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 I shows the semantics of the domain variables used for those tasks.
Tables II and III show the logical variables used for encoding the Bayesian Network.
Table IV represents the encoded Bayesian Network using ENC1 and table V contains the corresponding weights. Table VI shows the fully expanded CNF from table IV.
Likewise, table VII represents the encoded Bayesian Network using ENC2 and table VIII contains the corresponding weights. Table IX shows the fully expanded CNF from table VII.
The variables that are not listed in table V and table VIII, 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	$\lambda_{a1} \vee \lambda_{a2}$ $\neg\lambda_{a1} \vee \neg\lambda_{a2}$	$\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \theta_{a1\mid b1,e1}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b1,e1}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\mid b1,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a1\mid b1,e1})$ $\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \theta_{a1\mid b1,e2}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b1,e2}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\mid b1,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a1\mid b1,e2})$ $\neg\lambda_{a1} \vee \neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \theta_{a1\mid b1,e3}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b1,e3}) \wedge (\lambda_{b1} \vee \neg\theta_{a1\mid b1,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a1\mid b1,e3})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \theta_{a1\mid b2,e1}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b2,e1}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\mid b2,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a1\mid b2,e1})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \theta_{a1\mid b2,e2}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b2,e2}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\mid b2,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a1\mid b2,e2})$ $\neg\lambda_{a1} \vee \neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \theta_{a1\mid b2,e3}$ $(\lambda_{a1} \vee \neg\theta_{a1\mid b2,e3}) \wedge (\lambda_{b2} \vee \neg\theta_{a1\mid b2,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a1\mid b2,e3})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e1} \vee \theta_{a2\mid b1,e1}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b1,e1}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\mid b1,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a2\mid b1,e1})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e2} \vee \theta_{a2\mid b1,e2}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b1,e2}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\mid b1,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a2\mid b1,e2})$ $\neg\lambda_{a2} \vee \neg\lambda_{b1} \vee \neg\lambda_{e3} \vee \theta_{a2\mid b1,e3}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b1,e3}) \wedge (\lambda_{b1} \vee \neg\theta_{a2\mid b1,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a2\mid b1,e3})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e1} \vee \theta_{a2\mid b2,e1}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b2,e1}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\mid b2,e1}) \wedge (\lambda_{e1} \vee \neg\theta_{a2\mid b2,e1})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e2} \vee \theta_{a2\mid b2,e2}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b2,e2}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\mid b2,e2}) \wedge (\lambda_{e2} \vee \neg\theta_{a2\mid b2,e2})$ $\neg\lambda_{a2} \vee \neg\lambda_{b2} \vee \neg\lambda_{e3} \vee \theta_{a2\mid b2,e3}$ $(\lambda_{a2} \vee \neg\theta_{a2\mid b2,e3}) \wedge (\lambda_{b2} \vee \neg\theta_{a2\mid b2,e3}) \wedge (\lambda_{e3} \vee \neg\theta_{a2\mid b2,e3})$
J	$\lambda_{j1} \vee \lambda_{j2}$ $\neg\lambda_{j1} \vee \neg\lambda_{j2}$	$\neg\lambda_{j1} \vee \neg\lambda_{a1} \vee \theta_{j1\mid a1}$ $(\lambda_{j1} \vee \neg\theta_{j1\mid a1}) \wedge (\lambda_{a1} \vee \neg\theta_{j1\mid a1})$ $\neg\lambda_{j1} \vee \neg\lambda_{a2} \vee \theta_{j1\mid a2}$ $(\lambda_{j1} \vee \neg\theta_{j1\mid a2}) \wedge (\lambda_{a2} \vee \neg\theta_{j1\mid a2})$ $\neg\lambda_{j2} \vee \neg\lambda_{a1} \vee \theta_{j2\mid a1}$ $(\lambda_{j2} \vee \neg\theta_{j2\mid a1}) \wedge (\lambda_{a1} \vee \neg\theta_{j2\mid a1})$ $\neg\lambda_{j2} \vee \neg\lambda_{a2} \vee \theta_{j2\mid a2}$ $(\lambda_{j2} \vee \neg\theta_{j2\mid a2}) \wedge (\lambda_{a2} \vee \neg\theta_{j2\mid a2})$
M	$\lambda_{m1} \vee \lambda_{m2}$ $\neg\lambda_{m1} \vee \neg\lambda_{m2}$	$\neg\lambda_{m1} \vee \neg\lambda_{a1} \vee \theta_{m1\mid a1}$ $(\lambda_{m1} \vee \neg\theta_{m1\mid a1}) \wedge (\lambda_{a1} \vee \neg\theta_{m1\mid a1})$ $\neg\lambda_{m1} \vee \neg\lambda_{a2} \vee \theta_{m1\mid a2}$ $(\lambda_{m1} \vee \neg\theta_{m1\mid a2}) \wedge (\lambda_{a2} \vee \neg\theta_{m1\mid a2})$ $\neg\lambda_{m2} \vee \neg\lambda_{a1} \vee \theta_{m2\mid a1}$ $(\lambda_{m2} \vee \neg\theta_{m2\mid a1}) \wedge (\lambda_{a1} \vee \neg\theta_{m2\mid a1})$ $\neg\lambda_{m2} \vee \neg\lambda_{a2} \vee \theta_{m2\mid a2}$ $(\lambda_{m2} \vee \neg\theta_{m2\mid a2}) \wedge (\lambda_{a2} \vee \neg\theta_{m2\mid a2})$

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 1 and 2. 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.

```
% grounding path(1,5) becomes:
path(1,5) :- edge(1,3), 5 \== 3, path(3,5).
path(1,5) :- edge(1,2), 5 \== 2, path(2,5).
% grounding path(3,5)
path(3,5) :- edge(3,4), 5 \== 4, path(4,5).
% grounding path(4,5).
path(4,5) :- edge(4,5).
% grounding path(2,5)
path(2,5) :- edge(2,5).
% putting the results together (and resolving the inequalities) gives:
path(1,5) :- edge(1,3), edge(3,4), edge(4,5).
path(1,5) :- edge(1,2), edge(2,5).
```

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

```
% grounding path(1,6) becomes:
path(1,6) :- edge(1,3), 6 \== 3, path(3,6).
path(1,6) :- edge(1,2), 6 \== 2, path(2,6).
% grounding path(3,6)
path(3,6) :- edge(3,4), 6 \== 4, path(4,6).
% grounding path(4,6).
path(4,6) :- edge(4,5), 6 \== 5, path(5,6).
% grounding path(5,6)
path(5,6) :- edge(5,6).
% grounding path(2,6)
path(2,6) :- edge(2,6).
path(2,6) :- edge(5,6), 6 \== 5, path(5,6).
% path(5,6) has already been grounded
% putting the results together (and resolving the inequalities) gives:
path(1,6) :- edge(1,3), edge(3,4), edge(4,5), edge(5,6).
path(1,6) :- edge(1,2), edge(2,5), edge(5,6).
path(1,6) :- edge(1,2), edge(2,6).
```

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 X. 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 X. Table XI 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*[1]. 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 I-D.

sharpSAT also uses DPLL, but combines this with *look ahead* technique that is based on *boolean constraint propagation* [2]. 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 XII to table XIV 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%

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%

D. Knowledge Compilation

REFERENCES

[1] Umut Oztok and Adnan Darwiche. A top-down compiler for sentential decision diagrams. In *IJCAI*, pages 3141–3148, 2015.

[2] Marc Thurley. sharpsat–counting models with advanced component caching and implicit bcp. In *International Conference on Theory and Applications of Satisfiability Testing*, pages 424–429. Springer, 2006.