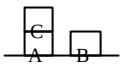
Problem Characteristics

- In order to choose the most appropriate method(s) for a particular problem, must analyse the problem along several dimensions.
- Some keywords:-
  - decomposition, undo steps, predictability, obviousness of good solution, amount of knowledge required.

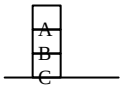
Problem Characteristics

- 1. Is the problem decomposable?
  - Can it be broken into a set of (nearly) independent smaller or easier sub problems?
  - Can then solve the smaller sets directly, or further break them down.
  - One example is the blocks world.
    - Given on the next slide with two operators:-
      - CLEAR(x) [x has nothing on it] → ON(x, Table) [put it on the table]
      - CLEAR(x) and CLEAR(y) → ON(x,y) [put x on y]

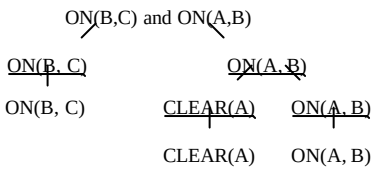
Problem Characteristics

- Given:- 

ON(C,A)

Goal is:- 

ON(B,C) and ON(A,B)



Problem Characteristics

- States not achieved are underlined.
- The solution above shows that the two sub problems are not independent.
  - They must be considered together in order to arrive at a solution for the entire problem.

Problem Characteristics

- 2. Can the solution steps be ignored or undone?
  - Three types of problem can be considered.
  - Solving a theorem.
    - If we proceed to prove a lemma which turns out to be no use, we can easily backtrack because all of the initial information is still true and in memory.
    - Any rules that could have been applied at any stage, still can.
    - Just lost the effort exploring the dead end.

Problem Characteristics

- The 8 puzzle.
  - Moving any tile to solve the problem may or not take us towards a solution.
  - A dumb move can be undone using backtracking. It requires more effort to undo than the theorem example, but it is possible.
  - Have to keep track of what moves were made.
- Chess.
  - Making a dumb move here cannot be backtracked or restarted, must make the best of a bad situation.

Problem Characteristics

- Three types of problem:-
  - Ignorable in which steps can be ignored.
  - Recoverable in which solution steps can be undone.
  - Irrecoverable in which solution steps cannot be undone.
- The recoverability of a problem influences the complexity of the control structure used.

Problem Characteristics

- Ignorable are easy.
- Recoverable requires a more complicated strategy.
  - Backtracking will be necessary to recover, so the control structure must use a push down stack to record decisions.
- Irrecoverable can use some sort of planning.
  - Examine several steps before one is actually taken.

Problem Characteristics

- 3. Is the problem universe predictable?
  - You can plan the 8 puzzle. You know what will happen every time you move a square.
  - Therefore a control structure that allows backtracking will be necessary.
  - However, this may not be so in other situations.
  - Playing cards:-
    - which card to play first. Don't know the location of all other cards.

Problem Characteristics

- Playing cards
  - will investigate several plans and try to use probabilities to choose a plan that may lead to a good score.
- This illustrates certain outcome and uncertain outcome problems.
- Certain outcome problems can be easily planned, not so with uncertain.

Problem Characteristics

- To solve uncertain outcome problems,
  - need to allow for plan revision as an initial plan is carried out and feedback is provided.
- The characteristics ignorable, recoverable and irrecoverable and certain and uncertain interact.
  - Already stated that to solve an irrecoverable problem, plan an entire solution.
  - Only possible with certain outcome problems.

Problem Characteristics

- So one of the hardest problems to solve will be irrecoverable uncertain outcome.
- Example
  - Playing cards.
  - Helping a lawyer to decide how to defend a client against a murder charge.

Problem Characteristics

- 4. Is a good solution relative or absolute?
  - How many ways can we prove Marcus is dead?
    - Once you find one solution, why bother evaluating another to see if he is dead another way?
  - Travelling Salesman
    - Requires that we find the best solution, so when you find one, you can only verify if it is a good solution by finding the other possible outcomes.
  - Illustrates any path problems and best path problems.

Problem Characteristics

- 5. Is the solution a state or a path to a state?
  - For natural language understanding, the interaction among the interpretations of the constituents of a sentence may cause ambiguity.
  - To solve the problem of finding the interpretation required, we need to produce only the interpretation itself, the workings are not necessary.

Problem Characteristics

  - However, for the jug problem, the final state of (2,0) is not sufficient. What is required is the path to the solution.
- 6. What is the role of knowledge?
  - Two situations.
  - Playing chess. Even with unlimited computing power, the only knowledge required is the legal moves, and an appropriate search engine.
    - Additional knowledge will help, but is not essential.

Problem Characteristics

  - Scanning a paper to see which party they support.
  - Need names of party members, party objectives and the association with people.
- In the first instance, a lot of knowledge helps to constrain the search for a solution.
- In the second, need a lot of knowledge to even recognise a solution.

Problem Characteristics

- 7. Does the task require interaction with a person?
  - Can distinguish two types of problem here:-
  - Solitary
    - in which the computer is given a problem description and produces an answer with no intermediate communication and no demand for an explanation of the reasoning process.

Problem Characteristics

  - Conversational
    - in which there is intermediate communication between a person and the computer, either to provide additional assistance to the computer or to provide additional information to the user, or both.

Problem Characteristics

- Looking at these questions, it is clear that there are several broad classes of problems.
- These classes can be associated with generic control strategies appropriate to solving the problem.
  - Classification Problem - examine input and classify - medical diagnosis.
  - Propose and refine - design and planning problems.

Problem Characteristics

- There is no one single way of solving all problems.
- However, each new problem need not be considered in isolation.

Production System Characteristics

- Having looked at these problem types and bearing in mind that production systems are a good way to describe operations to be performed in search of a solution, there are two questions.
  - 1. Can production systems like problems be described by a set of characteristics that shed some light on how they can easily be implemented. (yes they can)

Production System Characteristics

- monotonic production systems - the application of a rule never prevents the later application of another rule which was an option at this time.
- Partially commutative systems - the application of a set of rules transforms state x into state y. Any permutation of those rules also transforms state x into state y.
- Commutative system is both monotonic and partially commutative.

Production System Characteristics

  - 2. What relationships are there between problem types and the types of production systems best suited to solving the problems.
    - In theory, there is no relationship as any type of production system can solve any type of problem.
    - In practice however, there is a definite relationship between the kinds of problems and the systems that lend themselves naturally to describing those problems.

Production System Characteristics

	Monotonic	Nonmonotonic
Partially Commutative	Theorem Proving	Robot navigation
Not Partially Commutative	Chemical synthesis	Bridge (cards)

- Partially comm. Monotonic
  - useful for ignorable problems
  - can be implemented with backtracking to optimise the search

Production System Characteristics

- Because the database does not need to be restored, the decisions made and the positions of changes in the search process are not recorded.
- Partially comm. Nonmonotonic
  - useful for problems in which change occurs but can be reversed and the order of operation is not important.
  - Common in physical manipulation problems.

Production System Characteristics

- Non partially comm.
  - Useful in situations where irreversible change occurs
- Partially comm systems can produce the same individual states during a search.
- Non Partially comm systems are less likely to produce the same node many times.

Production System Characteristics

- Issues in design of search programs
- the search process must find a path through the tree that connects an initial state with a goal state.
- In theory
  - the tree to be searched could be constructed in its entirety from the rules that define allowable moves in the state space.

Production System Characteristics

- In Practice
  - the theoretical tree is too large.
  - Rather than building the tree explicitly and then building it, most systems represent the tree implicitly in the rules and generate explicitly only those parts which are being explored.
- There are many search types, but some important issues arise in all, no matter which is used.

Production System Characteristics

- the direction in which to conduct the search
  - forward or backward reasoning.
- How to select the applicable rules (matching).
  - Critical to be efficient as a lot of time is spent matching.
- How to represent each node
  - knowledge representation problem and the frame problem