# REPORT Lab 4

**Group 2, Subgroup 7 (*prigu857* and *fabcr549*)**

Task 2

5.a. $P(Meltdown) = 0.02578$

$P\ (Meltdown \mid IcyWeather) = 0.03472$

5.b. $P\ (Meltdown \mid PumpFailureWarning, WaterLeakWarning) = 0.14535$

$P\ (Meltdown \mid PumpFailureWarning, WaterLeakWarning, PumpFailure, WaterLeak) = 0.2$

5.c. Not all variables can be estimated even after a substantial number of experiments because they could be random. In this case a good example of hard to estimate variable could be IcyWeather.

5.d. The domain for a hypothetic "Temperature" variable could be both finite (I.e., Low, Medium, High) or infinite (I.e., -15.4 °C)

In the finite case situation, the distribution, compared to the IcyWeather, is lowered given that we have 3 assignments instead of two, thus the conditional probability will increase.

In the infinite case situation, since the possibilities are even more, the conditional probability will be even higher.

6.a. Probability table in a Bayesian Network represents the conditional probability for all variable' values cases with a finite domain.

6.b A full joint probability distribution represents the probability distribution for a pair of variables with all the possible values' combinations.

$$P\ (Meltdown = F, PumpFailureWarning = F, PumpFailure = F, WaterLeakWaring = F, WaterLeak = F, IcyWeather = F) =$$

$$P\ (Meltdown = F \mid PumpFailureWarning = F, PumpFailure = F, WaterLeakWaring = F, WaterLeak = F, IcyWeather = F) *$$

$$P\ (PumpFailureWarning = F \mid PumpFailure = F, WaterLeakWaring = F, WaterLeak = F, IcyWeather = F) *$$

$$P\ (PumpFailure = F \mid WaterLeakWaring = F, WaterLeak = F, IcyWeather = F)$$

$$P\ (WaterLeakWaring = F \mid WaterLeak = F, IcyWeather = F) *$$

$$P\ (WaterLeak = F \mid IcyWeather = F) *$$

$$P(IcyWeather = F) = 0.999 * 0.95 * 0.9 * 0.95 * 0.9 * 0.95 = 0.69378$$

There is a high chance that plant will not meltdown.

6.c $P\ (Meltdown \mid WaterLeak, PumpFailure) = 0.2$

Knowing the state of variable IcyWeather matters in terms of calculating the above probability as, based on the Bayesian Network, P(waterLeak) is depended on the state of variable IcyWeather.

6.d $P\ (Meltdown \mid PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F)$

$$= \alpha * \Sigma\, P\ (Meltdown, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure)$$

$$= \alpha * \big(P\ (Meltdown, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = T) + P\ (Meltdown, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = F)\big)$$

$$= \alpha * < 0.001218375 + 0.000694474, 0.006904125 + 0.693779276 >$$

$$= \alpha * < 0.001912849, 0.700683401 > = < 0.002722544, 0.997277456 >$$

$$\alpha = 1 / 0.70259625 = 1.423292538$$

$$\boldsymbol{P\ (Meltdown = T, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = T)}$$

$$= \boldsymbol{\alpha} * (\boldsymbol{P}(IcyWeather = F) * P\ (WaterLeak = F \mid IcyWeather = F) * P\ (WaterLeakWarning = F \mid WaterLeak = F) * P(PumpFailure = T) * P\ (PumpfailureWarning = F \mid PumpFailure = T) * P\ (Meltdown = T \mid PumpFailure = T, WaterLeak = F)$$

$$= \alpha * (0.95 * 0.9 * 0.95 * 0.1 * 0.1 * 0.15) = \alpha * 0.001218375$$

$$\boldsymbol{P\ (Meltdown = F, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = T)}$$

$$= \boldsymbol{\alpha} * (\boldsymbol{P}(IcyWeather = F) * P\ (WaterLeak = F \mid IcyWeather = F) * P\ (WaterLeakWarning = F \mid WaterLeak = F) * P(PumpFailure = T) * P\ (PumpfailureWarning = F \mid PumpFailure = T) * P\ (Meltdown = F \mid PumpFailure = T, WaterLeak = F)$$

$$= \boldsymbol{\alpha} * (0.95 * 0.9 * 0.95 * 0.1 * 0.1 * 0.85) = \alpha * 0.006904125$$

$$\boldsymbol{P\ (Meltdown = T, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = F)}$$

$$= \boldsymbol{\alpha} * (\boldsymbol{P}(IcyWeather = F) * P\ (WaterLeak = F \mid IcyWeather = F) * P\ (WaterLeakWarning = F \mid WaterLeak = F) * P(PumpFailure = F) * P\ (PumpfailureWarning = F \mid PumpFailure = F) * P\ (Meltdown = T \mid PumpFailure = F, WaterLeak = F)$$

$$= \boldsymbol{\alpha} * (0.95 * 0.9 * 0.95 * 0.9 * 0.95 * 0.001) = \boldsymbol{\alpha} * 0.000694474$$

$$\boldsymbol{P\ (Meltdown = F, PumpfailureWarning = F, WaterLeak = F, WaterLeakWarning = F, IcyWeather = F, PumpFailure = F)}$$

$$= \boldsymbol{\alpha} * (\boldsymbol{P}(IcyWeather = F) * P\ (WaterLeak = F|\ IcyWeather = F) * P\ (WaterLeakWarning = F|\ WaterLeak = F) * P(PumpFailure = F) * P\ (PumpfailureWarning = F|\ PumpFailure = F) * P\ (Meltdown = F|\ PumpFailure = F, WaterLeak = F) = \boldsymbol{\alpha} * (0.95 * 0.9 * 0.95 * 0.9 * 0.95 * 0.999) = \boldsymbol{\alpha} * 0.693779276$$

Task 3

Question2

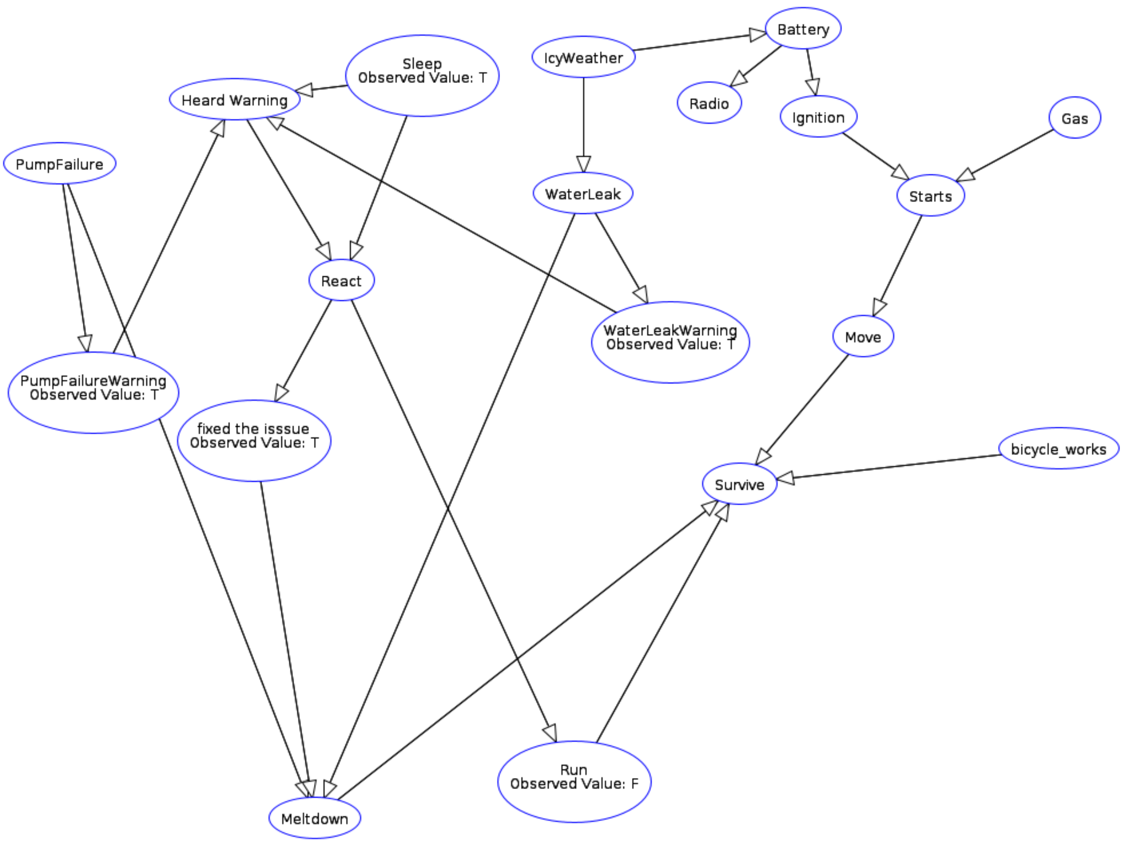
a. The only observation than can be made is that the car radio will not work.
$P\ (Survive\ |\ Radio = F) = 0.98116$

b. $P(Survive) = 0.99505$

c. The complexity of exact inference in Bayesian Networks is quite high compared to exact inference in propositional logic as Bayesian Networks works with full truth tables that are used along with backpropagation to calculate probability distribution of a given variable. An alternative to exact inference could approximate inference.

Task 4

Question 1




We introduced five variables: Sleep, Heard Warning, React, Run and Fixed The Issue.

Sleep is self-explanatory and models the probability that H.S is sleeping. Based on the information provided we put a probability of 0.75 that it is sleeping.

Heard Warning represents the probability that H.S hears a warning, and it depends on whether it is sleeping or not.

React represents the probability that H.S reacts to one of the two warnings. Beside depending on these two variables and it also logically depends on Sleeps.

Run is one of the reaction H.S can have: it will just escape since it doesn't know what to do. We introduced this variable to answer better to the third question in the next part.

H.S is also able to fix the issue sometime, and this is represented by the "fixed the issue" state. Meltdown logically depends on this variable.

Question 2

a. Even if we replace the current with a better one, it is not possible to compensate for H.S lack of expertise because his reaction is not dependent on the Pump quality.
b. As per our initial model, the disjunction will be between the variables Meltdown and Move. But as we do not have any relation between them, we cannot calculate the chances of survival. To answer we can use the state named run, which is conditionally dependent on the React variable.

c. When realizing a Bayesian network model of a person a lot of simplification and assumptions are involved. There are Independence assumptions that are made: we cannot for example really know how the preferences for a behaviour in place of another are related to each other. Moreover, this assumption might be valid only for a certain period because people tend to change their behaviours throughout time. To conclude, the amount of information available during the modelling phase play a key role in the realization of the network.
d. We can have a separate variable termed as "DBY_IcyWeather?," to which IcyWeather will depend on. Based on the new variable we can update the probability distribution of the IcyWeather variable. We will only be considering 3 days in a sequence.