Production System

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Production Rules [1,2]

- **Rule/Condition-Action Rule** also called a *production* or ***production rule*** is a rule of the form **if** (*condition*) **then** (*action*).

  Example: **If** tomorrow is exam **then** study today.

- The condition may be a compound one using connectives like **and**, **or**, and **not**. The action can also be compound.

Production Rules…

- The action can affect the value of working memory variables, or take some real world action, or potentially do other things, including stopping the production system.
- *The knowledge of many expert systems is principally stored in their* ***collections of rules***.

Production System [3]

- The production system is **a Model of Computation** that can be **applied to implement search algorithms** and **model human problem solving**.

- Such problem solving knowledge can be packed up in the form of little quanta called **productions**.

Architecture/Components of Production System [3]

- A **Set of Production Rules** which are of the form **If (condition) THEN (action)**. Each rule consists of left hand side constituent that represent the current problem state and a right hand side that represent an output state. A rule is applicable if its left hand side matches with the current problem state.
- One or more **Knowledge-Bases** which contain all the appropriate information for the particular task. Some parts of the database may be permanent while others may temporary and only exist during the solution of the current problem.

Architecture/Components of Production System…

- A **Control Strategy** that specifies order in which the rules will be compared to the database of rules and a way of resolving the conflicts that arise when several rules match simultaneously.
- A **Rule Applier** which checks the ***capability of rule by matching the content state*** with the left hand side of the rule and finds the appropriate rule from database of rules.
- The production rules are also known as **Condition – Action**, **Antecedent – Consequent**, **Pattern – Action**, **Situation – Response**, **Feedback – Result Pairs**.

Architecture/Components of Production System…

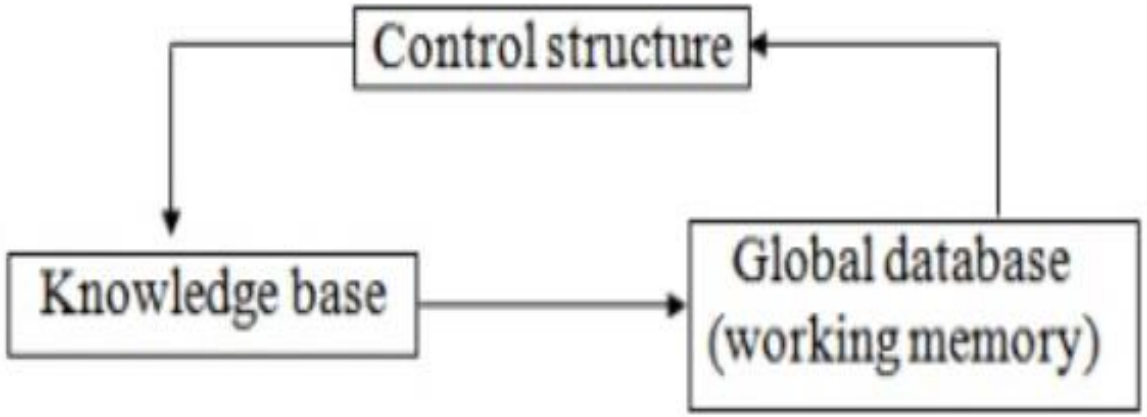


Fig 01: Architecture of Production System

Production System-Example

Water-Jug-Problem [4]

Statement : We are given 2 jugs, a **4 liter** one and a **3 liter** one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. How can we get exactly 2 liters of water in to the 4 liter jugs?

Production System-Example

To solve this we have to make some assumptions not mentioned in the problem. They are

- We can fill a jug from the pump.
- We can pour water out of a jug to the ground.
- We can pour water from one jug to another.
- There is no measuring device available.

Production System-Example

Rule no.	Rules
1	(x,y)→(4,y); Fill the 4 liter Jug if **x<4**
2	(x,y)→(x,3); Fill the 3 liter Jug if **y<3**
3	(x,y)→(0,y); Empty the 4 liter jug on the ground **if x>0**
4	(x,y)→(x,0); Empty the 3 liter jug on the ground **if y>0**
5	(x,y)→(4,y-(4-x)); Pour water from the 3 liter jug into the 4 liter jug until the 4 liter jug is full **if x+y >= 4** and **y>0**
6	(x,y)→(x-(3-y),3); Pour water from the 4 liter jug into the 3 liter jug until the 3 liter jug is full **if x+y >= 3** and **x>0**
7	(x,y)→(x+y,0); Pour all water from the 3 liter jug into the 4 liter jug **if x+y <= 4** and **y>0**
8	(x,y)→(0,x+y); Pour all water from the 4 liter jug into the 3 liter jug **if x+y <= 3** and **x>0**

Production System-Example

Liters in the 4-liter jug(x)	Liters in the 3-liter jug(y)	Rules applied
0	0	-
4	0	1
1	3	6
0	3	3
3	0	7
3	3	2
4	2	5
0	2	3
2	0	7

Features of Production System [3]

- **Simplicity:** The structure of each sentence in a production system is unique and uniform as they use "IF-THEN" structure. This structure provides **simplicity in knowledge representation**. This feature of production system improves the readability of production rules.

- **Modularity:** This means production rule code the knowledge available in discrete pieces. Information can be treated as a collection of independent facts which may be **added or deleted** from the system with essentially no deleterious side effects.

- **Modifiability:** This means the facility of **modifying rules**. It allows the development of production rules in a skeletal form first and then it is accurate to suit a specific application.

- **Knowledge intensive:** The knowledge base of production system stores pure knowledge. This part **does not contain any type of control or programming information**. Each production rule is normally written as an English sentence; the problem of semantics is solved by the very structure of the representation.

Types of Production System [5]

- Monotonic Production System: A system in which the application of a rule never prevents the later application of another rule, that could have also been applied at the time the first rule was selected.
- Non-monotonic Production System: A system in which the application of a rule prevents the later application of another rule.
- Partially Commutative Production System: A production system in which the application of a particular sequence of rules transforms state X into state Y, then any permutation of those rules that is allowable also transforms state X into state Y.
- Commutative Production System: A production system which is both monotonic and partial commutative.

Importance of Production System

- The important roles played by production systems include a **powerful knowledge representation** scheme.
- A production system not only represents knowledge but also action.
- It acts as **a bridge between AI** and **expert systems**.
- Production system provides a language in which the representation of expert knowledge is very natural.

Drawback of Production System [3]

- **Opacity:** This problem is generated by the combination of production rules. The opacity is generated because of less prioritization of rules. More priority to a rule has the less opacity.

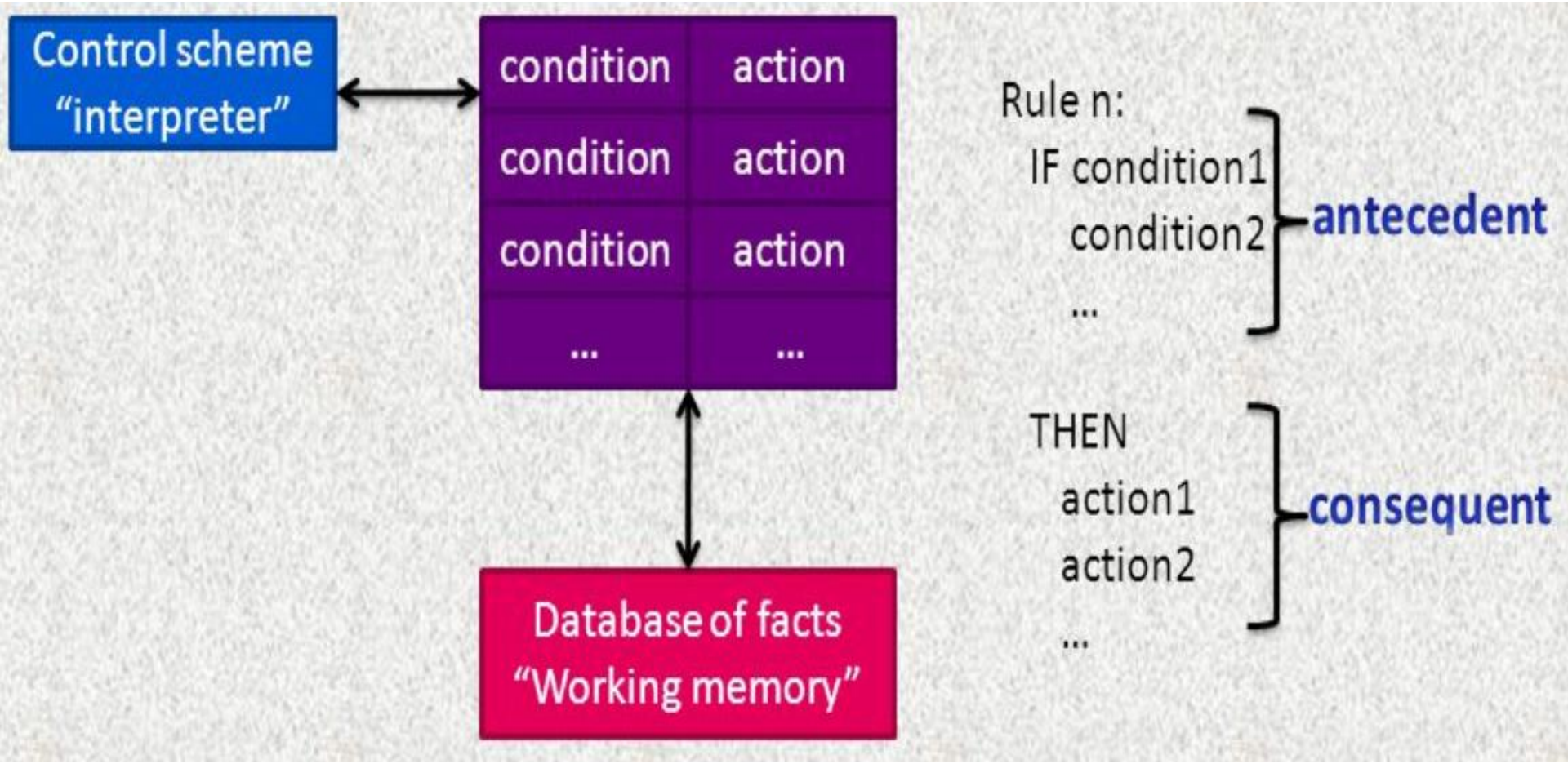
- **Inefficiency:** During execution of a program several rules may active. A well devised control strategy reduces this problem. As the rules of the production system are large in number and they are hardly written in hierarchical manner, it requires some forms of **complex search** through all the production rules for each cycle of control program.

- **Conflict resolution:** The rules in a production system should not have any type of conflict operations. When a new rule is added to a database, it should ensure that it does not have any conflicts with the existing rules.

Rule-Based System

- ✓ Rule-based systems consist of **a set of rules**, **a working memory** and an **inference engine**.
- ✓ The simplest form of artificial intelligence, which is generally used in industry, is the rule-based system, also known as the expert system.
- ✓ A rule-based system is a way of encoding a human expert's knowledge in a fairly narrow area into an automated system.
- ✓ The knowledge of the expert is captured in a set of rules, each of which encodes a small piece of the expert's knowledge. Each rule has a left hand side and a ride hand side. The left hand side contains information about certain facts and objects, which must be true in order for the rule to potentially, fire (that is, execute).
- ✓ Any rules whose left hand sides match in this manner at a given time are placed on an agenda. One of the rules on the agenda is picked (there is no way of predicting which one), and its right hand side is executed, and then it is removed from the agenda. The agenda is then updated (generally using a special algorithm called the Rete algorithm), and a new rules is picked to execute. This continues until there are no more rules on the agenda.

Rule-Based System…



When one part of the IF portion matches a fact in working memory, the antecedent is SATISFIED. When all antecedents are satisfied, the rule is TRIGGERED. When the consequent of a rule is performed, the rule is FIRED.

Rule-Based System Versus Production System [6]

- In a production system, the **if...then... rules** are gathered together in a **rule base**, and the controlling part of the system **has some way of choosing a rule (rule applier)** from this knowledge base which is appropriate to the current circumstances, and then using it.

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THANKS