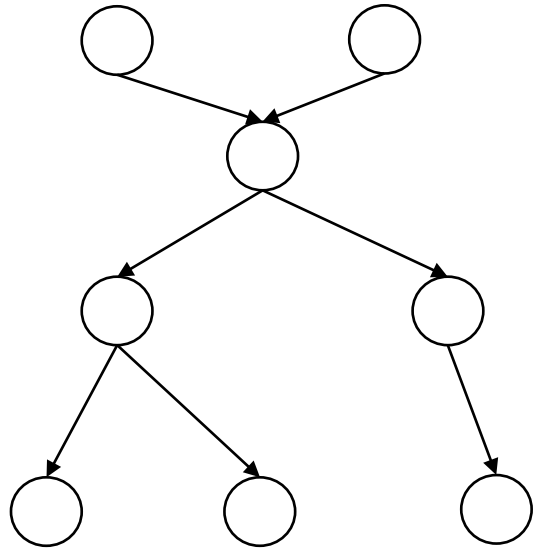
Q1-1: Consider a case with 8 random variables, how many parameters does a BN with the following graph structure have?

1. 24
2. 28
3. 32
4. 52



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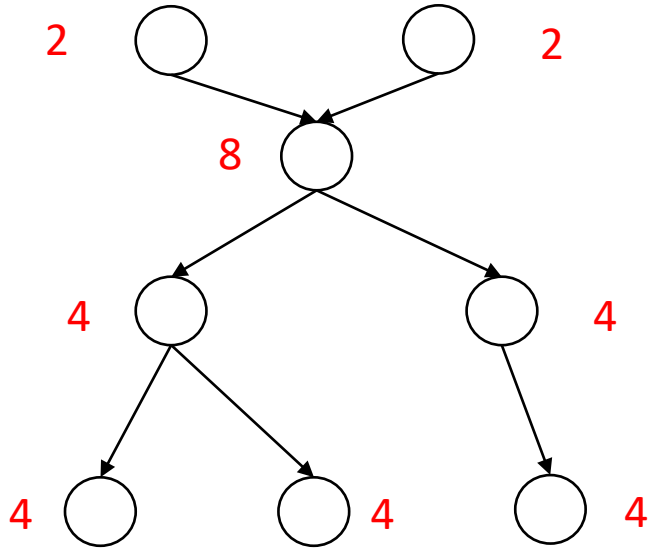

So we have 32 parameters in total.

Q1-2: Are these statements true or false for BN?
(A) If each variable has few parents in the DAG, the distribution can be represented with very few parameters.
(B) The corresponding DAG models the dependencies between variables, and also models conditional probability distributions at each node.

1. True, True
2. True, False
3. False, True
4. False, False

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1. True, True
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3. False, True
4. False, False

(A) If a node has fewer parents, then the conditional probability distribution at that node can be represented with fewer parameters.
(B) The DAG can only model the dependencies. It does not place any constraint on how we define our conditional probabilities. It only defines which variables allowed to take in as arguments.

Q2-1: Are these statements true or false?
(A) We can only query variables at those nodes without parents.
(B) Dependencies between variables are unknown in the parameter learning task.

1. True, True
2. True, False
3. False, True
4. False, False

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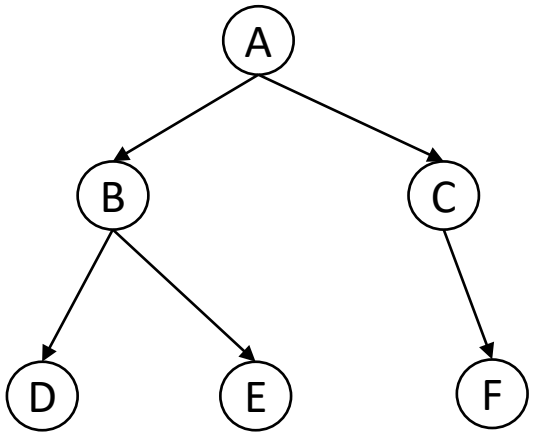
(A) We can only query variables at those nodes without parents.
(B) Dependencies between variables are unknown in the parameter learning task.

1. True, True
2. True, False
3. False, True
4. False, False 

(A) Any set of variables in the graph can be query variables by the flexibility of the BN structure.
(B) The graph structure (dependencies between variables) are known in the parameter learning task.

Q2-2: Suppose we are given the query $p(a|d,e,f)$, it can by computed by $p(a|d,e,f) = \frac{p(a,d,e,f)}{p(d,e,f)} = \frac{p(a,d,e,f)}{p(a,d,e,f)+p(\neg a,d,e,f)}$, and $p(a,d,e,f)$, $p(\neg a,d,e,f)$ can be computed in a similar way.
Please compute $p(a,d,e,f)$ based on the following graph structure.



1. $p(a)\sum_{b,\neg b}\sum_{c,\neg c} p(B)p(C|a)p(d|B)p(e|B)p(f|C)$
2. $p(a)\sum_{b,\neg b}\sum_{c,\neg c} p(B)p(C)p(d|B)p(e|B)p(f|C)$
3. $p(a)\sum_{b,\neg b}\sum_{c,\neg c} p(B|a)p(C)p(d|B)p(e|B)p(f|C)$
4. $p(a)\sum_{b,\neg b}\sum_{c,\neg c} p(B|a)p(C|a)p(d|B)p(e|B)p(f|C)$

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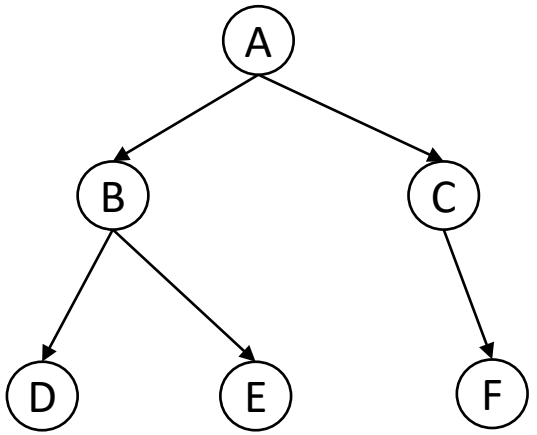

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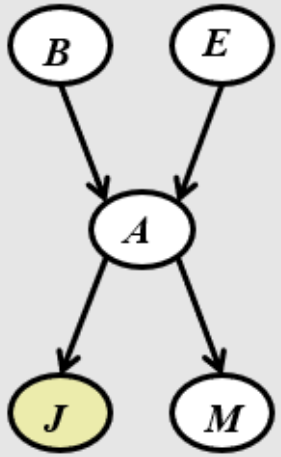
4. $p(a)\sum_{b,\neg b}\sum_{c,\neg c} p(B|a)p(C|a)p(d|B)p(e|B)p(f|C)$ ⬅

By the graph structure, we can see that $p(A,B,C,D,E,F) = p(A)p(B|A)p(C|A)p(D|B)p(E|B)p(F|C)$.
Plug in values of a,d,e,f and enumerate values over B,C, we get the expression above. P(a d e f) = \sum_{B ,C } P(a B C d e f)

Q3-1: Please choose the correct CPD parameter estimates for J in the alarm network given the following dataset.

1. $p(m|a) = 0.625$
2. $p(\neg m|a) = 0.325$
3. $p(m|\neg a) = 0.25$
4. $p(\neg m|\neg a) = 0.5$



B	E	A	J	M
f	f	f	t	f
f	t	f	f	f
f	f	f	t	t
t	f	f	f	t
f	f	t	t	f
f	f	t	f	t
f	f	t	t	t
f	f	t	t	t

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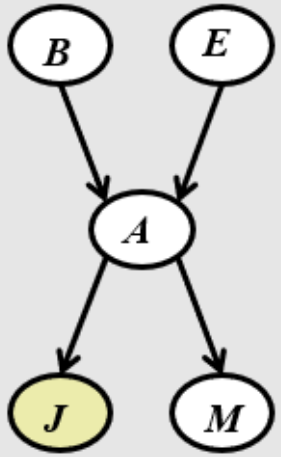


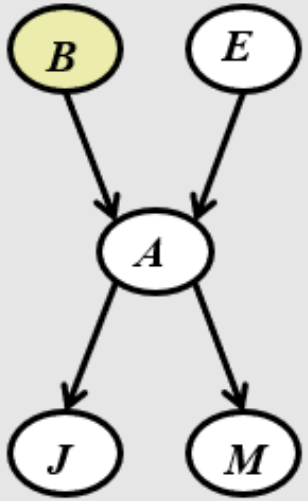
B	E	A	J	M
f	f	f	t	f
f	t	f	f	f
f	f	f	t	t
t	f	f	f	t
f	f	t	t	f
f	f	t	f	t
f	f	t	t	t
f	f	t	t	t

$p(m|a) = \frac{3}{4} = 0.75,$
$p(\neg m|a) = \frac{1}{4} = 0.25,$
$p(m|\neg a) = \frac{2}{4} = 0.5,$
$p(\neg m|\neg a) = \frac{2}{4} = 0.5.$

Q3-2: Please estimate parameters for E using m-estimates with $m = 4$ and $p_e = 0.05$ in the alarm network given the following dataset.

1. $p(e) = 0.125, p(\neg e) = 0.875$
2. $p(e) = 0.2, p(\neg e) = 0.8$
3. $p(e) = 0.1, p(\neg e) = 0.9$
4. $p(e) = 0.17, p(\neg e) = 0.83$

$$P(X = x) = \frac{n_x + p_x m}{\left(\sum_{v \in \text{Values}(X)} n_v \right) + m}$$



B	E	A	J	M
f	f	f	t	f
f	t	f	f	f
f	f	f	t	t
t	f	f	f	t
f	f	t	t	f
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f	f	t	t	t
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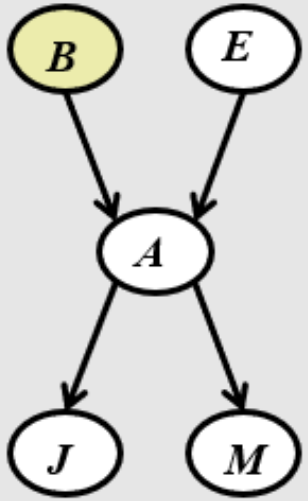
$$p(e) = \frac{1+4*0.05}{8+4} = \frac{1.2}{12} = 0.1,$$
$$p(\neg e) = \frac{7+4*0.95}{8+4} = 0.9.$$



B	E	A	J	M
f	f	f	t	f
f	t	f	f	f
f	f	f	t	t
t	f	f	f	t
f	f	t	t	f
f	f	t	f	t
f	f	t	t	t
f	f	t	t	t