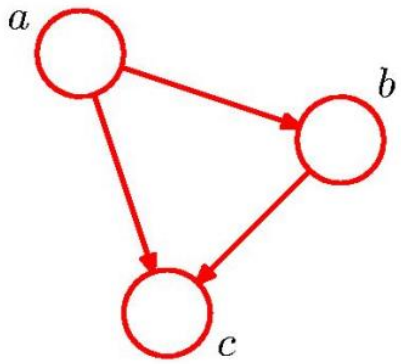
Live Interaction #8:

3rd March 2024

E-masters Next Generation Wireless Technologies

EE902 Advanced ML Techniques for Wireless Technology

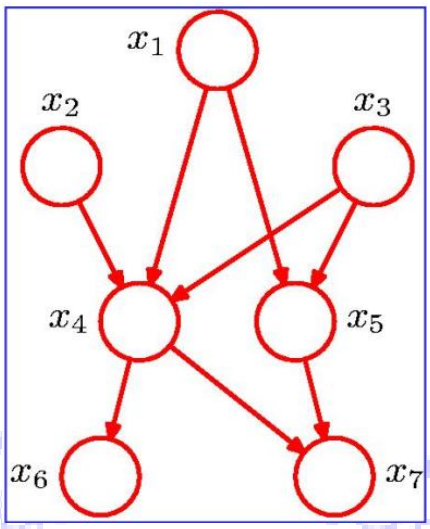
- **Probabilistic Graphical Models:**



- Nodes: ***Random variables***.
- Edges: **Probabilistic relationships**.
- Joint PDF

$$p(x_1, x_2, \dots, x_K) = p(x_1) \times p(x_2|x_1) \times p(x_3|x_1, x_2) \times p(x_4|x_1, x_2, x_3) \times \dots \times p(x_K|x_1, x_2, \dots, x_{K-1})$$

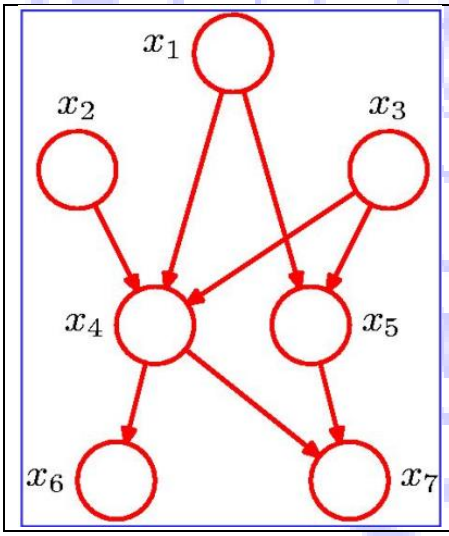
- **Bayesian Network:**



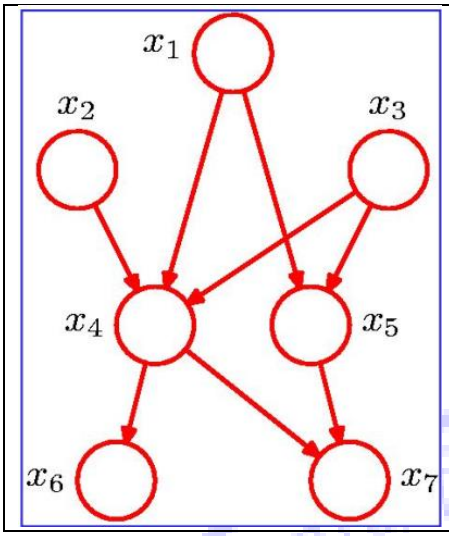
- **Parent nodes**:

$$x_5$$
$$\mathcal{P}_5 = \{x_1, x_3\}$$
$$p(x_k|x_1, x_2, \dots, x_{k-1}) = p(x_k|\mathcal{P}_k)$$

- Given parents, x_k is **conditionally independent** of others!

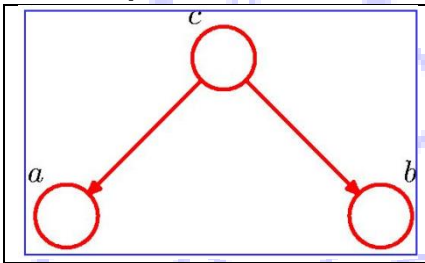


$$p(x_1, x_2, x_3, x_4, x_5, x_6, x_7)$$
$$= p(x_1) \times p(x_2|x_1)$$
$$\times p(x_3|x_1, x_2)$$
$$\times p(x_4|x_1, x_2, x_3)$$
$$\times p(x_5|x_1, x_2, x_3, x_4)$$
$$\times p(x_6|x_1, x_2, x_3, x_4, x_5)$$
$$\times p(x_7|x_1, x_2, x_3, x_4, x_5, x_6)$$

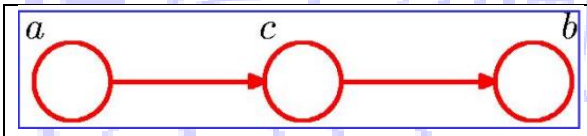


$$p(x_1, x_2, x_3, x_4, x_5, x_6, x_7) = p(x_1) \times p(x_2) \times p(x_3) \times p(x_4|x_1, x_2, x_3) \times p(x_5|x_1, x_3) \times p(x_6|x_4) \times p(x_7|x_4, x_5)$$

- Example



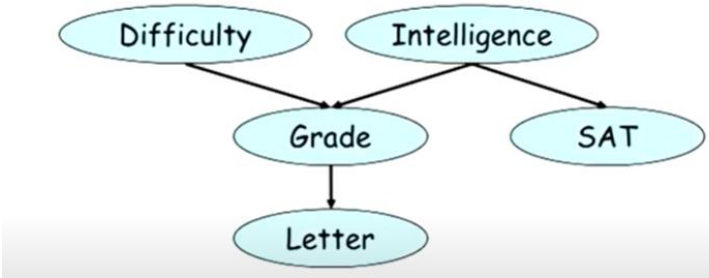
$$p(c) \times p(a|c) \times p(b|c)$$



Markov chain

$$p(a, b, c, d) = p(a) \times p(c|a) \times p(b|c) \times p(d|b)$$

- Student example:

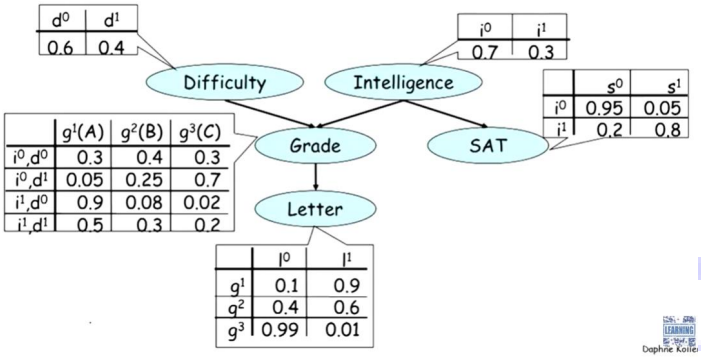


$$p(D, I, G, L, S) = p(D) \times p(I) \times p(G|D, I), p(L|G)$$

$$\times p(S|I)$$

$$p(D,I,G,L,S) = p(D) \times p(I|D) \times p(G|D,I), p(L|G,D,I) \times p(S|D,I,G,L)$$

- Probabilities



- BN aids in compact representation!
- Computing any **joint probability**

$$p(d^1, i^0, g^3, s^1, l^1)$$
$$= 0.4 \times 0.7 \times 0.7 \times 0.05 \times 0.01$$
$$= 0.000098$$

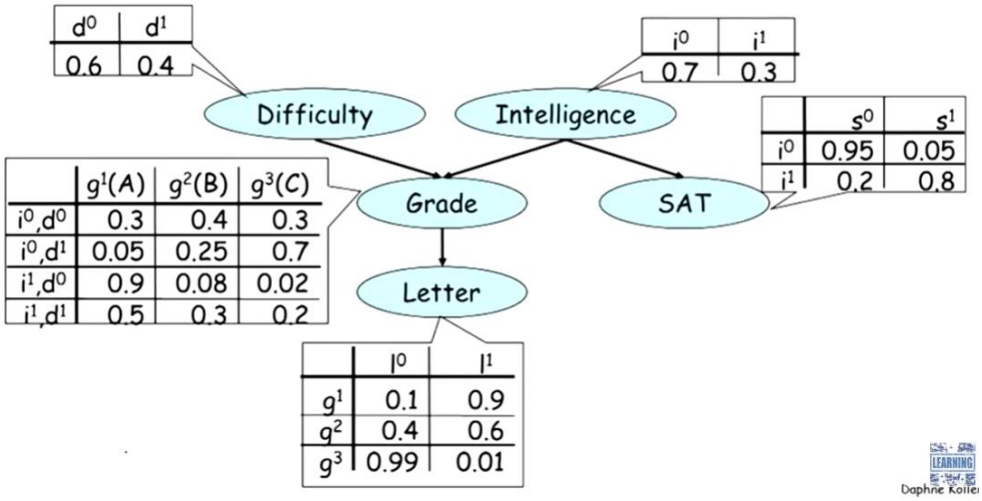
- Computing the conditional probability:

$$p(i^1|s^1, l^0) = \frac{p(i^1, s^1, l^0)}{p(s^1, l^0)}$$
$$= \frac{\sum_{D,G} p(i^1, s^1, l^0, D, G)}{\sum_{I,D,G} p(s^1, l^0, I, D, G)}$$
$$\sum_{D,G} p(i^1, s^1, l^0, D, G)$$
$$= p(i^1, s^1, l^0, d^0, g^1) + p(i^1, s^1, l^0, d^0, g^2) + p(i^1, s^1, l^0, d^0, g^3)$$
$$+ p(i^1, s^1, l^0, d^1, g^1) + p(i^1, s^1, l^0, d^1, g^2) + p(i^1, s^1, l^0, d^1, g^3)$$

- **Causal reasoning:**

$$p(G|D), p(L|I)$$

- **Evidential reasoning:**

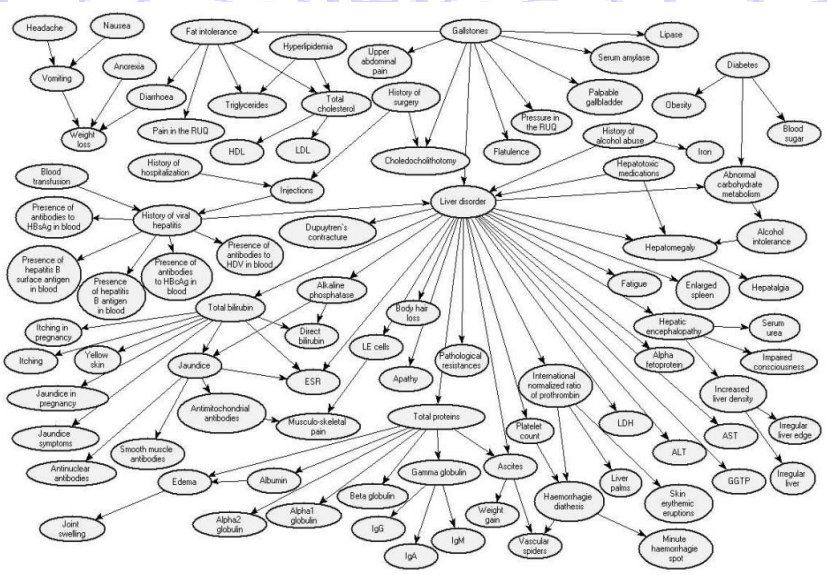


$$p(I|L), p(D|L)$$

- **Intercausal reasoning:**

$$p(I|D,L)$$

- Medical diagnosis:



- **Assignment #8 Deadline: 7th March Thursday 11:59 PM.**
- **Assignment #7, 8 Discussion: 8th March Friday 8:00 PM – 8:30 PM.**
- **Quiz #4: 8th March Friday 9:00 - 9:45 PM.**
- **Final Exam: 10th March Sunday 9:00 AM – 12:00 PM. (Please check!!)**