Inference for SRL Report

Capita Selecta AI (Probabilistic Programming) 2016-2017

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I. Probabilistic Inference Using Weighted Model Counting

A. PGM to CNF

Table **??** shows the semantics of the domain variables used for those tasks.
Tables **??** and **??** show the logical variables used for encoding the Bayesian Network.
Table **??** represents the encoded Bayesian Network using ENC1 and table **??** contains the corresponding weights. Table **??** shows the fully expanded CNF from table **??**.
Likewise, table **??** represents the encoded Bayesian Network using ENC2 and table **??** contains the corresponding weights. Table **??** shows the fully expanded CNF from table **??**.
The variables that are not listed in table **??** *and table* **??**, *have a weight equal to 1.*

Table I. Variables and domain semantics

Variable	Domain
B = Burglary	b1 = theres is a burglary b2 = theres is no burglary
E = Earthquake	e1 = there is a heavy earthquake e2 = there is a mild earthquake e3 = there is no earthquake
A = Alarm	a1 = alarm rings a2 = alarm does not ring
J = John	j1 = John calls j2 = John does not call
M = Mary	m1 = Mary calls m2 = Mary does not call

Table II. Logical variables using ENC1

Network variables	Indicator Variable	CTP
B	λ_{b1}, λ_{b2}	θ_{b1}, θ_{b2}
E	λ_{e1}, λ_{e2}, λ_{3}	θ_{e1}, θ_{e2}, θ_{3}
A	λ_{a1}, λ_{a2}	$\theta_{a1\|b1,e1}$, $\theta_{a1\|b1,e2}$,$\theta_{a1\|b1,e3}$, $\theta_{a1\|b2,e1}$, $\theta_{a1\|b2,e2}$, $\theta_{a1\|b2,e3}$, $\theta_{a2\|b1,e1}$, $\theta_{a2\|b1,e2}$,$\theta_{a2\|b1,e3}$, $\theta_{a2\|b2,e1}$, $\theta_{a2\|b2,e2}$, $\theta_{a2\|b2,e3}$
J	λ_{j1}, λ_{j2}	$\theta_{j1\|a1}$, $\theta_{j2\|a1}$, $\theta_{j1\|a2}$, $\theta_{j2\|a2}$
M	λ_{m1}, λ_{m2}	$\theta_{m1\|a1}$, $\theta_{m2\|a1}$,$\theta_{m1\|a2}$, $\theta_{m2\|a2}$

Table III. Logical variables using ENC2

Variables	Indicator Variable	CTP
B	λ_{b1}, λ_{b2}	ρ_{b1}
E	λ_{e1}, λ_{e2}, λ_{3}	ρ_{e1}, ρ_{e2}
A	λ_{a1}, λ_{a2}	$\rho_{a1\|b1,e1}$, $\rho_{a1\|b1,e2}$, $\rho_{a1\|b1,e3}$, $\rho_{a1\|b2,e1}$, $\rho_{a1\|b2,c2}$, $\rho_{a1\|b2,e3}$
J	λ_{j1}, λ_{j2}	$\rho_{j1\|a1}$, $\rho_{j1\|a2}$
M	λ_{m1}, λ_{m2}	$\rho_{m1\|a1}$, $\rho_{m1\|a2}$

Table IV. ENC1 REPRESENTATION OF BAYESIAN NETWORK

Variables	CNF	
B	$\lambda_{b1} \vee \lambda_{b2}$ $\neg\lambda_{b1} \vee \neg\lambda_{b2}$	$\lambda_{b1} \Leftrightarrow \theta_{b1}$ $\lambda_{b2} \Leftrightarrow \theta_{b2}$
E	$\lambda_{e1} \vee \lambda_{e2} \vee \lambda_{e3}$ $\neg\lambda_{e1} \vee \neg\lambda_{e2}$ $\neg\lambda_{e1} \vee \neg\lambda_{e3}$ $\neg\lambda_{e2} \vee \neg\lambda_{e3}$	$\lambda_{e1} \Leftrightarrow \theta_{e1}$ $\lambda_{e2} \Leftrightarrow \theta_{e2}$ $\lambda_{e3} \Leftrightarrow \theta_{e3}$
A	$\lambda_{a1} \vee \lambda_{a2}$ $\neg\lambda_{a1} \vee \neg\lambda_{a2}$	$\lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e1} \Leftrightarrow \theta_{a1\|b1,e1}$ $\lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e2} \Leftrightarrow \theta_{a1\|b1,e2}$ $\lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e3} \Leftrightarrow \theta_{a1\|b1,e3}$ $\lambda_{a1} \wedge \lambda_{b2} \wedge \lambda_{e1} \Leftrightarrow \theta_{a1\|b2,e1}$ $\lambda_{a1} \wedge \lambda_{b2} \wedge \lambda_{e2} \Leftrightarrow \theta_{a1\|b2,e2}$ $\lambda_{a1} \wedge \lambda_{b2} \wedge \lambda_{e3} \Leftrightarrow \theta_{a1\|b2,e3}$ $\lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e1} \Leftrightarrow \theta_{a2\|b1,e1}$ $\lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e2} \Leftrightarrow \theta_{a2\|b1,e2}$ $\lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e3} \Leftrightarrow \theta_{a2\|b1,e3}$ $\lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e1} \Leftrightarrow \theta_{a2\|b2,e1}$ $\lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e2} \Leftrightarrow \theta_{a2\|b2,e2}$ $\lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e3} \Leftrightarrow \theta_{a2\|b2,e3}$
J	$\lambda_{j1} \vee \lambda_{j2}$ $\neg\lambda_{j1} \vee \neg\lambda_{j2}$	$\lambda_{j1} \wedge \lambda_{a1} \Leftrightarrow \theta_{j1\|a1}$ $\lambda_{j1} \wedge \lambda_{a2} \Leftrightarrow \theta_{j1\|a2}$ $\lambda_{j2} \wedge \lambda_{a1} \Leftrightarrow \theta_{j2\|a1}$ $\lambda_{j2} \wedge \lambda_{a2} \Leftrightarrow \theta_{j2\|a2}$
M	$\lambda_{m1} \vee \lambda_{m2}$ $\neg\lambda_{m1} \vee \neg\lambda_{m2}$	$\lambda_{m1} \wedge \lambda_{a1} \Leftrightarrow \theta_{m1\|a1}$ $\lambda_{m1} \wedge \lambda_{a2} \Leftrightarrow \theta_{m1\|a2}$ $\lambda_{m2} \wedge \lambda_{a1} \Leftrightarrow \theta_{m2\|a1}$ $\lambda_{m2} \wedge \lambda_{a2} \Leftrightarrow \theta_{m2\|a2}$

Table V. WEIGHTS ASSOCIATION USING ENC1

Weights	Value
W(θ_{b1})	0.7
W(θ_{b2})	0.3
W(θ_{e1})	0.01
W(θ_{e2})	0.19
W(θ_{e3})	0.80
W($\theta_{a1\|b1,e1}$)	0.90
W($\theta_{a1\|b1,e2}$)	0.85
W($\theta_{a1\|b1,e3}$)	0.80
W($\theta_{a1\|b2,e1}$)	0.30
W($\theta_{a1\|b2,e2}$)	0.10
W($\theta_{a1\|b2,e3}$)	0.00
W($\theta_{a2\|b1,e1}$)	0.10
W($\theta_{a2\|b1,e2}$)	0.15
W($\theta_{a2\|b1,e3}$)	0.20
W($\theta_{a2\|b2,e1}$)	0.70
W($\theta_{a2\|b2,e2}$)	0.90
W($\theta_{a2\|b2,e3}$)	1.00
W($\theta_{j1\|a1}$)	0.80
W($\theta_{j1\|a2}$)	0.10
W($\theta_{j2\|a1}$)	0.20
W($\theta_{j2\|a2}$)	0.90
W($\theta_{m1\|a1}$)	0.80
W($\theta_{m1\|a2}$)	0.10
W($\theta_{m2\|a1}$)	0.20
W($\theta_{m2\|a2}$)	0.90

Table VI. FULL CNF REPRESENTATION OF BAYESIAN NETWORK USING ENC1

Variables	CNF	
B	$\lambda_{b1} \vee \lambda_{b2}$ $\neg\lambda_{b1} \vee \neg\lambda_{b2}$	$\neg\lambda_{b1} \vee \theta_{b1}$ $\lambda_{b1} \vee \neg\theta_{b1}$ $\neg\lambda_{b2} \vee \theta_{b2}$ $\lambda_{b2} \vee \neg\theta_{b2}$
E	$\lambda_{e1} \vee \lambda_{e2} \vee \lambda_{e3}$ $\neg\lambda_{e1} \vee \neg\lambda_{e2}$ $\neg\lambda_{e1} \vee \neg\lambda_{e3}$ $\neg\lambda_{e2} \vee \neg\lambda_{e3}$	$\neg\lambda_{e1} \vee \theta_{e1}$ $\lambda_{e1} \vee \neg\theta_{e1}$ $\neg\lambda_{e2} \vee \theta_{e2}$ $\lambda_{e2} \vee \neg\theta_{e2}$ $\neg\lambda_{e3} \vee \theta_{e3}$ $\lambda_{e3} \vee \neg\theta_{e3}$
A	$\lambda_{a1} \vee \lambda_{a2}$ $\neg\lambda_{a1} \vee \neg\lambda_{a2}$	$\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \theta_{a1\|b1,e1}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b1,e1}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\|b1,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a1\|b1,e1})$ $\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \theta_{a1\|b1,e2}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b1,e2}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\|b1,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a1\|b1,e2})$ $\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \theta_{a1\|b1,e3}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b1,e3}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\|b1,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a1\|b1,e3})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \theta_{a1\|b2,e1}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b2,e1}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\|b2,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a1\|b2,e1})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \theta_{a1\|b2,e2}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b2,e2}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\|b2,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a1\|b2,e2})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \theta_{a1\|b2,e3}$ $(\lambda_{a1} \vee \neg\theta_{a1\|b2,e3}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\|b2,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a1\|b2,e3})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \theta_{a2\|b1,e1}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b1,e1}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\|b1,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a2\|b1,e1})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \theta_{a2\|b1,e2}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b1,e2}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\|b1,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a2\|b1,e2})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \theta_{a2\|b1,e3}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b1,e3}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\|b1,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a2\|b1,e3})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \theta_{a2\|b2,e1}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b2,e1}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\|b2,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a2\|b2,e1})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \theta_{a2\|b2,e2}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b2,e2}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\|b2,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a2\|b2,e2})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \theta_{a2\|b2,e3}$ $(\lambda_{a2} \vee \neg\theta_{a2\|b2,e3}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\|b2,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a2\|b2,e3})$
J	$\lambda_{j1} \vee \lambda_{j2}$ $\neg\lambda_{j1} \vee \neg\lambda_{j2}$	$\neg\lambda_{j1} \vee \neg\lambda_{a1} \vee \theta_{j1\|a1}$ $(\lambda_{j1} \vee \neg\theta_{j1\|a1}) \wedge (\lambda_{a1} \vee \neg\theta_{j1\|a1})$ $\neg\lambda_{j1} \vee \neg\lambda_{a2} \vee \theta_{j1\|a2}$ $(\lambda_{j1} \vee \neg\theta_{j1\|a2}) \wedge (\lambda_{a2} \vee \neg\theta_{j1\|a2})$ $\neg\lambda_{j2} \vee \neg\lambda_{a1} \vee \theta_{j2\|a1}$ $(\lambda_{j2} \vee \neg\theta_{j2\|a1}) \wedge (\lambda_{a1} \vee \neg\theta_{j2\|a1})$ $\neg\lambda_{j2} \vee \neg\lambda_{a2} \vee \theta_{j2\|a2}$ $(\lambda_{j2} \vee \neg\theta_{j2\|a2}) \wedge (\lambda_{a2} \vee \neg\theta_{j2\|a2})$
M	$\lambda_{m1} \vee \lambda_{m2}$ $\neg\lambda_{m1} \vee \neg\lambda_{m2}$	$\neg\lambda_{m1} \vee \neg\lambda_{a1} \vee \theta_{m1\|a1}$ $(\lambda_{m1} \vee \neg\theta_{m1\|a1}) \wedge (\lambda_{a1} \vee \neg\theta_{m1\|a1})$ $\neg\lambda_{m1} \vee \neg\lambda_{a2} \vee \theta_{m1\|a2}$ $(\lambda_{m1} \vee \neg\theta_{m1\|a2}) \wedge (\lambda_{a2} \vee \neg\theta_{m1\|a2})$ $\neg\lambda_{m2} \vee \neg\lambda_{a1} \vee \theta_{m2\|a1}$ $(\lambda_{m2} \vee \neg\theta_{m2\|a1}) \wedge (\lambda_{a1} \vee \neg\theta_{m2\|a1})$ $\neg\lambda_{m2} \vee \neg\lambda_{a2} \vee \theta_{m2\|a2}$ $(\lambda_{m2} \vee \neg\theta_{m2\|a2}) \wedge (\lambda_{a2} \vee \neg\theta_{m2\|a2})$

Table VII. ENC2 REPRESENTATION OF BAYESIAN NETWORK

Variables	CNF	
B	$\lambda_{b1} \vee \lambda_{b2}$ $\neg\lambda_{b1} \vee \neg\lambda_{b2}$	$\rho_{b1} \Rightarrow \lambda_{b1}$ $\neg\rho_{b1} \Rightarrow \lambda_{b2}$
E	$\lambda_{e1} \vee \lambda_{e2} \vee \lambda_{e3}$ $\neg\lambda_{e1} \vee \neg\lambda_{e2}$ $\neg\lambda_{e1} \vee \neg\lambda_{e3}$ $\neg\lambda_{e2} \vee \neg\lambda_{e3}$	$\rho_{e1} \Rightarrow \lambda_{e1}$ $\neg\rho_{e1} \wedge \rho_{e2} \Rightarrow \lambda_{e2}$ $\neg\rho_{e1} \wedge \neg\rho_{e2} \Rightarrow \lambda_{e3}$
A	$\lambda_{a1} \vee \lambda_{a2}$ $\neg\lambda_{a1} \vee \neg\lambda_{a2}$	$\lambda_{b1} \wedge \lambda_{e1} \wedge \rho_{a1\|b1,e1} \Rightarrow \lambda_{a1}$ $\lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1\|b1,e2} \Rightarrow \lambda_{a1}$ $\lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1\|b1,e3} \Rightarrow \lambda_{a1}$ $\lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1\|b2,e1} \Rightarrow \lambda_{a1}$ $\lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1\|b2,e2} \Rightarrow \lambda_{a1}$ $\lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1\|b2,e3} \Rightarrow \lambda_{a1}$ $\lambda_{b1} \wedge \lambda_{e1} \wedge \neg\rho_{a1\|b1,e1} \Rightarrow \lambda_{a2}$ $\lambda_{b1} \wedge \lambda_{e2} \wedge \neg\rho_{a1\|b1,e2} \Rightarrow \lambda_{a2}$ $\lambda_{b1} \wedge \lambda_{e3} \wedge \neg\rho_{a1\|b1,e3} \Rightarrow \lambda_{a2}$ $\lambda_{b2} \wedge \lambda_{e1} \wedge \neg\rho_{a1\|b2,e1} \Rightarrow \lambda_{a2}$ $\lambda_{b2} \wedge \lambda_{e2} \wedge \neg\rho_{a1\|b2,e2} \Rightarrow \lambda_{a2}$ $\lambda_{b2} \wedge \lambda_{e3} \wedge \neg\rho_{a1\|b2,e3} \Rightarrow \lambda_{a2}$
J	$\lambda_{j1} \vee \lambda_{j2}$ $\neg\lambda_{j1} \vee \neg\lambda_{j2}$	$\lambda_{a1} \wedge \rho_{j1\|a1} \Rightarrow \lambda_{j1}$ $\lambda_{a2} \wedge \rho_{j1\|a2} \Rightarrow \lambda_{j1}$ $\lambda_{a1} \wedge \neg\rho_{j1\|a1} \Rightarrow \lambda_{j2}$ $\lambda_{a2} \wedge \neg\rho_{j1\|a2} \Rightarrow \lambda_{j2}$
M	$\lambda_{m1} \vee \lambda_{m2}$ $\neg\lambda_{m1} \vee \neg\lambda_{m2}$	$\lambda_{a1} \wedge \rho_{m1\|a1} \Rightarrow \lambda_{m1}$ $\lambda_{a2} \wedge \rho_{m1\|a2} \Rightarrow \lambda_{m1}$ $\lambda_{a1} \wedge \neg\rho_{m1\|a1} \Rightarrow \lambda_{m2}$ $\lambda_{a2} \wedge \neg\rho_{m1\|a2} \Rightarrow \lambda_{m2}$

Table VIII. WEIGHTS ASSOCIATION USING ENC2

Weights	Value
W(ρ_{b1})	0.7
W($\neg\rho_{b1}$)	0.3
W(ρ_{e1})	0.01
W(ρ_{e2})	0.19/(1-0.01) $\approx$ 0.19
W($\neg\rho_{e1}$)	1-0.01 = 0.99
W($\neg\rho_{e2}$)	1-0.19 = 0.81
W($\rho_{a1\|b1,e1}$)	0.90
W($\neg\rho_{a1\|b1,e1}$)	1-0.90=0.10
W($\rho_{a1\|b1,e2}$)	0.85
W($\neg\rho_{a1\|b1,e2}$)	1-0.85=0.15
W($\rho_{a1\|b1,e3}$)	0.80
W($\neg\rho_{a1\|b1,e3}$)	1-0.80=0.20
W($\rho_{a1\|b2,e1}$)	0.30
W($\neg\rho_{a1\|b2,e1}$)	1-0.30=0.70
W($\rho_{a1\|b2,e2}$)	0.10
W($\neg\rho_{a1\|b2,e2}$)	1-0-10=0.90
W($\rho_{a1\|b2,e3}$)	0
W($\neg\rho_{a1\|b2,e3}$)	1-0=1
W($\rho_{j1\|a1}$)	0.80
W($\neg\rho_{j1\|a1}$)	1-0.80=0.20
W($\rho_{j1\|a2}$)	0.10
W($\neg\rho_{j1\|a2}$)	1-0.10=0.90
W($\rho_{m1\|a1}$)	0.80
W($\neg\rho_{m1\|a1}$)	1-0.80=0.20
W($\rho_{m1\|a2}$)	0.10
W($\neg\rho_{m1\|a2}$)	1-0.10=0.90

Table IX. FULL CNF REPRESENTATION OF BAYESIAN NETWORK USING ENC2

Variables	CNF	
B	$\lambda_{b1} \vee \lambda_{b2}$ $\neg\lambda_{b1} \vee \neg\lambda_{b2}$	$\neg\rho_{b1} \vee \lambda_{b1}$ $\rho_{b1} \vee \lambda_{b2}$
E	$\lambda_{e1} \vee \lambda_{e2} \vee \lambda_{e3}$ $\neg\lambda_{e1} \vee \neg\lambda_{e2}$ $\neg\lambda_{e1} \vee \neg\lambda_{e3}$ $\neg\lambda_{e2} \vee \neg\lambda_{e3}$	$\neg\rho_{e1} \vee \lambda_{e1}$ $\rho_{e1} \vee \neg\rho_{e2} \vee \lambda_{e2}$ $\rho_{e1} \vee \rho_{e2} \vee \lambda_{e3}$
A	$\lambda_{a1} \vee \lambda_{a2}$ $\neg\lambda_{a1} \vee \neg\lambda_{a2}$	$\neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \neg\rho_{a1\|b1,e1} \vee \lambda_{a1}$ $\neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \neg\rho_{a1\|b1,e2} \vee \lambda_{a1}$ $\neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \neg\rho_{a1\|b1,e3} \vee \lambda_{a1}$ $\neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \neg\rho_{a1\|b2,e1} \vee \lambda_{a1}$ $\neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \neg\rho_{a1\|b2,e2} \vee \lambda_{a1}$ $\neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \neg\rho_{a1\|b2,e3} \vee \lambda_{a1}$ $\neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \rho_{a1\|b1,e1} \vee \lambda_{a2}$ $\neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \rho_{a1\|b1,e2} \vee \lambda_{a2}$ $\neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \rho_{a1\|b1,e3} \vee \lambda_{a2}$ $\neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \rho_{a1\|b2,e1} \vee \lambda_{a2}$ $\neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \rho_{a1\|b2,e2} \vee \lambda_{a2}$ $\neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \rho_{a1\|b2,e3} \vee \lambda_{a2}$
J	$\lambda_{j1} \vee \lambda_{j2}$ $\neg\lambda_{j1} \vee \neg\lambda_{j2}$	$\neg\lambda_{a1} \vee \neg\rho_{j1\|a1} \vee \lambda_{j1}$ $\neg\lambda_{a2} \vee \neg\rho_{j1\|a2} \vee \lambda_{j1}$ $\neg\lambda_{a1} \vee \rho_{j1\|a1} \vee \lambda_{j2}$ $\neg\lambda_{a2} \vee \rho_{j1\|a2} \vee \lambda_{j2}$
M	$\lambda_{m1} \vee \lambda_{m2}$ $\neg\lambda_{m1} \vee \neg\lambda_{m2}$	$\neg\lambda_{a1} \vee \neg\rho_{m1\|a1} \vee \lambda_{m1}$ $\neg\lambda_{a2} \vee \neg\rho_{m1\|a2} \vee \lambda_{m1}$ $\neg\lambda_{a1} \vee \rho_{m1\|a1} \vee \lambda_{m2}$ $\neg\lambda_{a2} \vee \rho_{m1\|a2} \vee \lambda_{m2}$

B. SRL to CNF

First the program must be grounded, while taking into account **Q** and **E**. In this case the evidence set **E** is empty (there is no evidence available). The grounding process of the queries will be described step-by-step in listings **??** and **??**. If only **query(path(1,5))** was considered, then **edge(5,6)** and **edge(2,6)** would have been irrelevant. With the inclusion of **query(path(1,6))** all edges become relevant.

Listing 1: Grounding of **path(1,5)**

Listing 2: Grounding of **path(1,6)**

The second step is to find an equivalent CNF of the ground program. Given the grounded rules **w :- r** and **w :- s**, the equivalent CNF contains the following three clauses: $\neg r \vee w$, $\neg s \vee w$ and $\neg w \vee s \vee r$. In our case r and s both are conjunctions, so De Morgans law is used to write the first two clauses. For the last clause, all permutations of the combinations of the elements $\neg w$, r and s are considered. For **path(1,5)** this yields $2 * 3 = 6$ combinations. For **path(1,6)** there are $2 * 3 * 4 = 24$ combinations. The CNF is shown in table **??**. Note that on the last big block of $path_{16}$ that the *and* operators can be removed, and the separate clauses can be listed underneath each other. We chose to use the current format because the resulting table would become too large (vertically) otherwise. It also clearly shows which clauses corresponds to the 24 combinations.

Table X. CNF REPRESENTATION OF THE GROUND RULES

Variables	CNF
$path_{15}$	$path_{15} \vee \neg\ edge_{13} \vee \neg\ edge_{34} \vee \neg\ edge_{45}$ $path_{15} \vee \neg\ edge_{12} \vee \neg\ edge_{25}$ $(\neg path_{15} \vee edge_{12} \vee edge_{13}) \wedge (\neg path_{15} \vee edge_{12} \vee edge_{34}) \wedge (\neg path_{15} \vee edge_{12} \vee edge_{45}) \wedge$ $(\neg path_{15} \vee edge_{25} \vee edge_{13}) \wedge (\neg path_{15} \vee edge_{25} \vee edge_{34}) \wedge (\neg path_{15} \vee edge_{25} \vee edge_{45})$
$path_{16}$	$path_{16} \vee \neg\ edge_{13} \vee \neg\ edge_{34} \vee \neg\ edge_{45} \vee \neg\ edge_{56}$ $path_{16} \vee \neg\ edge_{12} \vee \neg\ edge_{25} \vee \neg\ edge_{56}$ $path_{16} \vee \neg\ edge_{12} \vee \neg\ edge_{26}$ $(\neg path_{16} \vee edge_{13} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{13} \vee edge_{12} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{13} \vee edge_{25} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{13} \vee edge_{25} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{13} \vee edge_{56} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{13} \vee edge_{56} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{34} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{34} \vee edge_{12} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{34} \vee edge_{25} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{34} \vee edge_{25} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{34} \vee edge_{56} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{34} \vee edge_{56} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{45} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{45} \vee edge_{12} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{45} \vee edge_{25} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{45} \vee edge_{25} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{45} \vee edge_{56} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{45} \vee edge_{56} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{56} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{56} \vee edge_{12} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{56} \vee edge_{25} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{56} \vee edge_{25} \vee edge_{26}) \wedge$ $(\neg path_{16} \vee edge_{56} \vee edge_{56} \vee edge_{12}) \wedge (\neg path_{16} \vee edge_{56} \vee edge_{56} \vee edge_{26})$

The final step is to obtain a weighted CNF. Since there's no evidence in our example, the CNF remains the same as shown in table **??**. Table **??** displays the weighted literals. The weights for $path_{15}$, $path_{16}$, $\neg path_{15}$ and $\neg path_{16}$ equal 1 because they're defined in clauses. The weight of any world ω can be calculated as the product of the weight of all literals in ω. For example, the world $path_{15}, edge_{12}, edge_{25}, edge_{13}, edge_{34}, \neg edge_{45}$ has the weight $0.6 * 0.4 * 0.1 * 0.3 * 0.2 = 0.00144$.

Table XI. WEIGHTED LITERALS

Variables	Weight	Variables	Weight
$edge_{12}$	0.6	$\neg edge_{12}$	0.4
$edge_{13}$	0.1	$\neg edge_{13}$	0.9
$edge_{25}$	0.4	$\neg edge_{25}$	0.6
$edge_{26}$	0.3	$\neg edge_{26}$	0.7
$edge_{34}$	0.3	$\neg edge_{34}$	0.7
$edge_{45}$	0.8	$\neg edge_{45}$	0.2
$edge_{56}$	0.2	$\neg edge_{56}$	0.8
$path_{15}$	1	$\neg path_{15}$	1
$path_{16}$	1	$\neg path_{16}$	1

C. Weighted Model Counting

We used the following exact model counters: **MiniC2D**, **SDD** and **sharpSAT**.

MiniC2D uses exhaustive DPLL, a backtracking based search algorithm to solve the *boolean satisfiability problem*. It compiles CNFs into Decision-SDDs for the knowledge compilation, using a top-down approach. The top-down approach is considered to be faster by *Umut Oztok and Adnan Darwiche*[**?**]. The Decision-SDDs are a subset of SDDs which facilitate the top-down compilation of SDDs.

The SDD program is similar to MiniC2D in the sense that it compiles CNFs into SDD datastructures. The shape of the SDD can be manipulated to improve efficiency, as will be explained in section **??**.

sharpSAT also uses DPLL, but combines this with *look ahead* technique that is based on *boolean constraint propagation* [**?**]. The look ahead technique eliminates more variables that can not be part of a solution, and thus reduces the search space to backtrack over.

Table **??** to table **??** show the computational requirements of each exact model counter on the CNF from task 1 with encoding 1, task 1 with encoding 2 and task 2 respectively. There are 36 variables 94 clauses. *The CNF encodings are included with our program.*

Table XII. COMPUTATIONAL REQUIREMENTS TASK 1 ENC1.

	miniC2D	**SDD**	**sharpSAT**
total runtime	0.019s	0.044s	0.008s
memory (cache size)	0.011MB	0.3MB	7MB
cache hit rate	66.7%	85.2%	100%

Table XIII. COMPUTATIONAL REQUIREMENTS TASK 1 ENC2.

	miniC2D	**SDD**	**sharpSAT**
total runtime	0.017s	0.028s	0.004s
memory (cache size)	0.007MB	0.2MB	7MB
cache hit rate	43.4%	84.2%	100%

D. Knowledge Compilation

We use **MiniC2D** as tool for this section.

We tested different scenarios for the first two CNFs (with evidence, no evidence and some queries). Likewise we tested the CNFs constructed in section 2 separately, considering the grounded queries for path 1-5 and 1-6.

Table **??** to table **??** show the results of the different experiments. According with them, the best heuristic that gave us the most compact circuit was the natural elimination order method with incidence graph type, even though natural elimination order method with primal graph type showed the fastest results strictly speaking. However it is only a difference of 0.001s in some CNFs, even in the others it was no difference. This pattern is consistent in all the experiments were done.

The final conclusion is that natural elimination order method with incidence graph type would work better with DPLL because can increase the inference process due to the small circuit of the vtree and the virtually same time with the primal graph type.

II. BUILD AN INFERENCE ENGINE: PIPELINE

Table XIV. COMPUTATIONAL REQUIREMENTS TASK 2.

	miniC2D	SDD	sharpSAT
total runtime	0.020s	0.001s	0.005s
memory (cache size)	0.002MB	0.0MB	7MB
cache hit rate	40.0%	84.4%	100%

Table XV. VTREE STATISTICS OF CNF ENC1 WITH NO EVIDENCE

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.002s	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=20, c_con=48 v_con=20 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time:0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s
incidence graph	Vtree widths: con<=7, c_con=55 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=6, c_con=59 v_con=6 Vtree Time: 0.004s	Vtree widths: con<=7, c_con=42 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.004s

Table XVI. VTREE STATISTICS OF CNF ENC1 WITH QUERY(BURGLARY)

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.002s	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.002s	Vtree widths: con<=20, c_con=48 v_con=20 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s
incidence graph	Vtree widths: con<=7, c_con=53 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=6, c_con=59 v_con=6 Vtree Time: 0.004s	Vtree widths: con<=7, c_con=42 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.004s

Table XVII. VTREE STATISTICS OF CNF ENC1 WITH QUERY(EARTHQUAKE=HEAVY)

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=6, c_con=68 v_con=6 Vtree Time: 0.002s	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.002s	Vtree widths: con<=20, c_con=48 v_con=20 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s
incidence graph	Vtree widths: con<=6, c_con=49 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=6, c_con=59 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=42 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s

Table XVIII. VTREE STATISTICS OF CNF ENC1 WITH EVIDENCE

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=6, c_con=65 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=6, c_con=59 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=20, c_con=48 v_con=20 Vtree Time: 0.002s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.002s
incidence graph	Vtree widths: con<=6, c_con=59 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=6, c_con=49 v_con=6 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=42 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.003s	Vtree widths: con<=7, c_con=52 v_con=7 Vtree Time: 0.004s

Table XIX. VTREE STATISTICS OF CNF ENC2 WITH NO EVIDENCE

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=9, c_con=17 v_con=9 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s
incidence graph	Vtree widths: con<=7, c_con=27 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=18 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=23 v_con=7 Vtree Time=0.001s

Table XX. VTREE STATISTICS OF CNF ENC2 WITH QUERY(BURGLARY)

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=9, c_con=17 v_con=9 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s
incidence graph	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=18 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=23 v_con=7 Vtree Time=0.002s

Table XXI. VTREE STATISTICS OF CNF ENC2 WITH EVIDENCE

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=9, c_con=17 v_con=9 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s
incidence graph	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.003s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.002s	Vtree widths: con<=7, c_con=18 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=20 v_con=7 Vtree Time=0.001s	Vtree widths: con<=7, c_con=23 v_con=7 Vtree Time=0.001s

Table XXII. VTREE STATISTICS OF CNF WITH GROUNDED QUERY(PATH15)

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.001s	Vtree widths: con<=4, c_con=8 v_con=4 Vtree Time=0.001s	Vtree widths: con<=4, c_con=8 v_con=4 Vtree Time=0.000s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.000s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.000s
incidence graph	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.001s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.001s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.000s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.000s	Vtree widths: con<=4, c_con=7 v_con=4 Vtree Time=0.000s

Table XXIII. VTREE STATISTICS OF CNF WITH GROUNDED QUERY(PATH16)

	hypergraph with random balance factor (default)	**hypergraph with fixed balance factor**	**natural elimination order**	**reverse elimination order**	**minfill elimination order**
primal graph	Vtree widths: con<=6, c_con=27 v_con=6 Vtree Time=0.001s	Vtree widths: con<=6, c_con=27 v_con=6 Vtree Time=0.001s	Vtree widths: con<=6, c_con=27 v_con=6 Vtree Time=0.000s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.000s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.000s
incidence graph	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.002s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.002s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.001s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.001s	Vtree widths: con<=6, c_con=26 v_con=6 Vtree Time=0.001s