T-79.230 **Kevät 2003**
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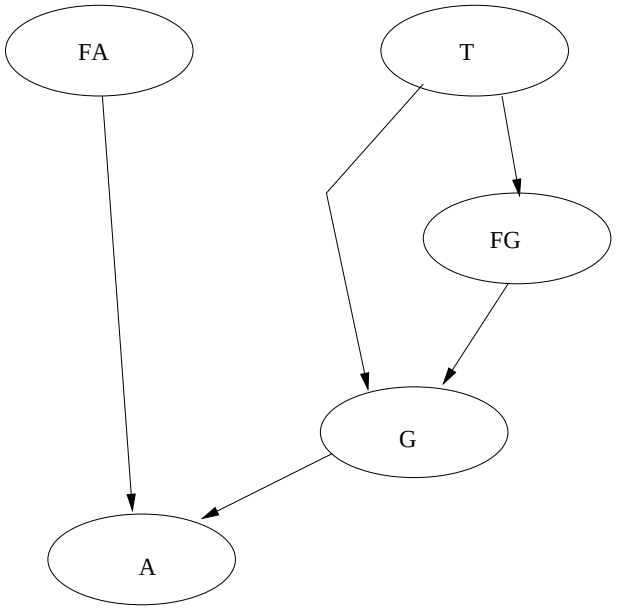
Laskuharjoitus 2
Solutions

1. a) We start by abstracting the temperatures so that there are only two possible values, safe and dangerous.

   We use the following nodes in the network:

   - FA — Is the alarm faulty?
   - T — Is the temperature too high?
   - FG — Is the temperature gauge faulty?
   - G — Does the gauge show dangerous temperature?
   - A — The alarm rings.

   Using the dependencies given in the exercise text, we get the following Bayesian network:



   b) The network is not a polytree, since there are two different routes from node T to node G.

   c) We attach the following probability tables to nodes of the network:

P(FA)	0.01

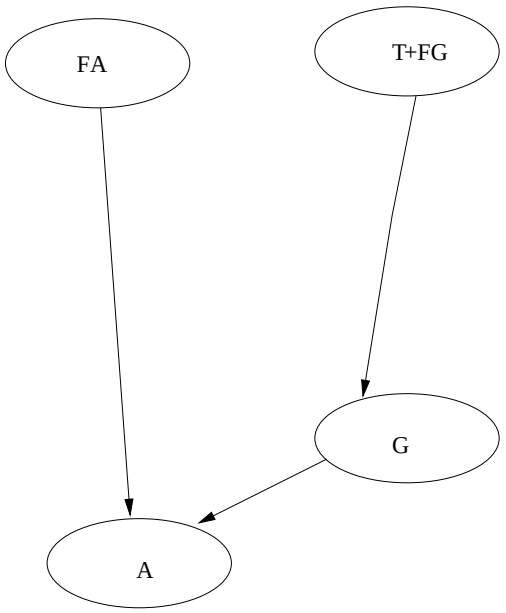
P(T)	0.001

T	P(FG)
T	0.05
F	0.01

T	FG	P(G)
T	T	0.4
T	F	0.95
F	T	0.6
F	F	0.05

G	FA	P(A)
T	T	0
T	F	1
F	T	0
F	F	0

d) In clustering, we combine two or more nodes of the network into one combined node. The probability table of the new node is obtained by combining the tables of the component nodes.



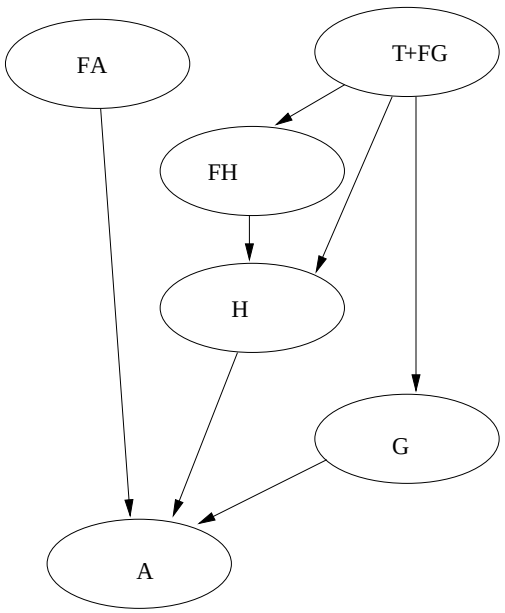
The new probability table will be:

P(T+FG)	
T T	0.00005
T F	0.00095
F T	0.00999
F F	0.98901

e) We want to compute $P(A \mid T)$.
Since all dependencies are encoded in the structure of the network,

$$\begin{aligned} P(A \mid T) &= P(A \mid \neg FA \wedge G)P(\neg FA)\cdot \\ &\quad (P(G \mid FG \wedge T)P(FG \mid T) + P(G \mid \neg FG \wedge T)P(\neg FG \wedge T)) \\ &= 1 \cdot 0.99 \cdot (0.4 \cdot 0.05 + 0.95 \cdot 0.95) = 0.913 \end{aligned}$$

f) When we compute probabilities from effects to causes, we try to establish how different predecessors contribute to the probability table of a node.

$$
\begin{aligned}
P(T \mid \neg FA \wedge \neg FG \wedge A) &= P(T \mid G \wedge \neg FG) \\
&= \frac{P(G \wedge \neg FG \mid T)P(T)}{P(G \wedge \neg FG)} \\
&= \frac{P(G \mid \neg FG \wedge T)P(\neg FG \mid T)P(T)}{P(G \wedge \neg FG \mid T) + P(G \wedge \neg FG \mid \neg T)} \\
&= \frac{P(G \mid \neg FG \wedge T)P(\neg FG \mid T)P(T)}{P(G \mid \neg FG \wedge T)P(\neg FG \mid T)P(T) + P(G \mid \neg FG \wedge \neg T)P(\neg FG \mid \neg T)P(\neg T)} \\
&= \frac{0.95 \cdot 0.00095}{0.95 \cdot 0.00095 + 0.05 \cdot 0.98901} \\
&= 0.018
\end{aligned}
$$

h) Another gauge H could be added to the system as follows: