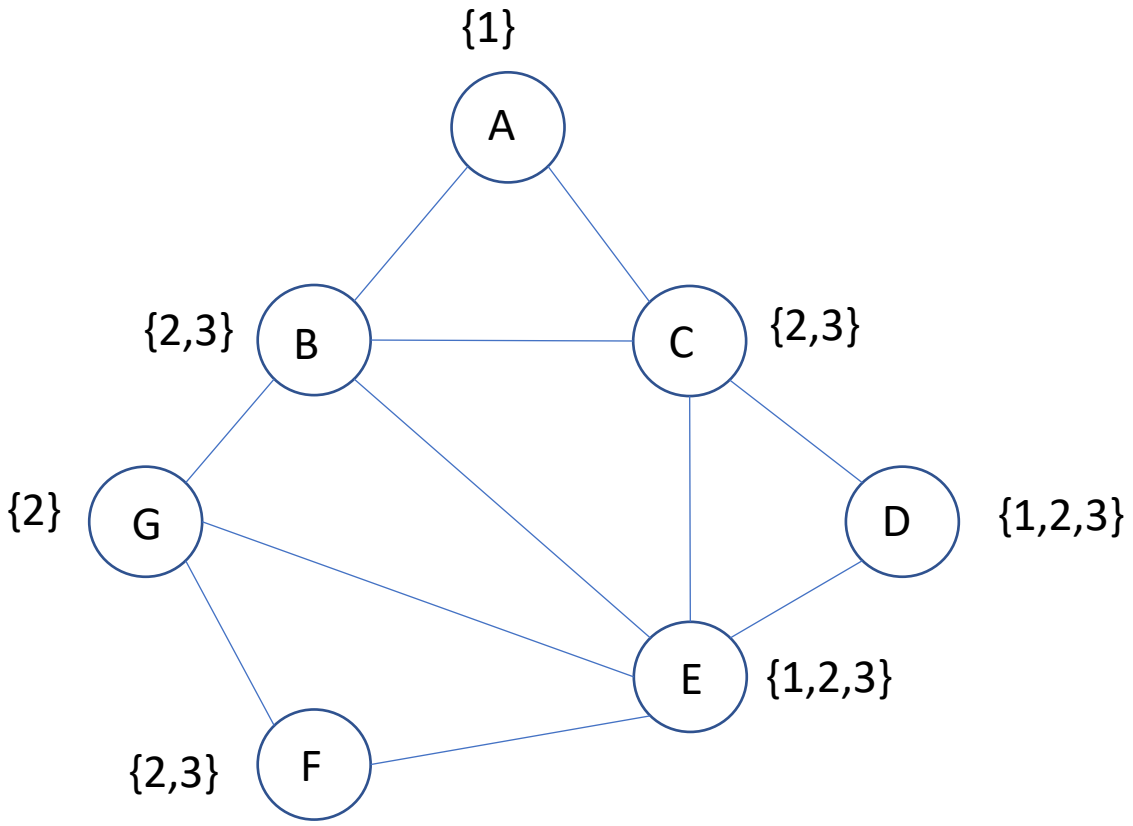
BBM405 Fundamentals of Artificial Intelligence

Final, Spring 2023, Part1

June 12, 2023

Q1) (24 pts) CSP

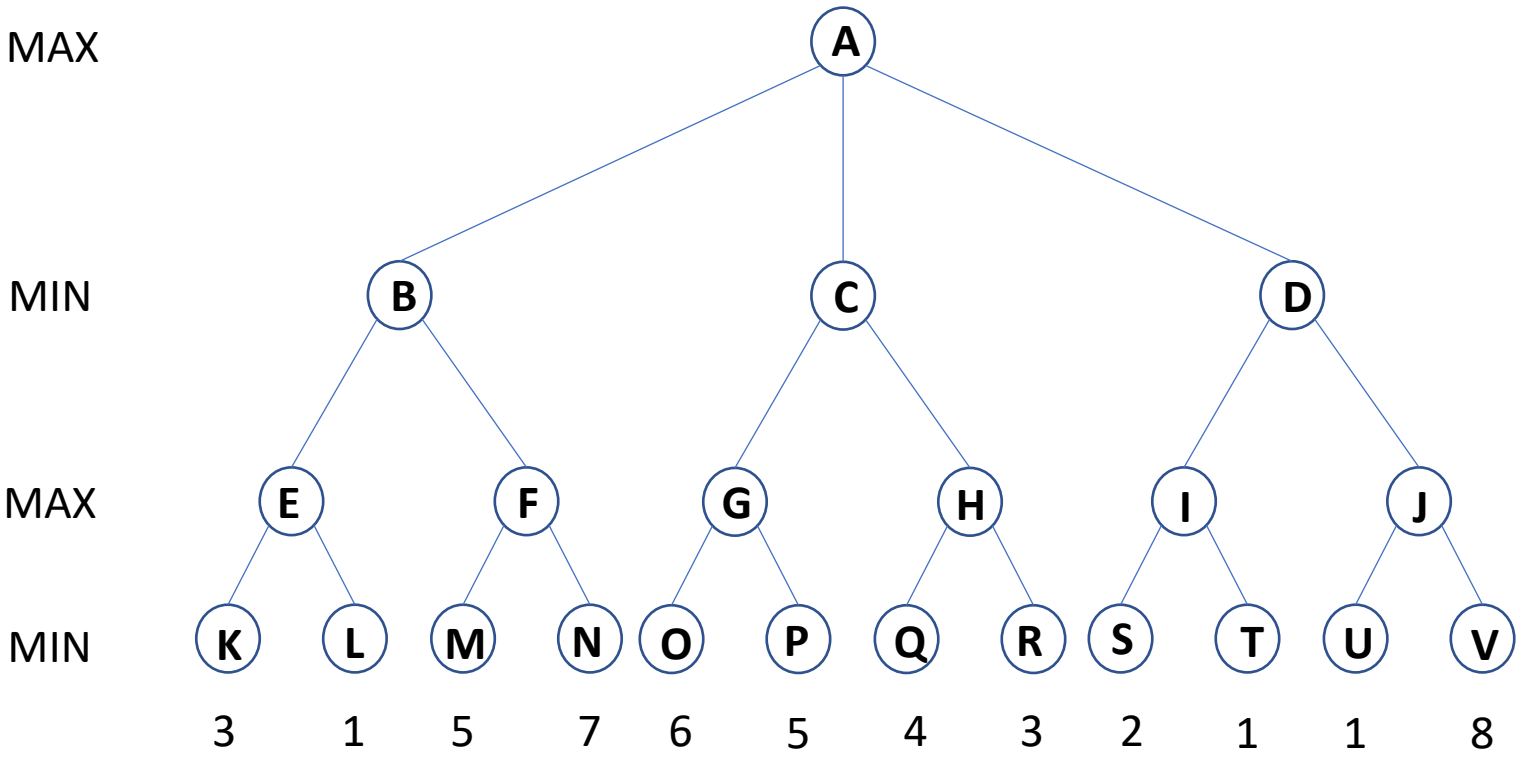
Consider the following constraint graph where nodes represent the variables (A-G) and arcs correspond to the binary constraints, such that connected nodes cannot have the same value assigned. Domains of each variable are given inside curly braces. Note that they are not the same. Unless mentioned otherwise, follow lexical ordering for the variables (A-B-C-D-E-F-G) and for the values (1-2-3).



a) (6 pts) Apply **arc-consistency** (constraint propagation) alone. Provide the resulting values assigned to each node.
b) (9 pts) Apply **backtracking with forward checking** using lexical ordering. Show the tree, backed-up nodes, and value pruning clearly.
c) (9 pts) Now, apply **pure backtracking** using the following variable ordering: (E-C-B-G-A-D-F}.

Q2) (10 pts) Games

Consider the game tree below



a) (2 pts) Compute the backed-up values found by the minimax algorithm. Write your answers on the nodes. Show the winning path.

b) (8 pts) Apply alpha-beta pruning. Which nodes will not be examined by the alpha-beta pruning algorithm? Show the cut-offs on the tree. Write the paths like X-Y where X and Y are the nodes connecting the pruned arc.

Q3) (22 pts) First Order Logic

a) (12 pts) Convert the following sentences into CNF and drop the quantifiers.

1. $\forall x\,([\forall y\ A(y) \wedge B(x,y)\ ] \rightarrow C(x))$
2. $\neg\ [\forall x\ \forall y\ A(y) \rightarrow B(x,y)\ ] \rightarrow [\ \exists z\ C(z)]$

b) (10 pts) Given the following knowledge base, derive the conclusion using resolution.

Knowledge base:

$(P \wedge T) \rightarrow Q$

$Q \rightarrow (R \rightarrow \neg U)$

$R \wedge S$

$(S \rightarrow T) \vee U$

Conclusion:

$\neg P$