Inference for SRL Report

Capita Selecta AI (Probabilistic Programming) 2016-2017

Alexander Tang s0189509 Daniel Andrés Pérez Pérez r0605947

table IV: comma's are sometimes wrongly placed and there's a disjunction without an implication in the middle

table VIII: I'm not sure if W(ro e2) = 0.19/(1-0.01); is it not just 0.19? Because it's a parent node and does not have any conditionals. I may be very worng on this; I'm not sure about this.

Daniel: Not sure if the 6th clause of the network variable A in IV is correctly substituted due to the property describe in the paper "Consider again Figure 1 and imagine that the parameter $\theta c1|a1$ were 0. Given that this parameter is known to be 0, all models that set this parameter variable to true will have weight 0."

Daniel: For VI, should we also chance the closure that contains a probability of 0, like we did in the ENC1 encoding? Look comment above

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 encoded the Bayesian Network in [1].

Table IV represents the encoded Bayesian Network using ENC1 and table V contains the corresponding weights.

Likewise, table VI represent the encoded Bayesian Network using ENC2 and table VII contains the corresponding weights.

Table I. RANDOM VARIABLES AND DOMAINS SEMANTICS

Variable	Domain
B = Burglary	b1 = theres is burglary
	b2 = theres is no burglary
E = Earthquake	a1 = there is heavyearthquake
	a2 = there is mild earthquake
	a3 = 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
В	$\lambda_{b1}, \lambda_{b2}$	θ_{b1},θ_{b2}
Е	$\lambda_{e1}, \lambda_{e2}, \lambda_3$	$\theta_{e1},\theta_{e2},\theta_3$
A	$\lambda_{a1},\lambda_{a2}$	$\begin{array}{c} \theta_{a1 b1,e1}, \theta_{a1 b1,e2}, \theta_{a1 b1,e3}, \\ \theta_{a1 b2,e1}, \theta_{a1 b2,e2}, \theta_{a1 b2,e3}, \\ \theta_{a2 b1,e1}, \theta_{a2 b1,e2}, \theta_{a2 b1,e3}, \\ \theta_{a2 b2,e1}, \theta_{a2 b2,e2}, \theta_{a2 b2,e3} \end{array}$
J	$\lambda_{j1}, \lambda_{j2}$	$\theta_{j1 a1}, \theta_{j2 a1}, \theta_{j1 a2}, \theta_{j2 a2}$
M	$\lambda_{m1}, \lambda_{m2}$	$\theta_{m1 a1}, \theta_{m2 a1}, \theta_{m1 a2}, \theta_{m2 a2}$

1

Table III. LOGICAL VARIABLES USING ENC2

Variables	Indicator Variable	CTP
В	$\lambda_{b1}, \lambda_{b2}$	$ ho_{b1}$
Е	$\lambda_{e1}, \lambda_{e2}, \lambda_3$	$ ho_{e1}, ho_{e2}$
A	$\lambda_{a1}, \lambda_{a2}$	$\rho_{a1 b1,c1}, \rho_{a1 b1,c2}, \rho_{a1 b1,c3}, \\ \rho_{a1 b2,c1}, \rho_{a1 b2,c2}, \rho_{a1 b2,c3}$
J	$\lambda_{j1}, \lambda_{j2}$	$ ho_{j1 a1}, ho_{j1 a2}$
M	$\lambda_{m1}, \lambda_{m2}$	$\rho_{m1 a1}, \rho_{m1 a2}$

Table IV. BAYESIAN NETWORK ENCODED USING ENC1

Network variable	Indicator Clauses	ENC1 Parameter Clauses
В	$\lambda_{b1} \vee \lambda_{b2}$,	$\lambda_{b1} \Rightarrow \theta_{b1}, \theta_{b1} \Rightarrow \lambda_{b1}$
ь	$\neg \lambda_{b1} \lor \neg \lambda_{b2}$	$\lambda_{b2}\Rightarrow heta_{b2}, heta_{b2}\Rightarrow \lambda_{b2}$
Е	$\lambda_{e1} \vee \lambda_{e2} \vee \lambda_{e3}, \\ \neg \lambda_{e1} \vee \neg \lambda_{e2},$	$\lambda_{e1} \Rightarrow \theta_{e1}, \theta_{e1} \Rightarrow \lambda_{e1} \ \lambda_{e2} \Rightarrow \theta_{e2}, \theta_{e2} \Rightarrow \lambda_{e2}$
L		$\lambda_{e3} \Rightarrow \theta_{e3}, \theta_{e3} \Rightarrow \lambda_{e3}$
A	$\lambda_{a1} \vee \lambda_{a2}, \\ \neg \lambda_{a1} \vee \neg \lambda_{a2}$	$\begin{array}{c} \lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e1} \Rightarrow \theta_{a1 b1,e1}, \ \theta_{a1 b1,e1} \Rightarrow \lambda_{a1}, \ \theta_{a1 b1,e1} \Rightarrow \lambda_{b1}, \ \theta_{a1 b1,e1} \Rightarrow \lambda_{e1} \\ \lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e2} \Rightarrow \theta_{a1 b1,e2}, \ \theta_{a1 b1,e2} \Rightarrow \lambda_{a1}, \ \theta_{a1 b1,e2} \Rightarrow \lambda_{b1}, \ \theta_{a1 b1,e2} \Rightarrow \lambda_{e2} \\ \lambda_{a1} \wedge \lambda_{b1} \wedge \lambda_{e3} \Rightarrow \theta_{a1 b1,e3}, \ \theta_{a1 b1,e3} \Rightarrow \lambda_{a1}, \ \theta_{a1 b1,e3} \Rightarrow \lambda_{b1}, \ \theta_{a1 b1,e3} \Rightarrow \lambda_{e3} \\ \lambda_{a1} \wedge \lambda_{b2} \wedge \lambda_{e1} \Rightarrow \theta_{a1 b2,e1}, \ \theta_{a1 b2,e1} \Rightarrow \lambda_{a1}, \ \theta_{a1 b2,e1} \Rightarrow \lambda_{b2}, \ \theta_{a1 b2,e1} \Rightarrow \lambda_{e1} \\ \lambda_{a1} \wedge \lambda_{b2} \wedge \lambda_{e2} \Rightarrow \theta_{a1 b2,e2}, \ \theta_{a1 b2,e2} \Rightarrow \lambda_{a1}, \ \theta_{a1 b2,e2} \Rightarrow \lambda_{b2}, \ \theta_{a1 b2,e2} \Rightarrow \lambda_{e2} \\ \neg \lambda_{a1} \vee \neg \lambda_{b2} \vee \neg \lambda_{c3} \\ \lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e1} \Rightarrow \theta_{a2 b1,e1}, \ \theta_{a2 b1,e1} \Rightarrow \lambda_{a2}, \ \theta_{a2 b1,e1} \Rightarrow \lambda_{b1}, \ \theta_{a2 b1,e1} \Rightarrow \lambda_{e1} \\ \lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e2} \Rightarrow \theta_{a2 b1,e2}, \ \theta_{a2 b1,e2} \Rightarrow \lambda_{a2}, \ \theta_{a2 b1,e2} \Rightarrow \lambda_{b1}, \ \theta_{a2 b1,e2} \Rightarrow \lambda_{e2} \\ \lambda_{a2} \wedge \lambda_{b1} \wedge \lambda_{e3} \Rightarrow \theta_{a2 b1,e3}, \ \theta_{a2 b1,e3} \Rightarrow \lambda_{a2}, \ \theta_{a2 b1,e3} \Rightarrow \lambda_{b1}, \ \theta_{a2 b1,e3} \Rightarrow \lambda_{e3} \\ \lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e1} \Rightarrow \theta_{a2 b2,e1}, \ \theta_{a2 b2,e1}, \ \theta_{a2 b2,e1} \Rightarrow \lambda_{a2}, \ \theta_{a2 b2,e1} \Rightarrow \lambda_{b2}, \ \theta_{a2 b2,e1} \Rightarrow \lambda_{e1} \\ \lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e2} \Rightarrow \theta_{a2 b2,e2}, \ \theta_{a2 b2,e2}, \ \lambda_{a2}, \ \theta_{a2 b2,e2} \Rightarrow \lambda_{b2}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{e3} \\ \lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e3} \Rightarrow \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{a2}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{b2}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{e3} \\ \lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e3} \Rightarrow \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{b3}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{b3}, \ \theta_{a2 b2,e3} \Rightarrow \lambda_{b3} \\ \lambda_{a2} \wedge \lambda_{b2} \wedge \lambda_{e3} \Rightarrow \theta_{a2 b2,e3}, \ \theta_{a2 b2,e3}, $
J	$\lambda_{j1} \vee \lambda_{j2}, \\ \neg \lambda_{j1} \vee \neg \lambda_{j2}$	$\lambda_{j1} \wedge \lambda_{a1} \Rightarrow \theta_{j1 a1}, \theta_{j1 a1} \Rightarrow \lambda_{j1}, \theta_{j1 a1} \Rightarrow \lambda_{a1}$ $\lambda_{j1} \wedge \lambda_{a2} \Rightarrow \theta_{j1 a2}, \theta_{j1 a2} \Rightarrow \lambda_{j1}, \theta_{j1 a2} \Rightarrow \lambda_{a2}$ $\lambda_{j2} \wedge \lambda_{a1} \Rightarrow \theta_{j2 a1}, \theta_{j2 a1} \Rightarrow \lambda_{j2}, \theta_{j2 a1} \Rightarrow \lambda_{a1}$ $\lambda_{j2} \wedge \lambda_{a2} \Rightarrow \theta_{j2 a2}, \theta_{j2 a2} \Rightarrow \lambda_{j2}, \theta_{j2 a2} \Rightarrow \lambda_{a2}$
M	$\lambda_{m1} \vee \lambda_{m2}, \\ \neg \lambda_{m1} \vee \neg \lambda_{m2}$	$\lambda_{m1} \wedge \lambda_{a1} \Rightarrow \theta_{m1 a1}, \theta_{m1 a1} \Rightarrow \lambda_{m1}, \theta_{m1 a1} \Rightarrow \lambda_{a1}$ $\lambda_{m1} \wedge \lambda_{a2} \Rightarrow \theta_{m1 a2}, \theta_{m1 a2} \Rightarrow \lambda_{m1}, \theta_{m1 a2} \Rightarrow \lambda_{a2}$ $\lambda_{m2} \wedge \lambda_{a1} \Rightarrow \theta_{m2 a1}, \theta_{m2 a1} \Rightarrow \lambda_{m2}, \theta_{m2 a1} \Rightarrow \lambda_{a1}$ $\lambda_{m2} \wedge \lambda_{a2} \Rightarrow \theta_{m2 a2}, \theta_{m2 a2} \Rightarrow \lambda_{m2}, \theta_{m2 a2} \Rightarrow \lambda_{a2}$

REFERENCES

[1] Bayesian networks.

Table V. Weights association using ENC1 where missing weights are set to one

Weights	Value
$W(\theta_{b1})$	0.7
$W(\theta_{b2})$	0.3
$W(\theta_{e1})$	0.01
$W(\theta_{e2})$	0.19
$W(\theta_{e3})$	0.80
$W(\theta_{a1 b1,e1})$	0.90
$\mathrm{W}(\theta_{a1 b1,e2})$	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
$W(\theta_{j2 a2}^{j2 a1})$	0.90
$W(\theta_{m1 a1})$	0.80
$W(\theta_{m1 a2})$	0.10
$W(\theta_{m2 a1})$	0.20
$W(\theta)$	0.20
$W(\theta_{m2 a2})$	0.90

Table VI. BAYESIAN NETWORK ENCODED USING ENC2

B $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
$\begin{array}{c} \mathbf{E} & \begin{array}{c} \neg \lambda_{e1} \vee \neg \lambda_{e2}, \\ \neg \lambda_{e1} \vee \neg \lambda_{e3}, \\ \neg \lambda_{e2} \vee \neg \lambda_{e3}, \end{array} & \begin{array}{c} \rho_{e1} \wedge \rho_{e2} \Rightarrow \lambda_{e1} \\ \neg \rho_{e1} \wedge \rho_{e2} \Rightarrow \lambda_{e2} \\ \neg \rho_{e1} \wedge \neg \rho_{e2} \Rightarrow \lambda_{e3} \end{array} \\ \\ & \begin{array}{c} \lambda_{b1} \wedge \lambda_{e1} \wedge \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e2} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{e4} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e4} \wedge \rho_{e4} \wedge \neg \rho_{e4} \\ \lambda_{e4} \wedge \neg \rho_{e4} \wedge \neg \rho_$	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
$\begin{array}{c c} & \neg \rho_{e1} \wedge \neg \rho_{e2} \Rightarrow \lambda_{e3} \\ \hline & \lambda_{b1} \wedge \lambda_{e1} \wedge \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ & \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ & \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ & \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ & \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ & \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ & \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ & \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ & \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ & \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ & \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \hline \end{array}$	
$\begin{array}{c} \lambda_{b1} \wedge \lambda_{e1} \wedge \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e2} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e3} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e4} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e5} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e5} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e5} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e5} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{e5} \wedge \rho_{e5} \wedge \rho_{e5} \Rightarrow \lambda_{e5} \wedge \rho_{e5} \\ \lambda_{e5} \wedge \rho_{e5} \wedge \rho_{e5} \wedge \rho_{e5} \\ \lambda_{e5} \wedge \rho_{e5} $	
$\begin{array}{c} \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e2} \wedge \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{e4} \wedge \rho_{a1 b1,e4} \Rightarrow \lambda_{e4} \\ \lambda_{e4} \wedge \rho_{e4} \\ $	
$\begin{array}{c} \lambda_{b1} \wedge \lambda_{e3} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{o} \\ \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{o} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{o} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{o} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{o} \\ \lambda_{o} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{o} \\ \lambda_{o} \wedge \rho_{a1 b1,e3} \Rightarrow \lambda_{o} \\ \lambda_{o} \wedge \rho_{o} \\ \lambda_{o} \wedge \rho_{o$	
$\begin{array}{c} \lambda_{b2} \wedge \lambda_{e1} \wedge \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{e} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_{e1 b2,e2} \Rightarrow \lambda_{e} \\ \lambda_{e} \wedge \lambda_{e1} \wedge \neg \rho_$.1
$\begin{array}{c} A \\ \lambda_{a1} \vee \lambda_{a2}, \\ \neg \lambda_{a1} \vee \neg \lambda_{a2} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e3} \\ \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{e3} \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{e3} \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e3} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e3} \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e3} \\ \lambda_{e3} \wedge \lambda_{e4} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3} \\ \lambda_{e4} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e4} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \\ \lambda_{e5} \wedge \lambda_{e5} \wedge \rho_{a1 b2,e5} \Rightarrow \lambda_{e5} \wedge$	
$\begin{array}{c c} \mathbf{A} & \lambda_{a1} \vee \lambda_{a2}, \\ \neg \lambda_{a1} \vee \neg \lambda_{a2} & \lambda_{b2} \wedge \lambda_{e3} \wedge \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda_{e3}, \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda_{e3}, \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b3} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{b4} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{e4} \wedge \nabla \rho_{a1 b2,e3} \Rightarrow \lambda_{e3}, \\ \lambda_{e4} \wedge \nabla \rho_{a1 b2,e3} \Rightarrow \lambda_{e4}, \\ \lambda_{e4} \wedge \nabla \rho_{a1 b2,e3} \Rightarrow \lambda_{e4}, \\ \lambda_{e5} \wedge \nabla \rho_{a1 b2,e3} \Rightarrow \lambda_{e5}, \\ \lambda_$:1
$ \begin{array}{c c} \neg \lambda_{a1} \vee \neg \lambda_{a2} & \lambda_{b1} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b1,e1} \Rightarrow \lambda \\ \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda \end{array} $	ı 1
$ \begin{vmatrix} \lambda_{b1} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b1,e2} \Rightarrow \lambda \\ \lambda_{b1} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b1,e3} \Rightarrow \lambda \\ \lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda \end{vmatrix} $	
$egin{array}{c} \lambda_{b1} \wedge \lambda_{e3} \wedge eg ho_{a1 b1,e3} \Rightarrow \lambda \ \lambda_{b2} \wedge \lambda_{e1} \wedge eg ho_{a1 b2,e1} \Rightarrow \lambda \end{array}$	
$\lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e1} $	a2
$\lambda_{b2} \wedge \lambda_{e1} \wedge \neg \rho_{a1 b2,e1} \Rightarrow \lambda_{e1} $	
	a2
$\lambda_{b2} \wedge \lambda_{e2} \wedge \neg \rho_{a1 b2,e2} \Rightarrow \lambda_{e2} \wedge \neg \rho_{a2 b2,e2} \Rightarrow \lambda_{e2} $	a2
$\lambda_{b2} \wedge \lambda_{e3} \wedge \neg \rho_{a1 b2,e3} \Rightarrow \lambda$	a2
$\lambda_{a1} \wedge \rho_{j1 a1} \Rightarrow \lambda_{j1}$	
$\neg \lambda_{j1} \lor \neg \lambda_{j2} \lambda_{a1} \land \neg \rho_{j1 a1} \Rightarrow \lambda_{j2}$	
$\lambda_{a2} \wedge \neg \rho_{j1 a2} \Rightarrow \lambda_{j2}$	
$\lambda_{a1} \wedge \rho_{m1 a1} \Rightarrow \lambda_{m1}$	
$ \begin{array}{c ccc} M & \lambda_{m1} \vee \lambda_{m2}, & \lambda_{a2} \wedge \rho_{m1 a2} \Rightarrow \lambda_{m1} \end{array} $	
$ \neg \lambda_{m1} \lor \neg \lambda_{m2} \lambda_{a1} \land \neg \rho_{m1 a1} \Rightarrow \lambda_{m2}$	
$\lambda_{a2} \wedge \neg \rho_{m1 a2} \Rightarrow \lambda_{m2}$	

Table VII. Weights association using ENC2 where missing weights are set to one

Weights	Value
$W(\rho_{b1})$	0.7
$W(\neg \rho_{b1})$	0.3
$W(\rho_{e1})$	0.01
$W(\rho_{e2})$	0.19/(1-0.01) = 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