Artificial Intelligence: A Modern Approach* by Norvig and Russell