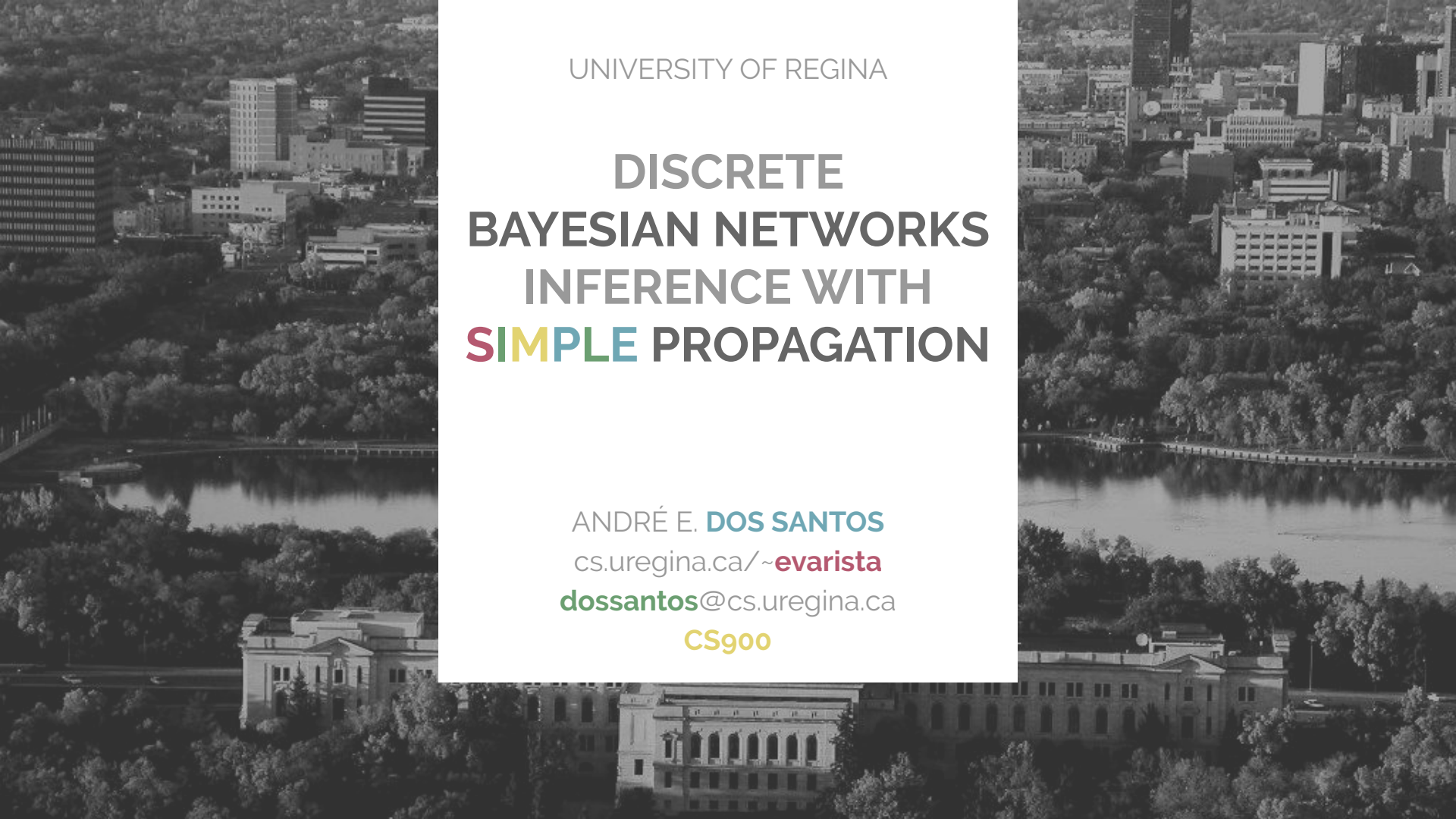

UNIVERSITY OF REGINA

DISCRETE BAYESIAN NETWORKS INFERENCE WITH SIMPLE PROPAGATION

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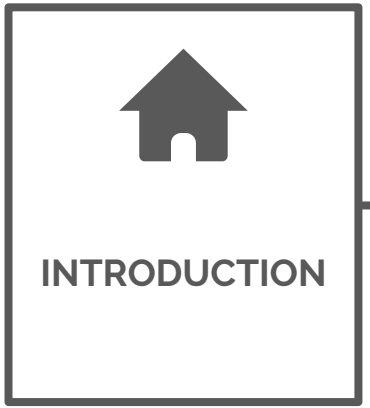
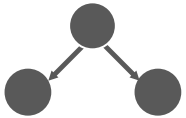
CS900

OUTLINE



INTRODUCTION



BAYESIAN NETWORKS
(BNs)

DARWINIAN NETWORKS
(DNs)

JOIN TREE PROPAGATION
(JTP)

OUTLINE

SIMPLE PROPAGATION
(SP)

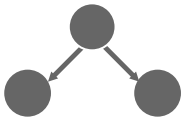
EXPERIMENTAL RESULTS

CONCLUSIONS

QUESTIONS

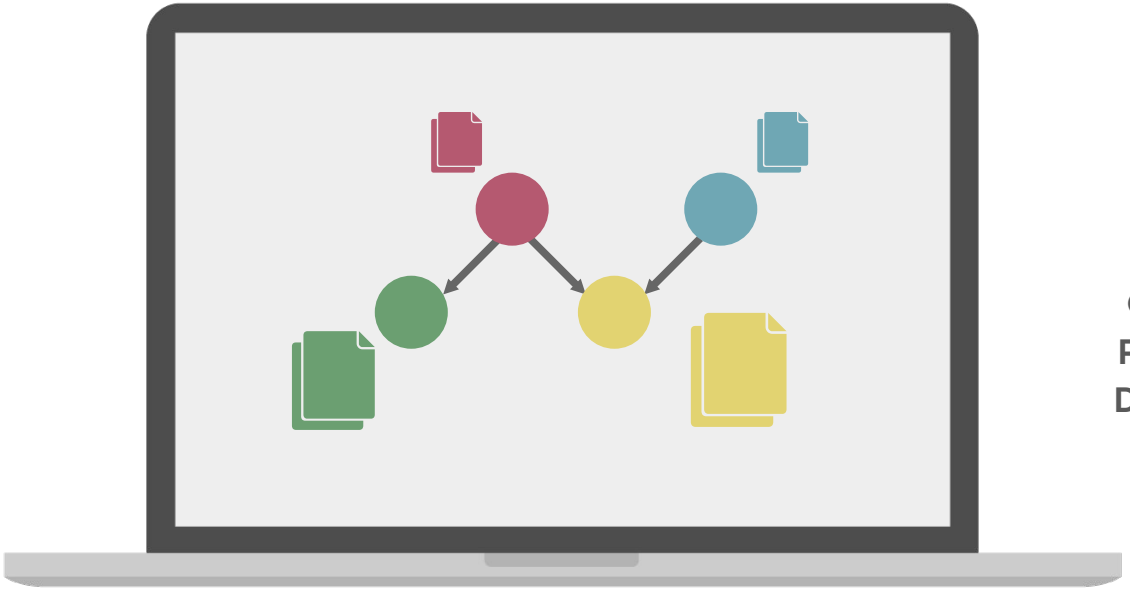
BAYESIAN NETWORKS

PROBABILISTIC GRAPHICAL MODEL



DIRECTED ACYCLIC GRAPH

DAG



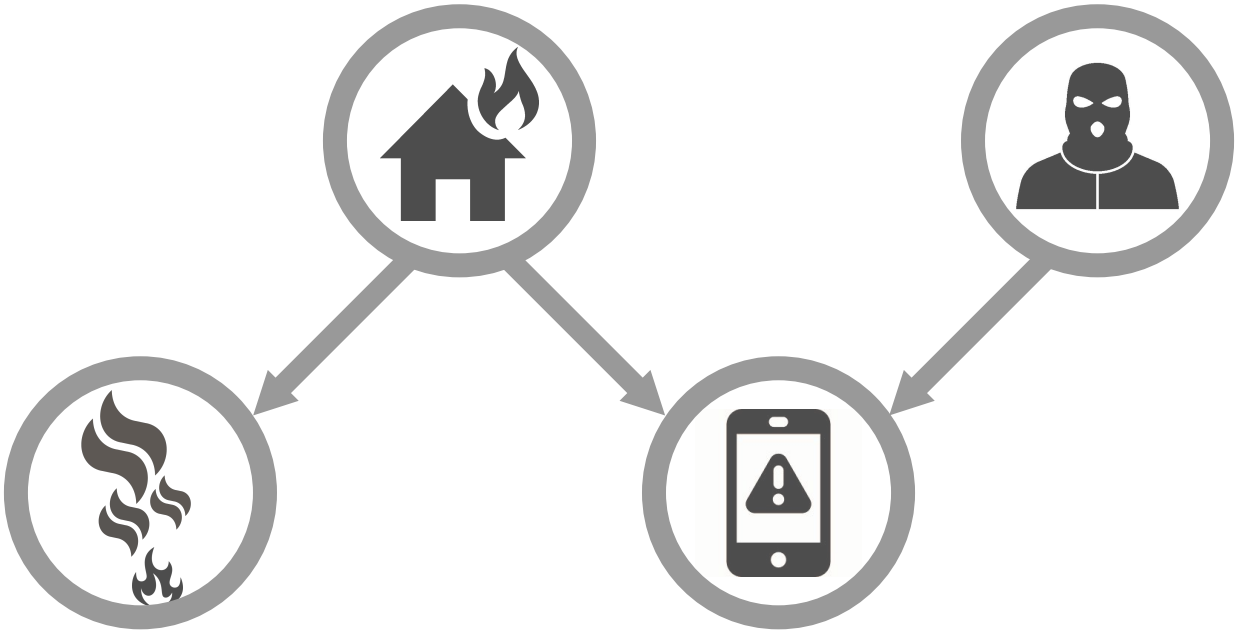
CONDITIONAL PROBABILISTIC DISTRIBUTIONS

CPD

Pearl

1988

BN EXAMPLE

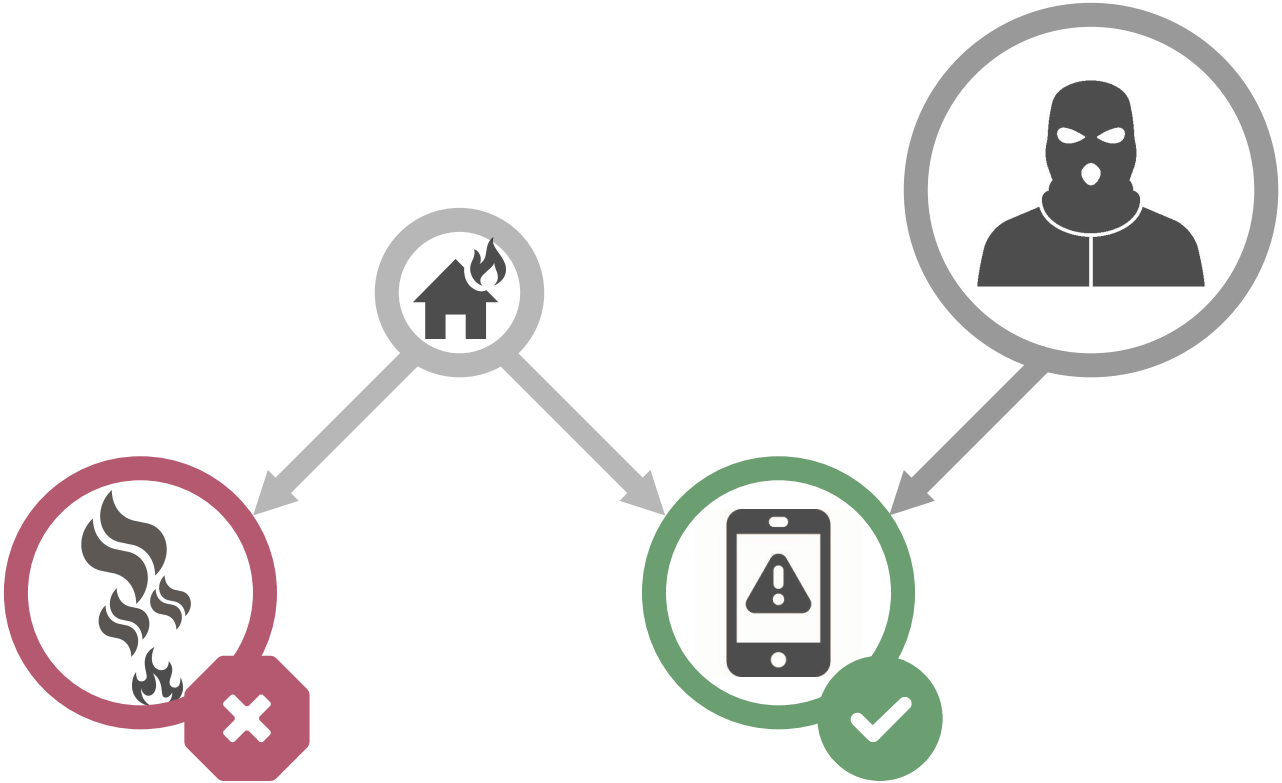


BN EXAMPLE

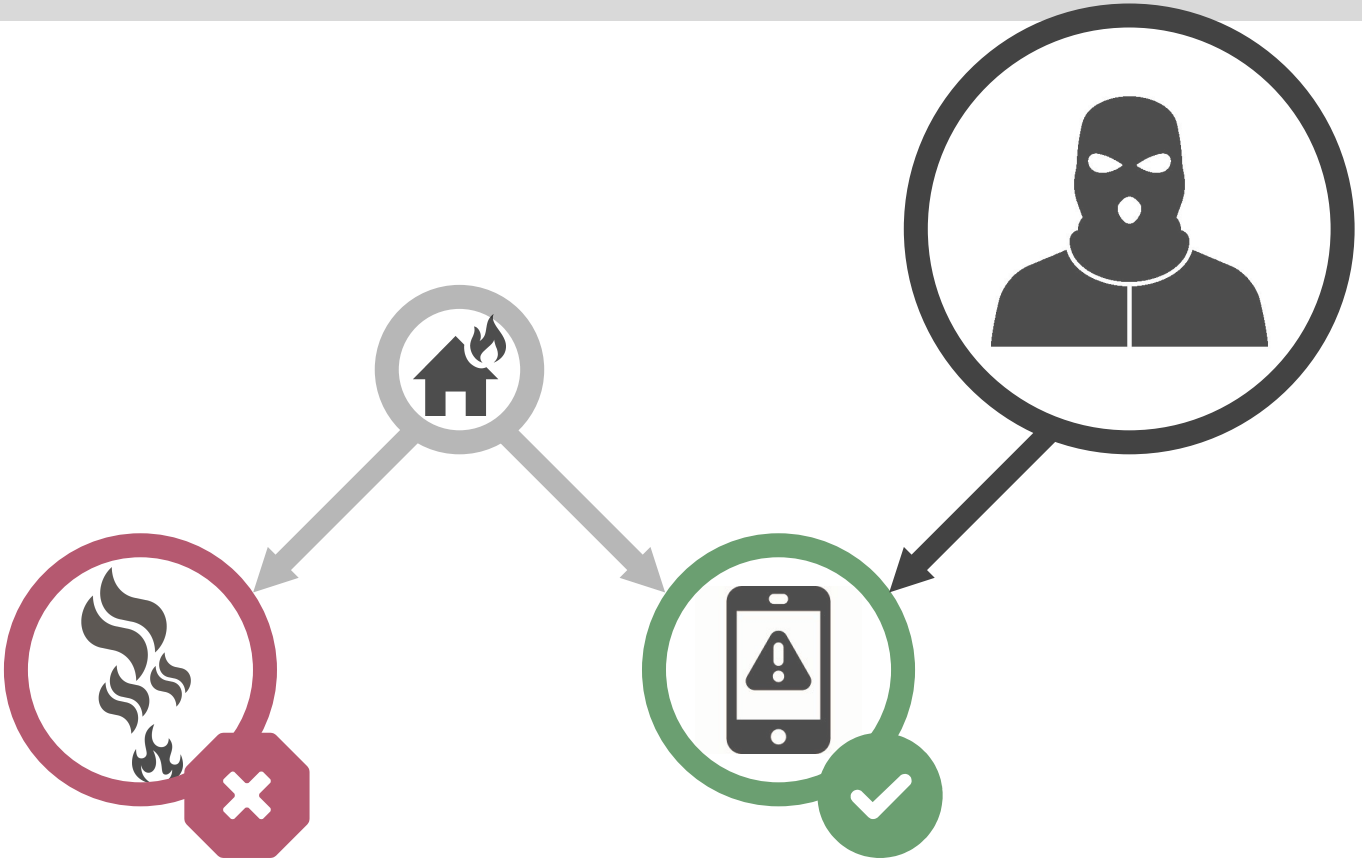
BN EXAMPLE

BN EXAMPLE

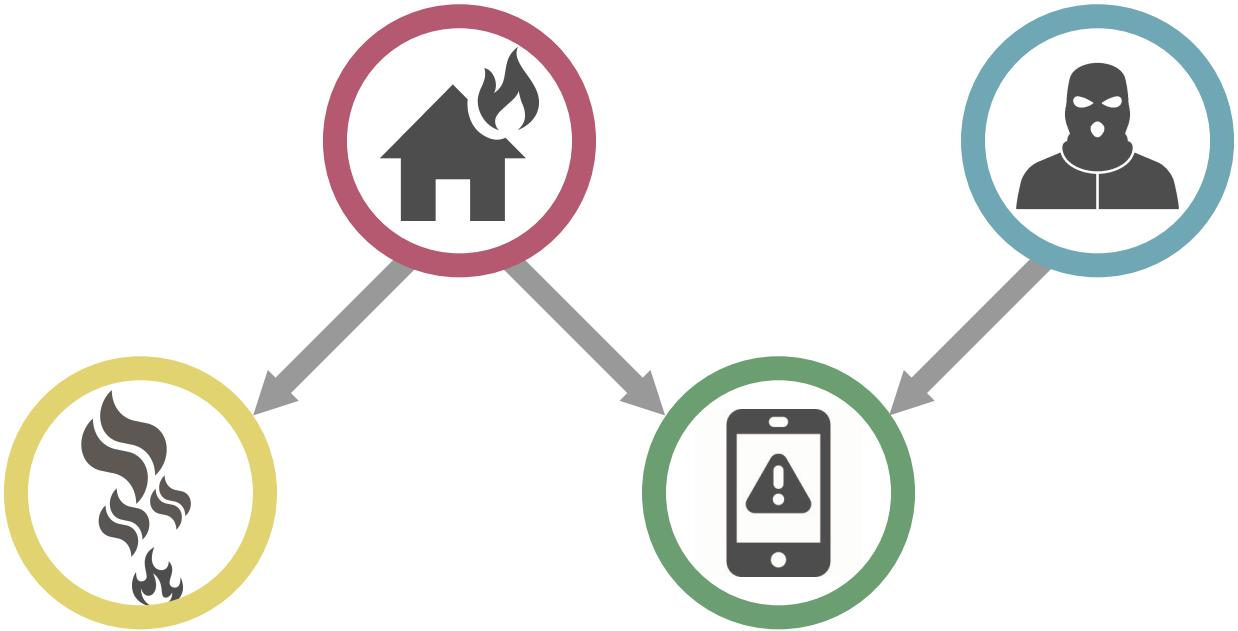
BN EXAMPLE



BN EXAMPLE



The ∏ of the CPTs is a **joint probability distribution** ρ(**U**)



$$\rho(\mathbf{U}) = \rho(\text{fire}) \cdot \rho(\text{burglar}) \cdot \rho(\text{smoke} \mid \text{fire}) \cdot \rho(\text{cellphone} \mid \text{fire}, \text{burglar})$$

DARWINIAN NETWORKS

SIMPLE PROPAGATION AROSE FROM DARWINIAN NETWORKS

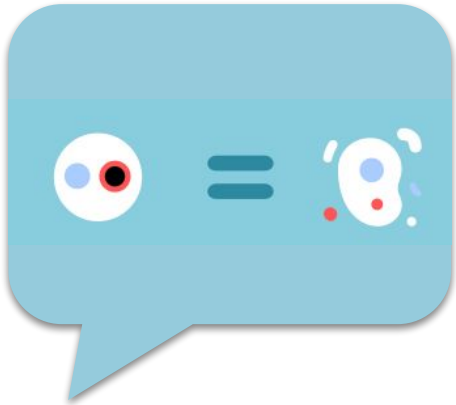
(CAI 2015, CI 2016)

CLEVER WAY TO VIEW CPTS

$$P(g|e,f)$$

DARWINIAN NETWORKS

POPULATION OF MICROORGANISMS



$$P(g|e, f)$$

MULTIPLICATION IS

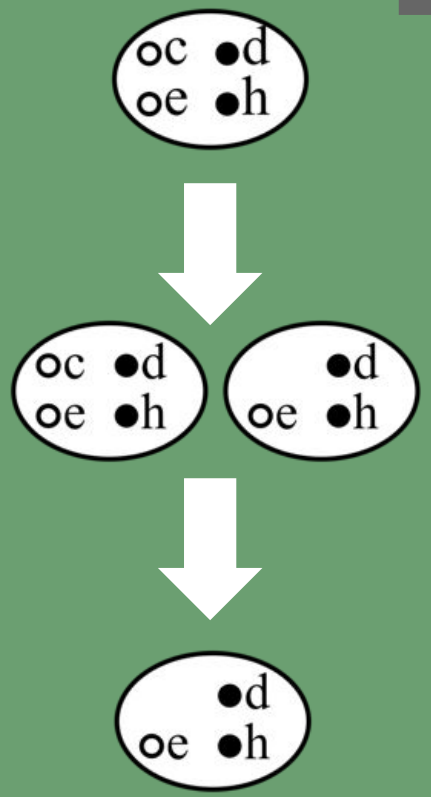
MERGE

○ white	+	● black	=	○ white
● black	+	○ white	=	○ white
● black	+	● black	=	● black
○ white	+	○ white	=	● black

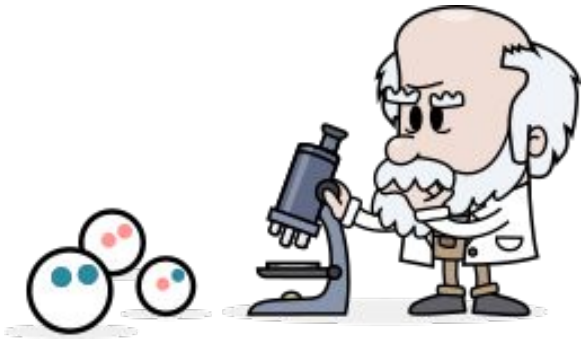
$$P(c|h) \cdot P(e|c,d) = P(c,e|d,h)$$

MARGINALIZATION IS REPLICATION AND NATURAL SELECTION

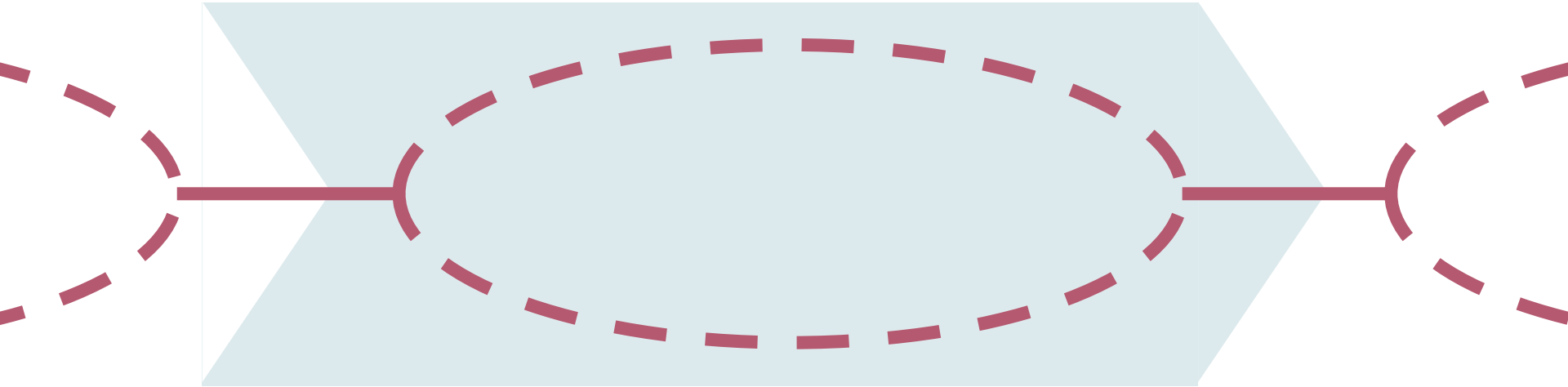
$$\sum_c P(c, e|d, h) = P(e|d, h)$$



Darwinian Networks Lab

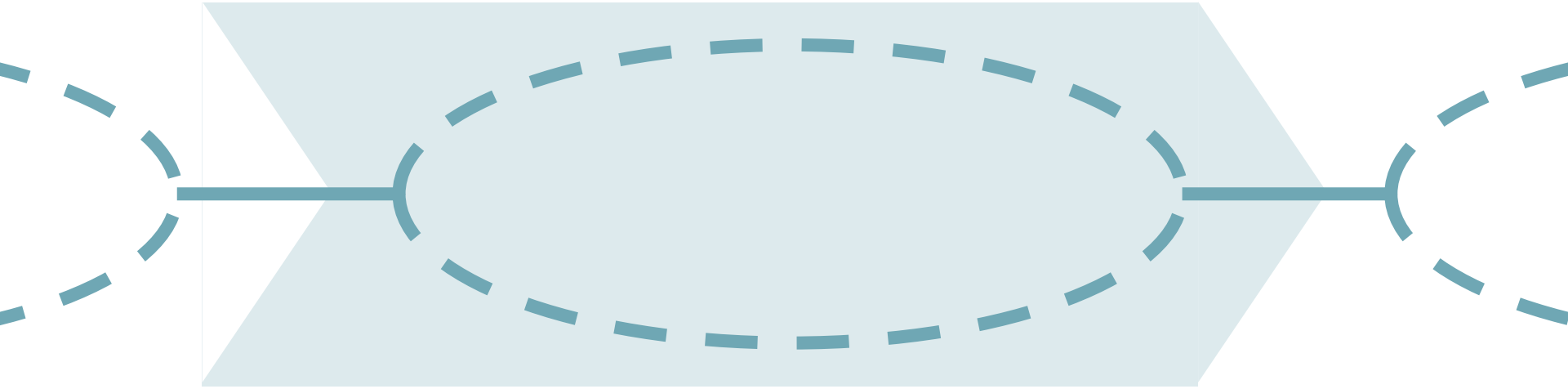


Scan me



SIMPLE PROPAGATION

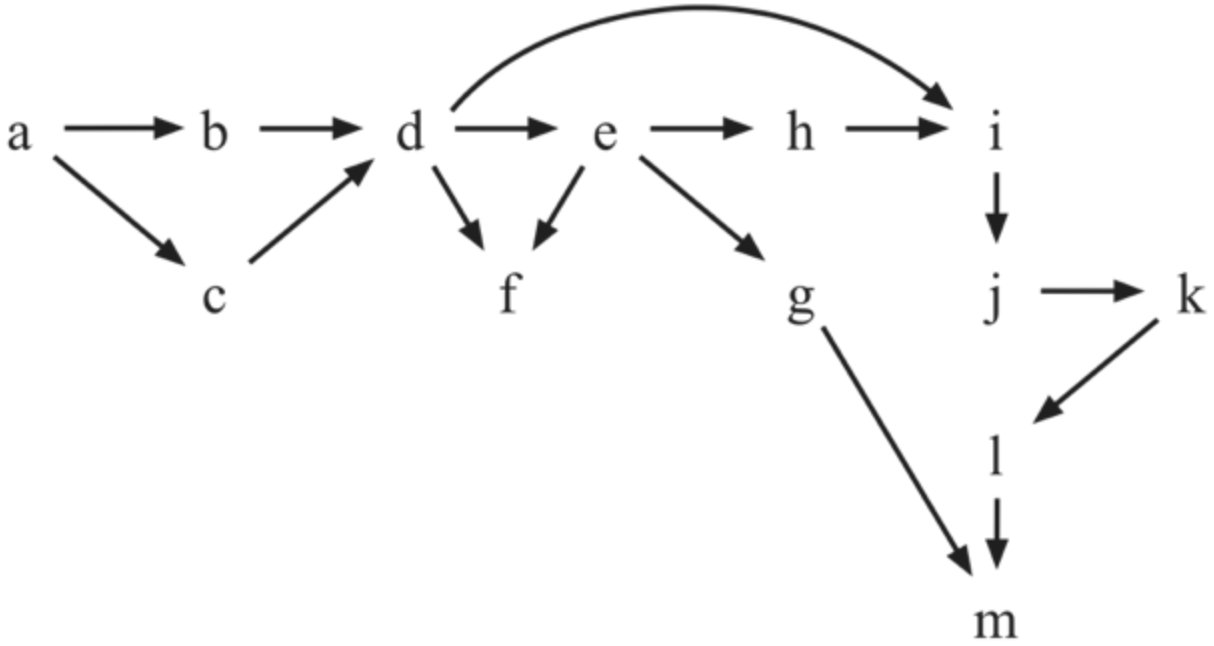
SP ONLY USES THE **“ONE IN, ONE OUT”** PROPERTY FOR JOIN TREE PROPAGATION



JOIN TREE PROPAGATION

JTP IS CENTRAL TO THE THEORY AND PRACTICE OF PROBABILISTIC EXPERT SYSTEMS

(Shafer 1996)


a
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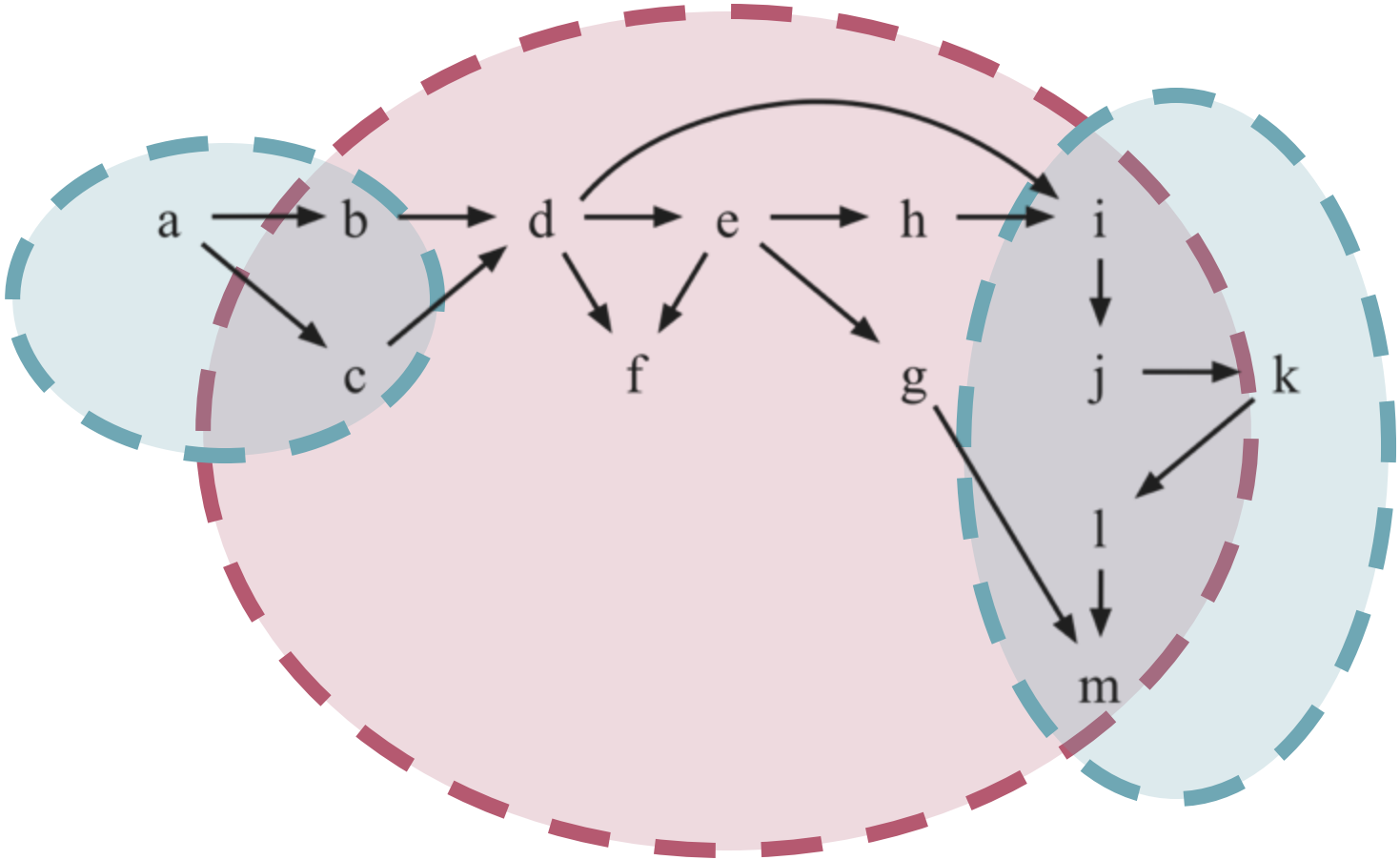
l
m


a
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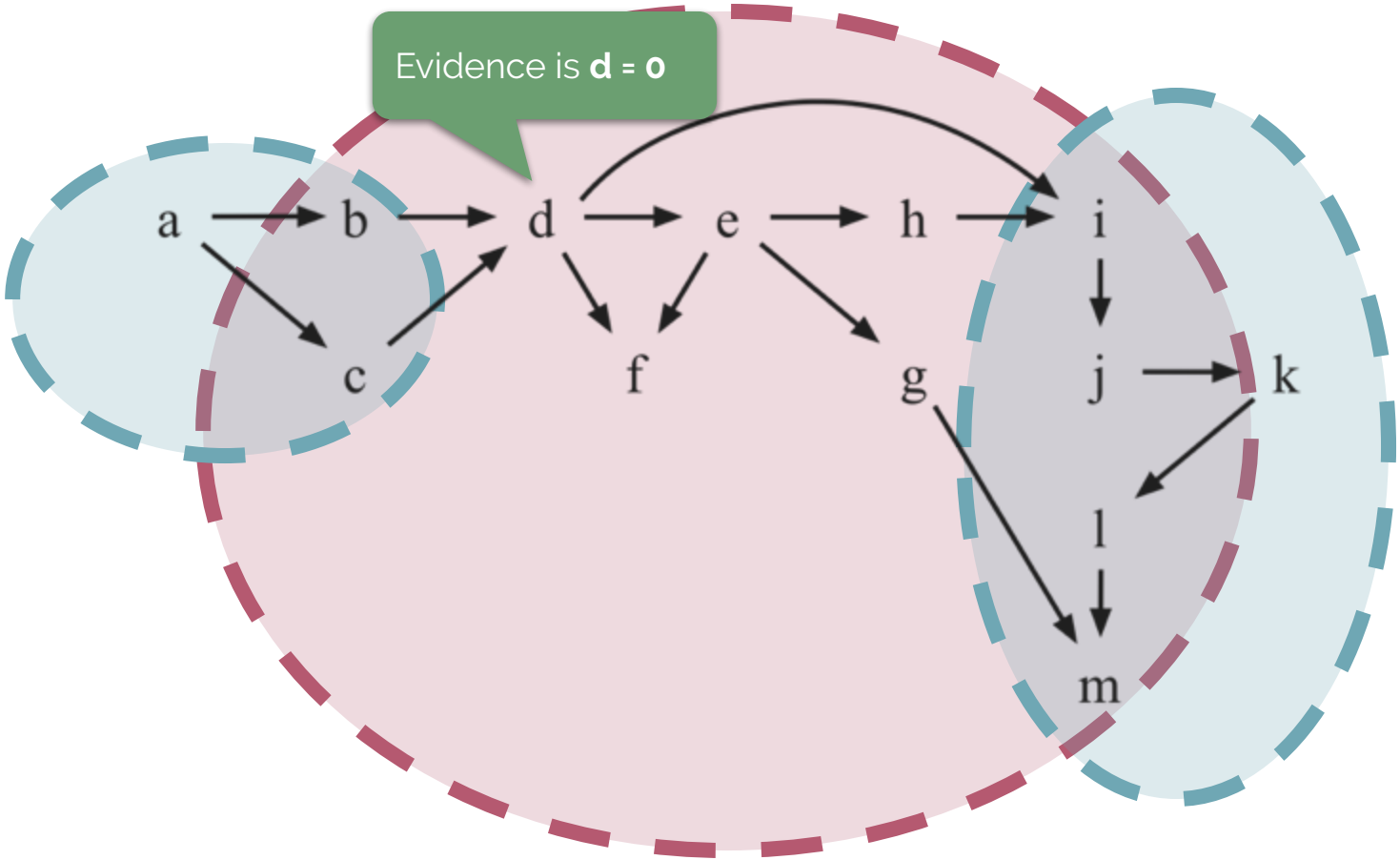
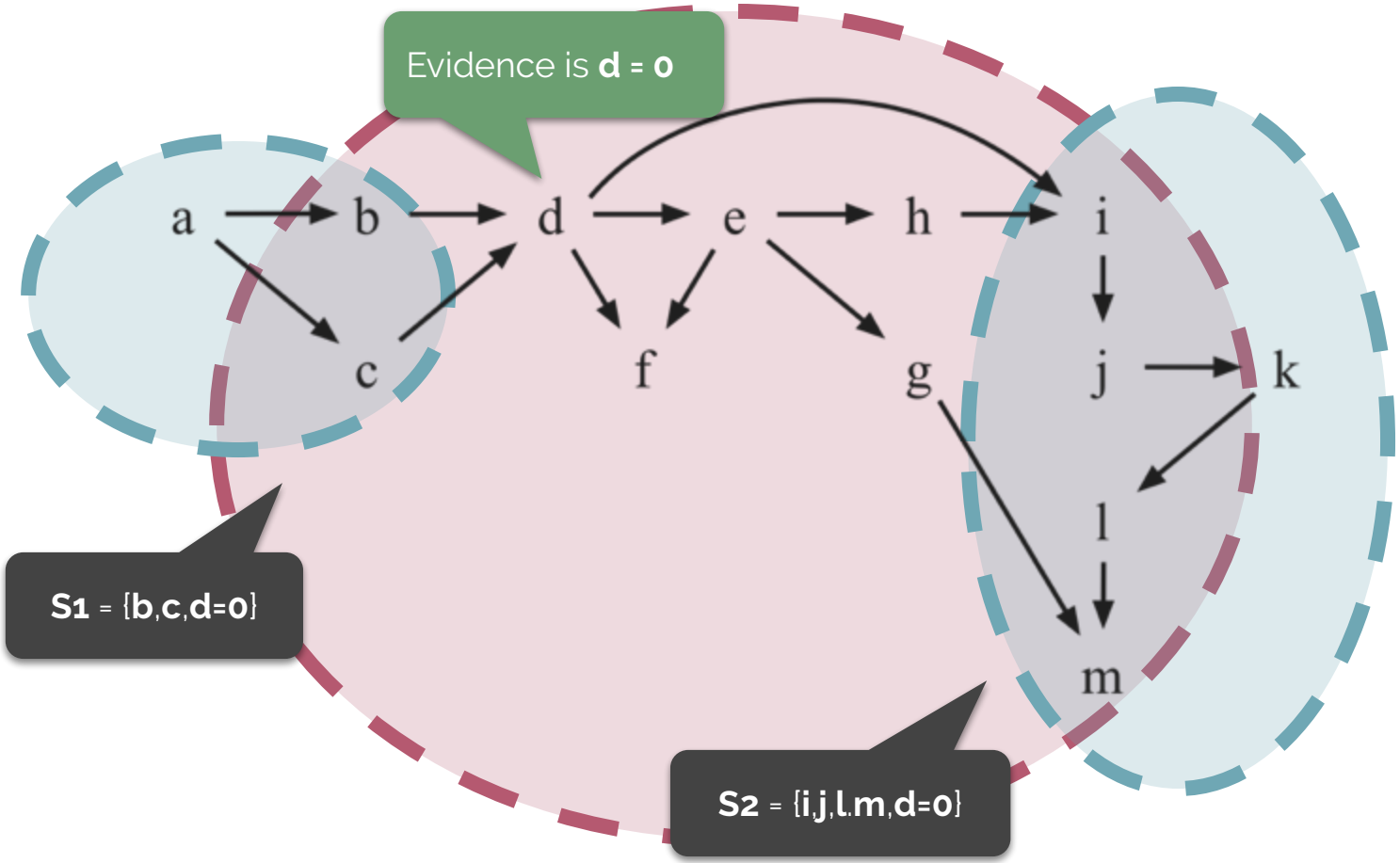
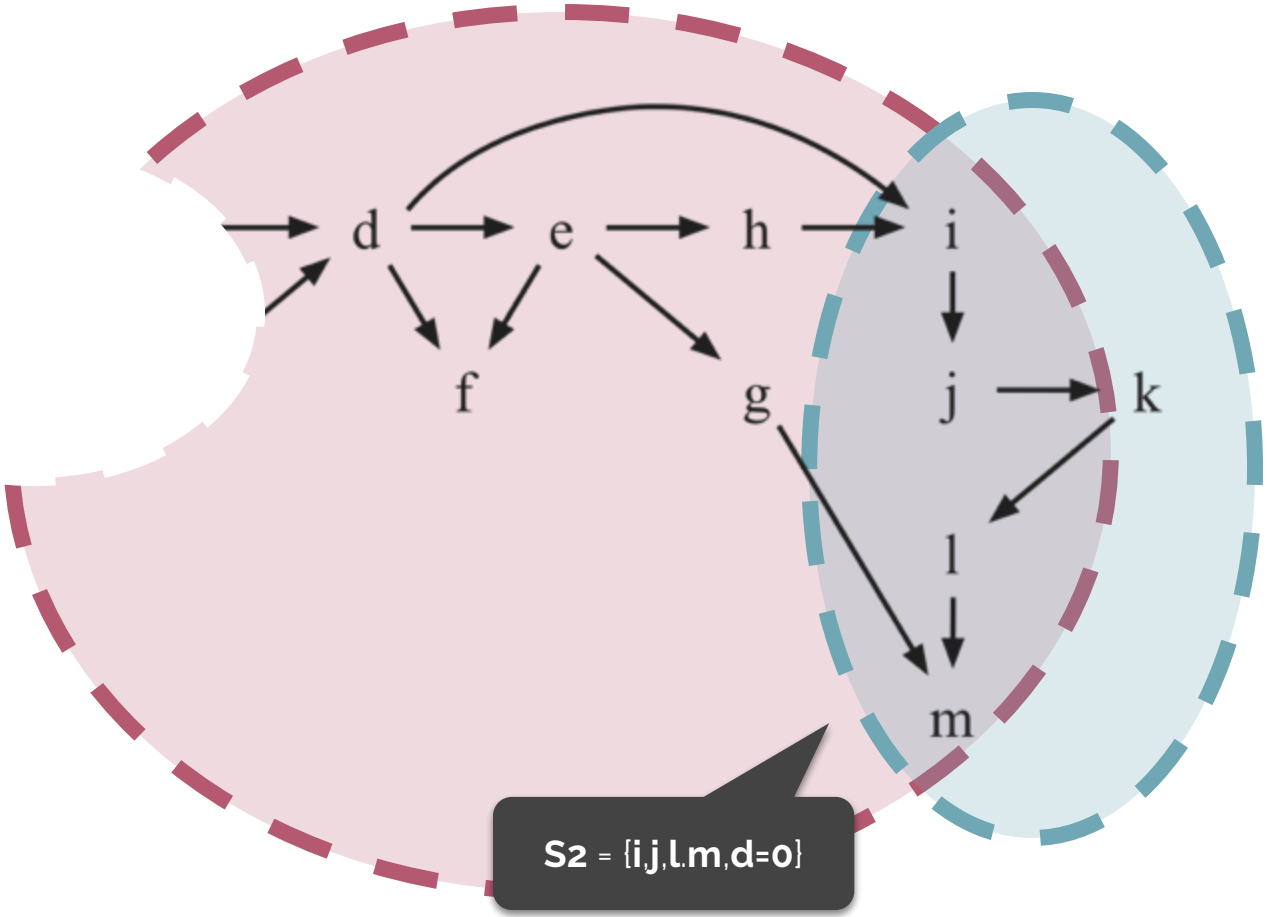

Evidence is d = 0
a
b
c
d
e
f
g
h
i
j
k
l
m


Evidence is d = 0
a
b
c
d
e
f
g
h
i
j
k
l
m
S1 = {b,c,d=0}
S2 = {i,j,l.m,d=0}


d
e
h
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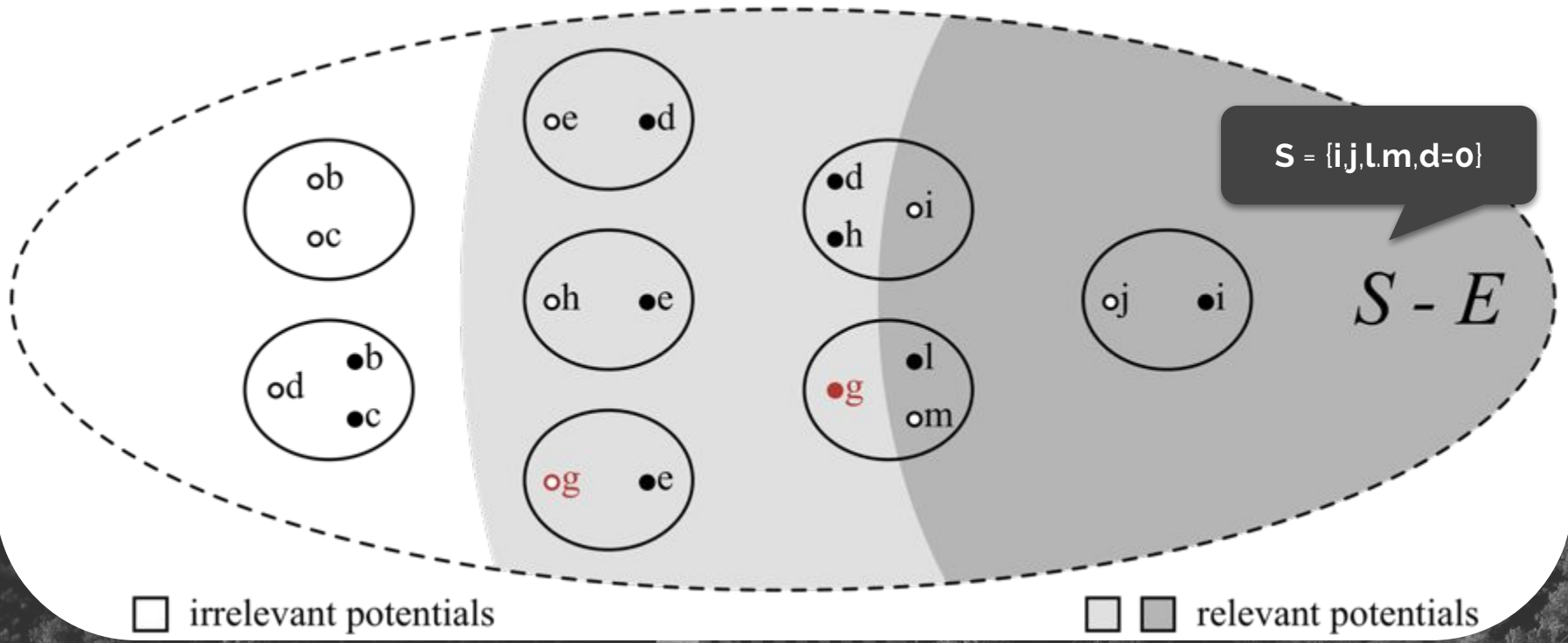
k
l
m
S2 = {i,j,l.m,d=0}


ob
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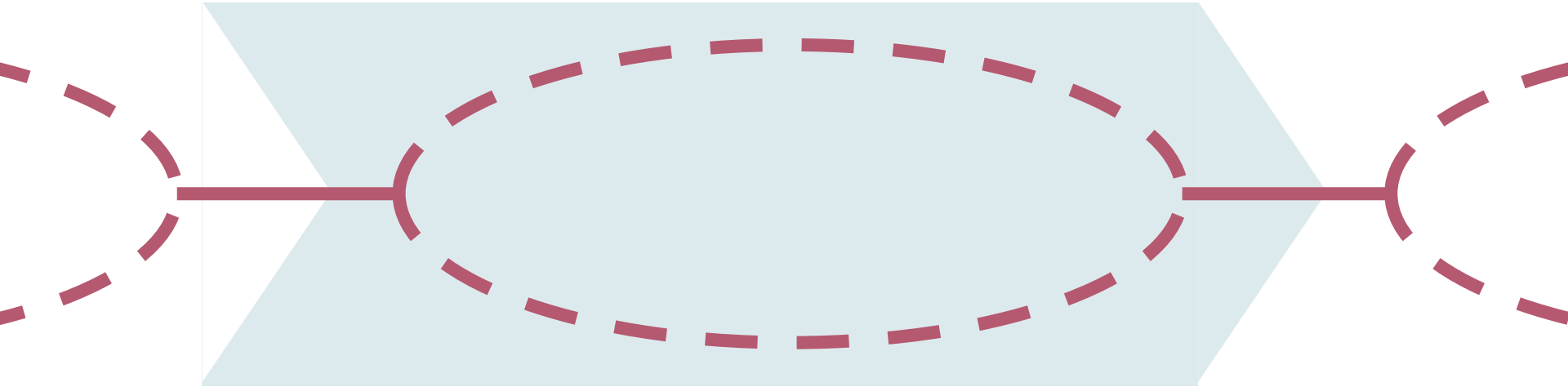
oe
●d
oh
●e
og
●e
●d
●h
oi
●g
●l
om
oj
●i
S - E
S = {i,j,l.m,d=o}
irrelevant potentials
relevant potentials



SIMPLE PROPAGATION

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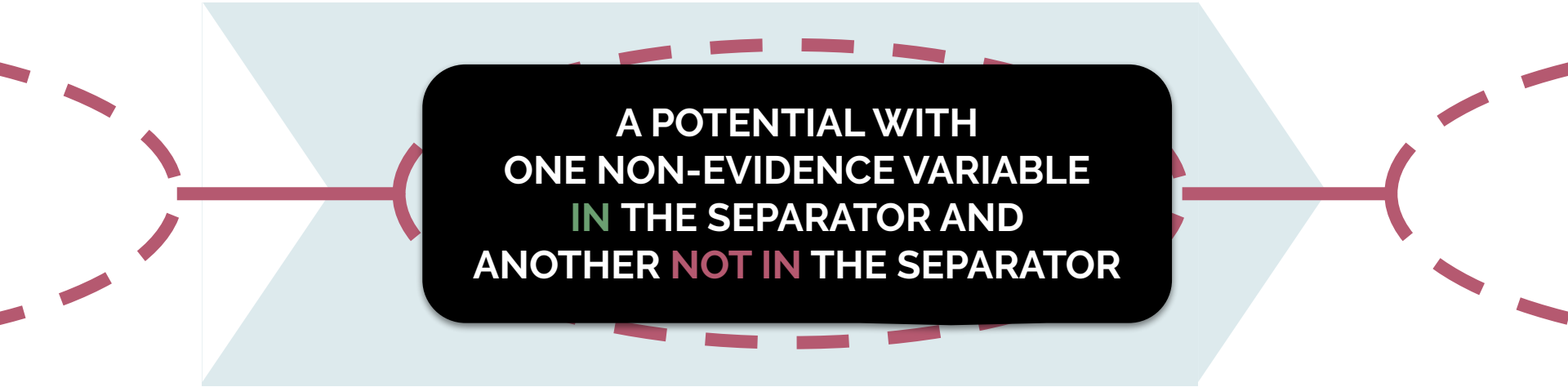
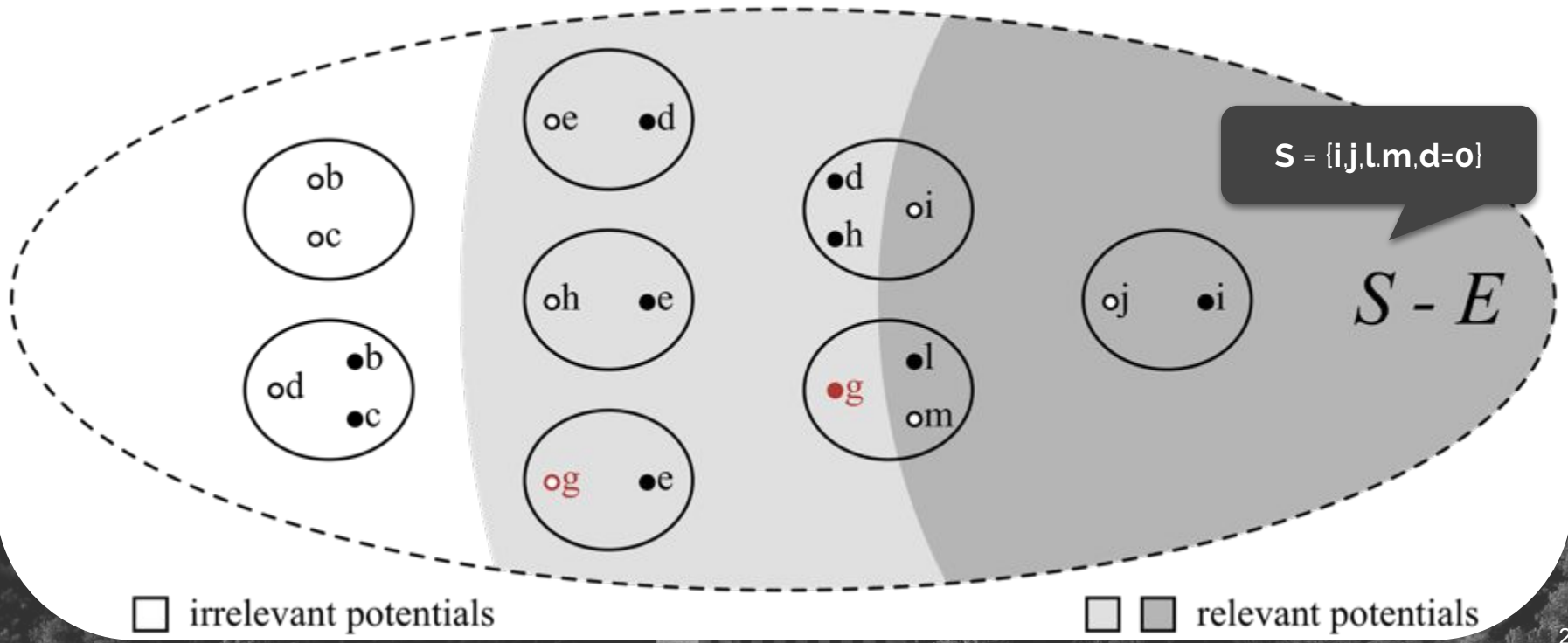


SIMPLE PROPAGATION

SP ONLY USES THE **"ONE IN, ONE OUT"** PROPERTY FOR JOIN TREE PROPAGATION


ob
oc
od
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oe
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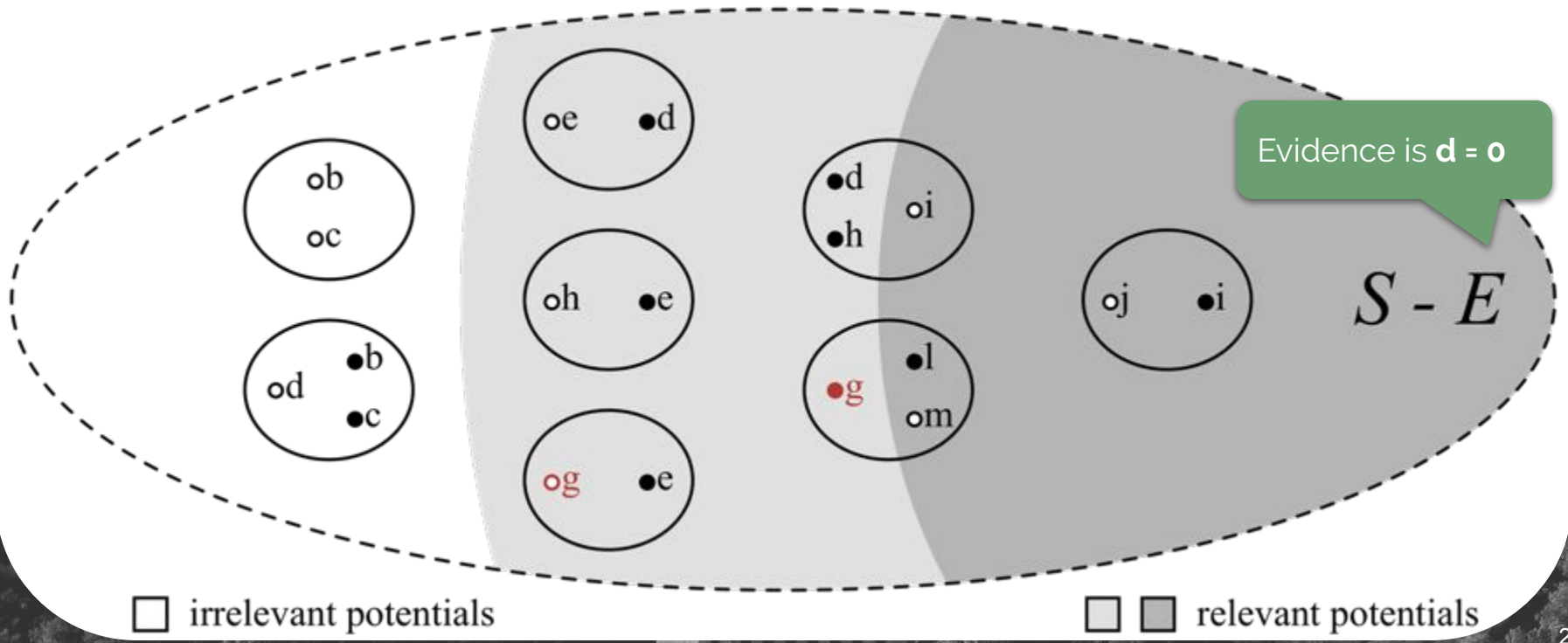
oh
●e
og
●e
●d
●h
oi
●g
●l
om
oj
●i
S - E
S = {i,j,l.m,d=o}
irrelevant potentials
relevant potentials


ob
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●b
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oe
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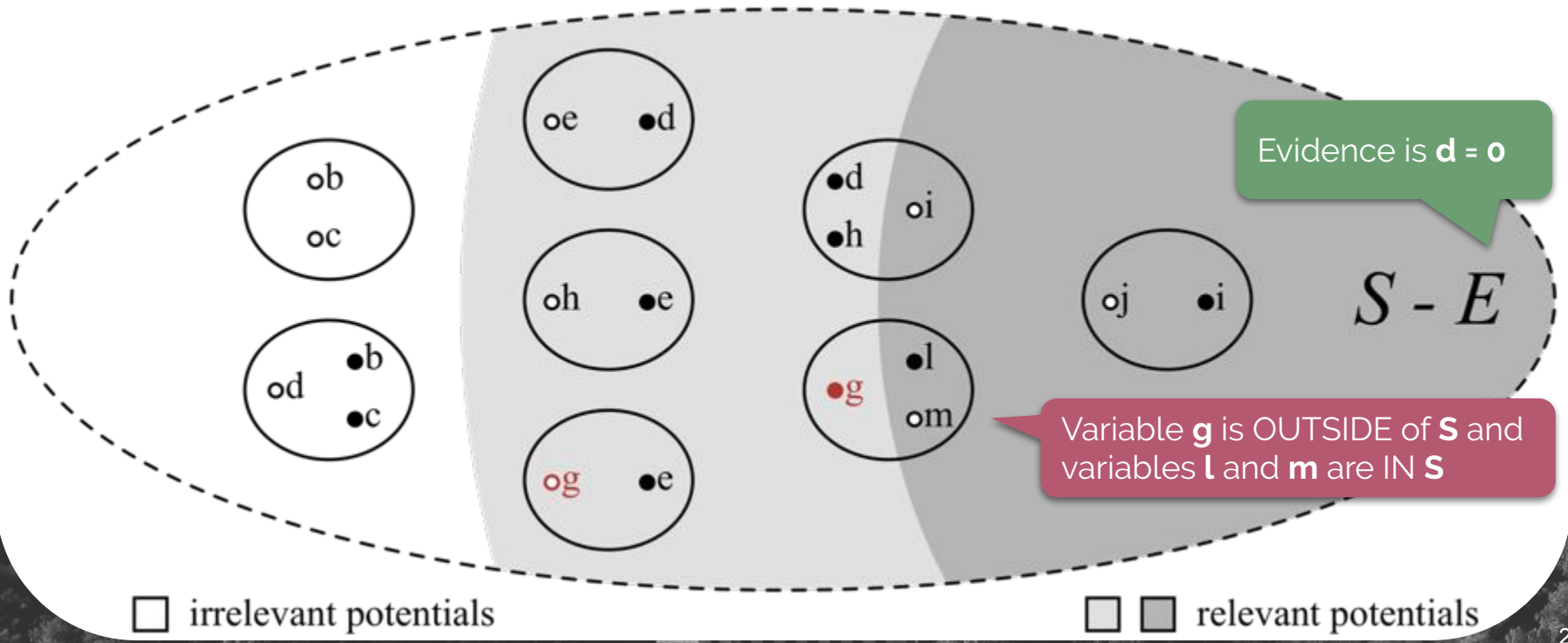
oh
●e
og
●e
●d
●h
oi
●g
●l
om
oj
●i
Evidence is d = o
S - E
irrelevant potentials
relevant potentials


ob
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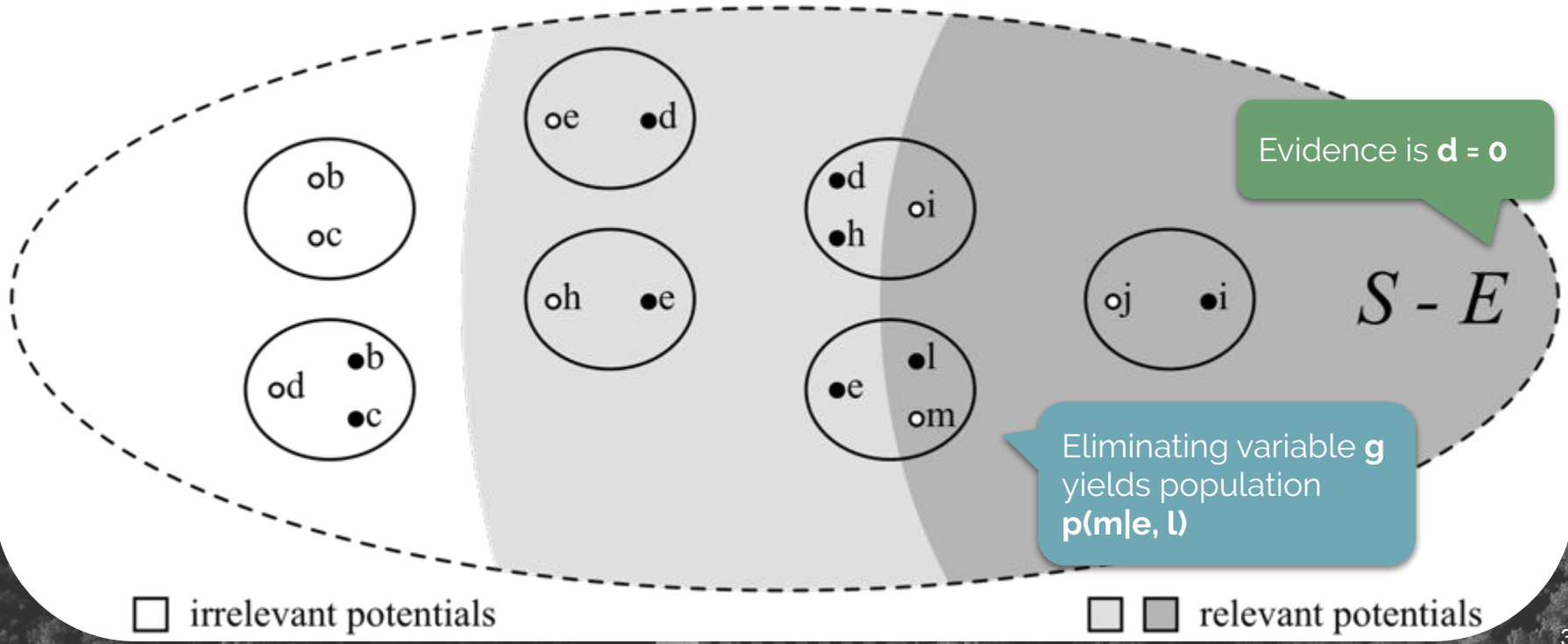
od
●b
●c
oe
●d
oh
●e
og
●e
●d
●h
oi
●g
●l
om
oj
●i
S - E
Evidence is d = o
Variable g is OUTSIDE of S and variables l and m are IN S
irrelevant potentials
relevant potentials


ob
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oe
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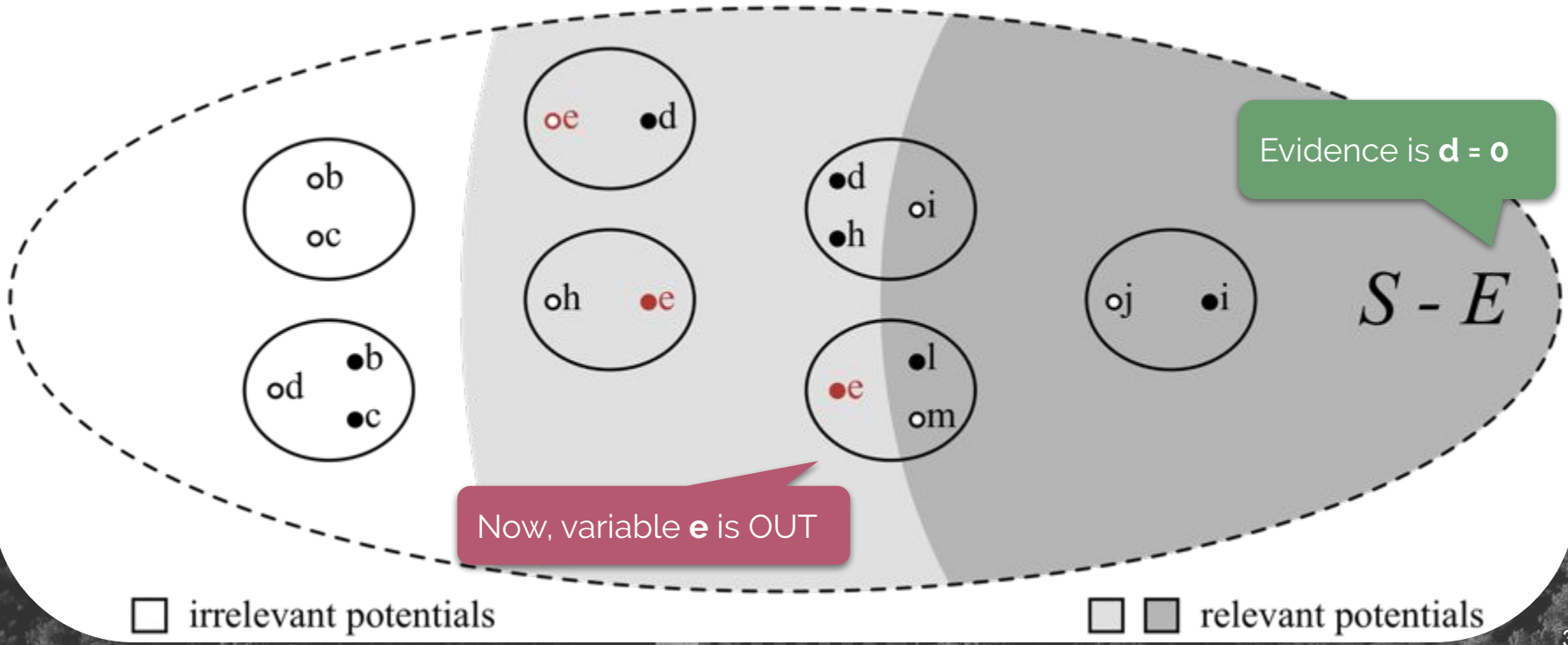
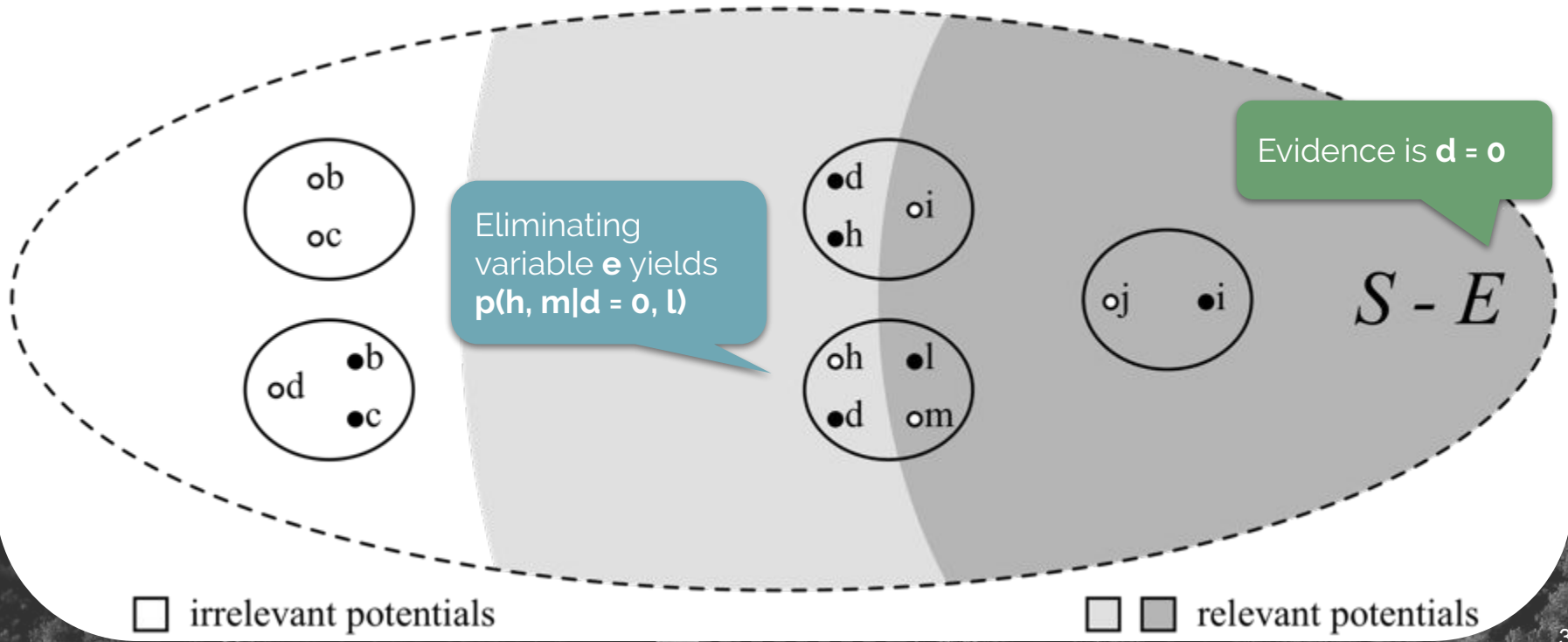
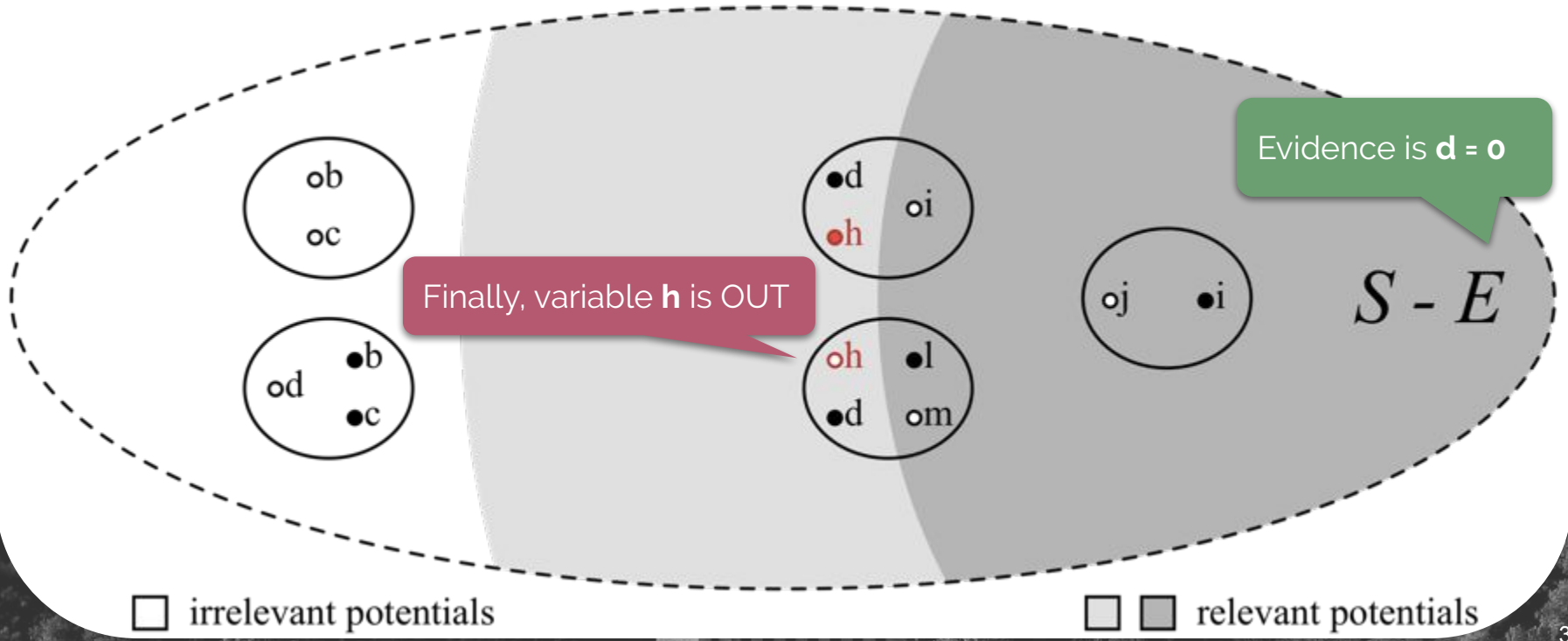
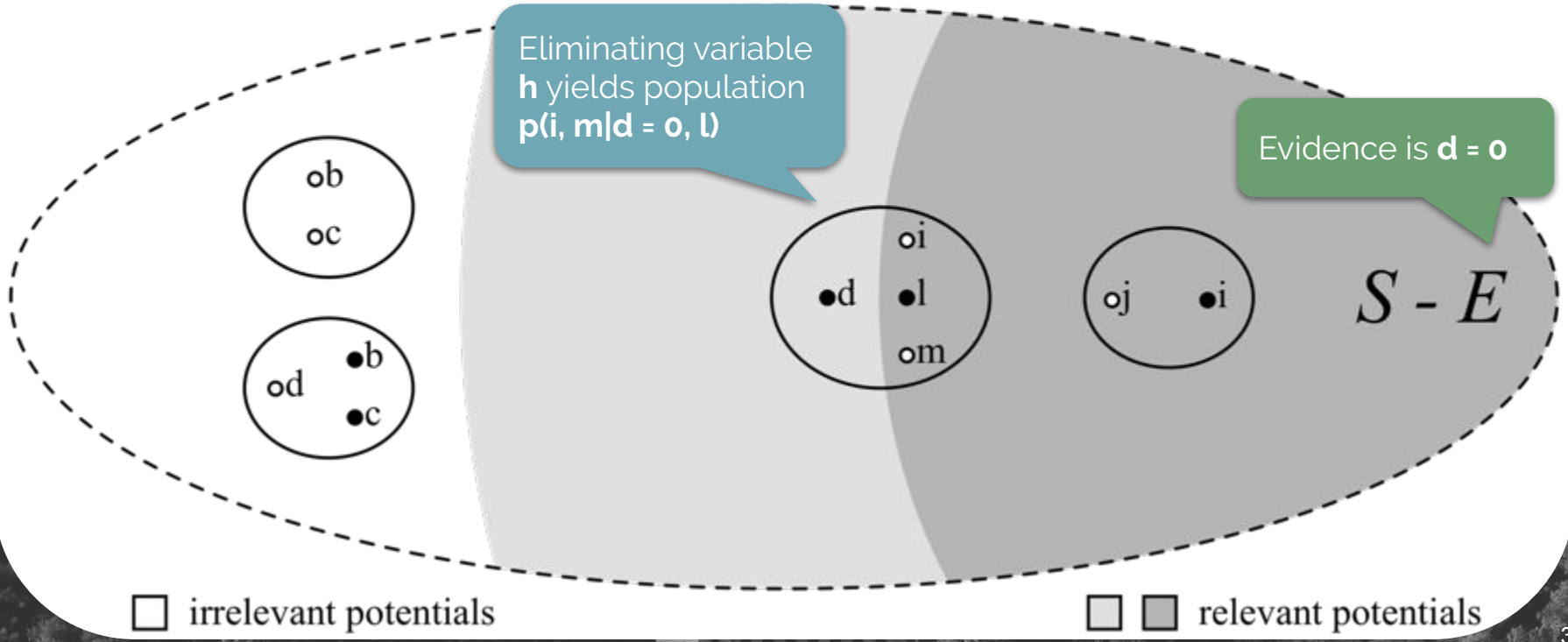
●e
●d
●h
oi
●e
●l
om
oj
●i
S - E
Evidence is d = o
Eliminating variable g yields population p(m|e, l)
irrelevant potentials
relevant potentials


ob
oc
od
●b
●c
oe
●d
oh
●e
●d
●h
oi
●e
●l
om
oj
●i
S - E
Evidence is d = o
Now, variable e is OUT
irrelevant potentials
relevant potentials

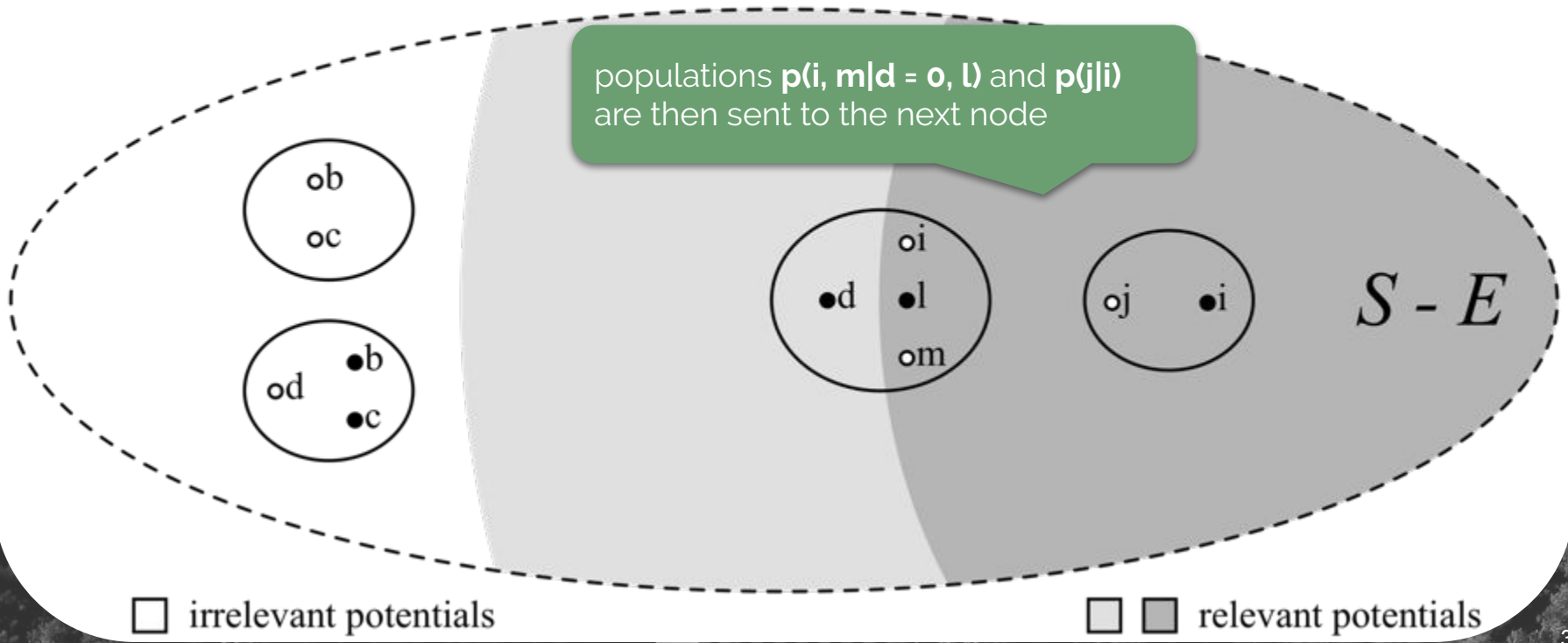

ob
oc
od
●b
●c
Eliminating variable **e** yields **p(h, m|d = o, l)**
●d
oi
●h
oh
●l
●d
om
Evidence is **d = o**
oj
●i
S - E
irrelevant potentials
relevant potentials


ob
oc
od
•b
•c
•d
oh
oi
oh
•l
•d
om
oj
•i
S - E
Evidence is d = o
Finally, variable h is OUT
irrelevant potentials
relevant potentials


Eliminating variable **h** yields population **p(i, m|d = 0, l)**
Evidence is **d = 0**
ob
oc
od
•b
•c
oi
•d
•l
om
oj
•i
S - E
irrelevant potentials
relevant potentials

No more populations with the **"ONE IN, ONE OUT"** property

$$P(j|i) \cdot P(i, m|d = 0, l)$$



EXPERIMENTAL RESULTS

BN	Vars	LP	SP	Savin
Water	32	0.06	0.05	17%
Oow	33	0.07	0.06	14%
Oow_Bas	33	0.04	0.03	25%
Mildew	35	0.05	0.04	20%
Oow_Solo	40	0.07	0.06	14%
Hkv2005	44	0.23	0.27	-17%
Barley	48	0.09	0.1	-11%
Kk	50	0.09	0.09	0%
Ship	50	0.16	0.17	-6%
Hailfinder	56	0.02	0.02	0%
Medianus	56	0.04	0.03	25%
3Nt	58	0.02	0.01	50%
Hepar_Ii	70	0.03	0.03	0%
Win95Pts	76	0.03	0.03	0%
System_V57	85	0.06	0.05	17%
Fwe_Model8	109	0.14	0.15	-7%
Pathfinder	109	0.12	0.11	8%
Adapt_T1	133	0.04	0.04	0%
Cc145	145	0.1	0.08	20%
Munin1	189	0.54	0.75	-39%
Andes	223	0.15	0.13	13%
Cc245	245	0.2	0.18	10%
Diabetes	413	0.34	0.31	9%
Adapt_T2	671	0.24	0.22	8%
Amirali	681	0.45	0.41	9%
Munin2	1003	0.49	0.45	8%
Munin4	1041	0.61	0.57	7%
Munin3	1044	0.66	0.64	3%

EXPERIMENTS CONDUCTED ON OPTIMAL JTs BUILT FROM 28 REAL-WORLD AND BENCHMARK BNs

- **SP** was **faster** in **18**
- **SP** tied **LP** in **5**
- **LP** was faster in **5**

CONCLUSION

SP IS A NEW BN INFERENCE ALGORITHM

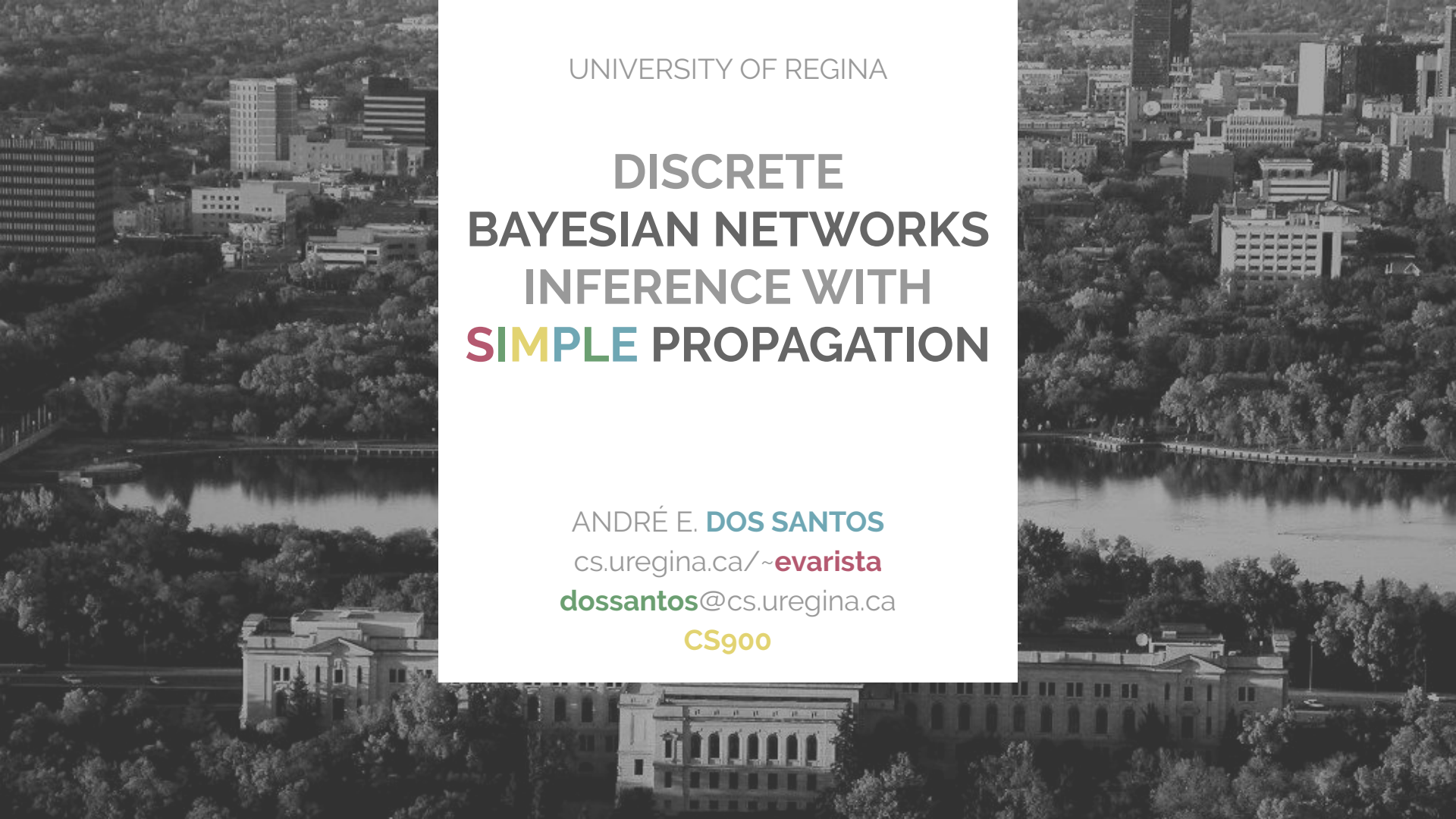
NO TESTING OF INDEPENDENCIES

"ONE IN, ONE OUT" PROPERTY

NO ELIMINATION ORDERINGS

SP IS FASTER THAN LP IN 18/28 REAL-WORLD BNs

SP PERFORMS POORLY IN NON-OPTIMAL JOIN TREES



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