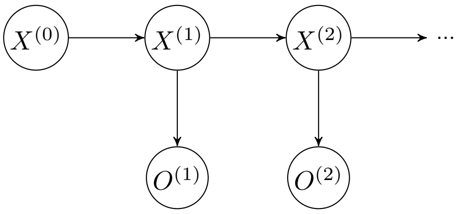


Figure 1: Dynamic Bayesian network

1 Exercises

Exercise 1.1 *Markov Assumption. If a dynamic system X satisfies the Markov assumption for all time $t \geq 0$, which of the following statements must be true? You may select 1 or more options, or none of them.*

a) $X^{(t+1)} \perp\!\!\!\perp X^{(t)}$

b) $X^{(t+1)} \perp\!\!\!\perp X^{(t)} | X^{(t-1)}$

c) $X^{(t+1)} \perp\!\!\!\perp X^{(0:(t-1))} | X^{(t)}$

Exercise 1.2 *Independencies in DBNs. In the DBN of Figure 1, which of the following independence assumptions are true? You may select 1 or more options, or none of them.*

a) $O^{(t)} \perp\!\!\!\perp X^{(t+1)} | X^{(t)}$

b) $O^{(t)} \perp\!\!\!\perp X^{(t-1)} | X^{(t)}$

c) $O^{(t)} \perp\!\!\!\perp O^{(t-1)}$

d) $O^{(t)} \perp\!\!\!\perp O^{(t-1)} | X^{(t)}$

Exercise 1.3 *Applications of DBNs. For which of the following applications might one use a DBN (i.e. the Markov assumption is satisfied)? You may select 1 or more options, or none of them.*

a) Modeling data taken at different locations along a road, where the data at each location is influenced by the data at many other locations.

b) Predicting the probability that today will be a snow day (school will be closed because of the snow), when this probability depends only on whether yesterday was a snow day.

c) Predicting the probability that today will be a snow day (school will be closed because of the snow), when this probability depends only on whether yesterday, the day before yesterday, and 2 Mondays ago were snow days.

d) Modeling time-series data, where the events at each time-point are influenced by only the events at the one time-point directly before it

Exercise 1.4 *Plate Semantics. Let A and B be random variables inside a common plate indexed by i. Which of the following statements must be true? You may select 1 or more options, or none of them.*

a) For each i, $A(i)$ and $B(i)$ have different CPDs.

b) For each i, $A(i)$ and $B(i)$ have edges connecting them to the same variables outside of the plate.

c) For each i, $A(i)$ and $B(i)$ have the same CPDs.

d) There is an instance of A and an instance of B for every i.

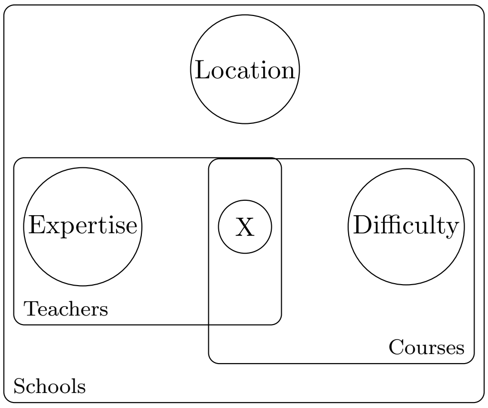


Figure 2: Plate model without edges for schools

Exercise 1.5 *Plate Interpretation. Consider the plate model of Figure 2 (with edges removed). Which of the following might a given instance of X possibly represent in the grounded model? You may select 1 or more options, or none of them.*

a) *Whether a specific teacher T taught a specific course C at school S*

b) *Whether someone with expertise E taught something of difficulty D at a place in location L*

c) *Whether a specific teacher T is a tough grader*

d) *None of these options can represent X in the grounded model*

e) *Whether a teacher with expertise E taught a course of difficulty D*

Exercise 1.6 *Grounded Plates. Consider the plate model of Figure 2 and assume that there are s schools, t teachers and c courses in each school. How many instances of the Difficulty variable are there?*

a) c

b) $s \cdot c$

c) *Not enough information to answer*

d) $s \cdot t$

Exercise 1.7 *Plate models. Consider the plate model of Figure 3. Assume we are given K Markets, L Products, M Consumers and N Locations. Which is the total number of instances of the variable P in the grounded BN?*

a) $K \cdot (L + M)$

b) $L \cdot M$

c) $K \cdot L \cdot M$

d) $K \cdot (N + (L \cdot M))$

e) $K + L + M$

Exercise 1.8 *Plate interpretation. Consider the plate model of Figure 3. What might P represent?*

a) *Whether a specific product PR was consumed by consumer C in market M*

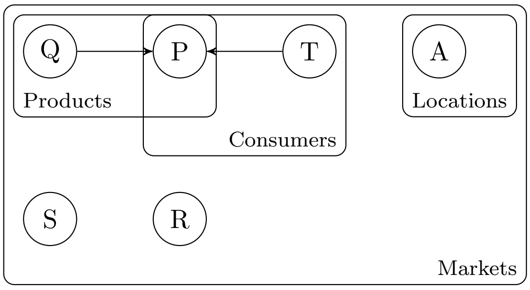
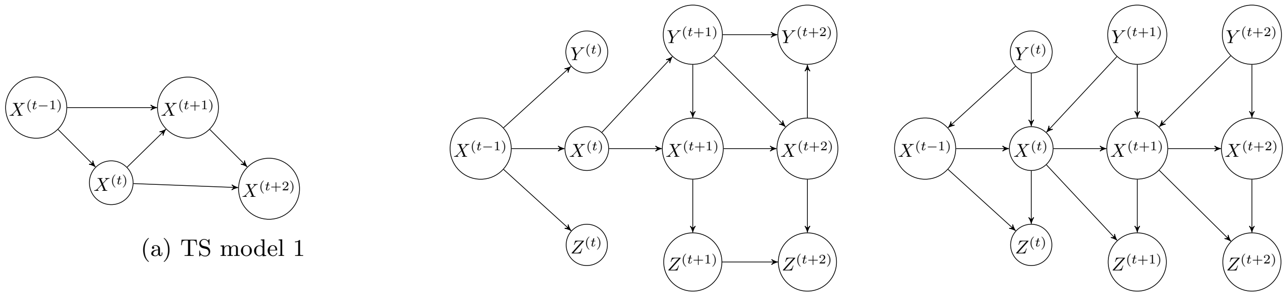


Figure 3: Plate model *market*



(a) TS model 1

(b) TS model 2

(c) TS model 3

Figure 4: Different TS models

b) *Whether a specific product PR was consumed by consumer C in market M that is supervised by supervisor S (assuming that there is exactly 1 unique supervisor per market) and has target audience R (assuming that there is exactly a unique target audience per market)*

c) *Whether a specific product PR was consumed by consumer C in all markets*

d) *Whether a specific product of brand Q was consumed by a consumer with age T in a market of type M*

Exercise 1.9 *Graphs for time series modeling. Which of the graphs in Figure 4 satisfies the Markov assumption? You may select 1 or more options, or none of them.*

a) *4a*

b) *4b*

c) *4c*

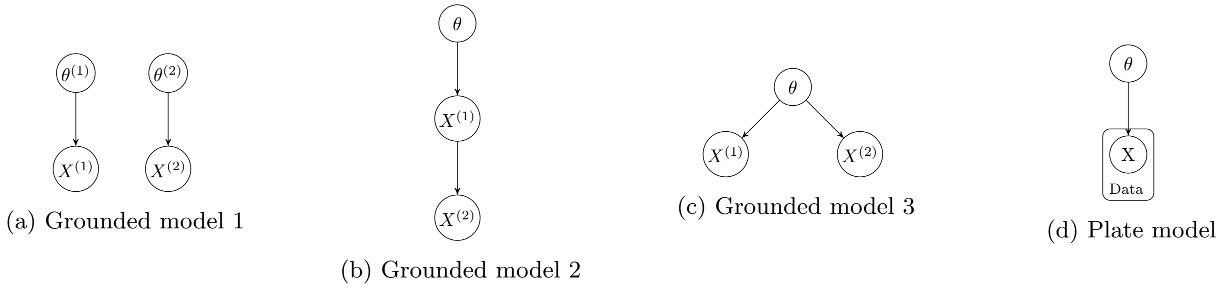
Exercise 1.10 *Grounded plates. Which graph in Figure 5 is a valid grounded model for the plate 5d? You may select 1 or more options, or none of them.*

a) *5a*

b) *5b*

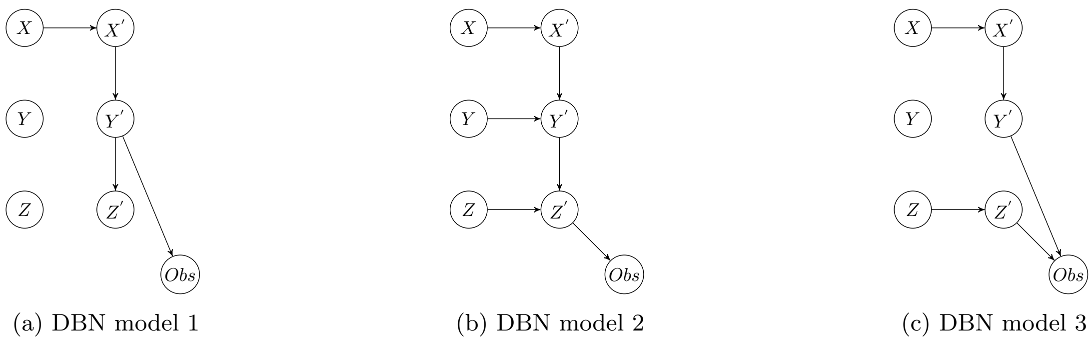
c) *5c*

Exercise 1.11 *Unrolling DBNs. In Figure 6 there are several 2-TBNs that could be unrolled into DBNs. Consider these unrolled DBNs (note that there are no edges within the first time-point). In which of them will $(X(t) \perp\!\!\!\perp Z(t)|Y(t))$ hold for all t, assuming $Obs(t)$ is observed for all t and $X(t)$ and $Z(t)$ are never observed? You may select 1 or more options, or none of them.*
Hint: Unroll these 2-TBNs into DBNs that are at least 3 time steps long (i.e., involving variables from $t-1$, t, $t+1$)



(a) Grounded model 1 (b) Grounded model 2 (c) Grounded model 3 (d) Plate model

Figure 5: Different grounded models



(a) DBN model 1 (b) DBN model 2 (c) DBN model 3

Figure 6: Different DBN models

a) 6a

b) 6b

c) 6c

Exercise 1.12 *Plate interpretation. Consider the following scenario:*

On each campus there are Computer Science and Psychology students. We have a binary variable for whether the campus is large, a binary variable for whether the CS student is shy, a binary variable for whether the Psychology student likes computers, and a binary variable for whether the Computer Science student and the Psychology student are friends.

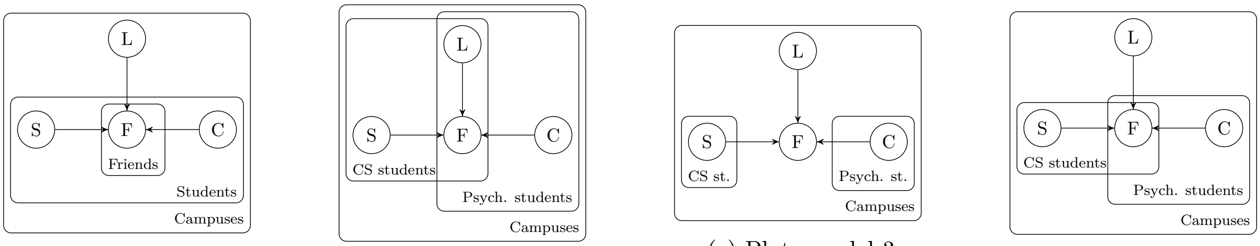
Which of the following plate models can represent this scenario?

a) Figure 7a

b) Figure 7b

c) Figure 7c

d) Figure 7d



(a) Plate model 1 (b) Plate model 2 (c) Plate model 3 (d) Plate model 4

Figure 7: Different plate models

Answers

Ex. 1.1: c

Ex. 1.2: a, b, d

Ex. 1.3: b, d

Ex. 1.4: d

Ex. 1.5: a

Ex. 1.6: b

Ex. 1.7: c

Ex. 1.8: a

Ex. 1.9: b

Ex. 1.10: c

Ex. 1.11: a

Ex. 1.12: d