Parameter Learning in Probabilistic Databases

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joint work with

Angelika Kimmig, Kristian Kersting, Luc De Raedt

KATHOLIEKE UNIVERSITEIT LEUVEN

DTAI MACHINE LEARNING

Motivation

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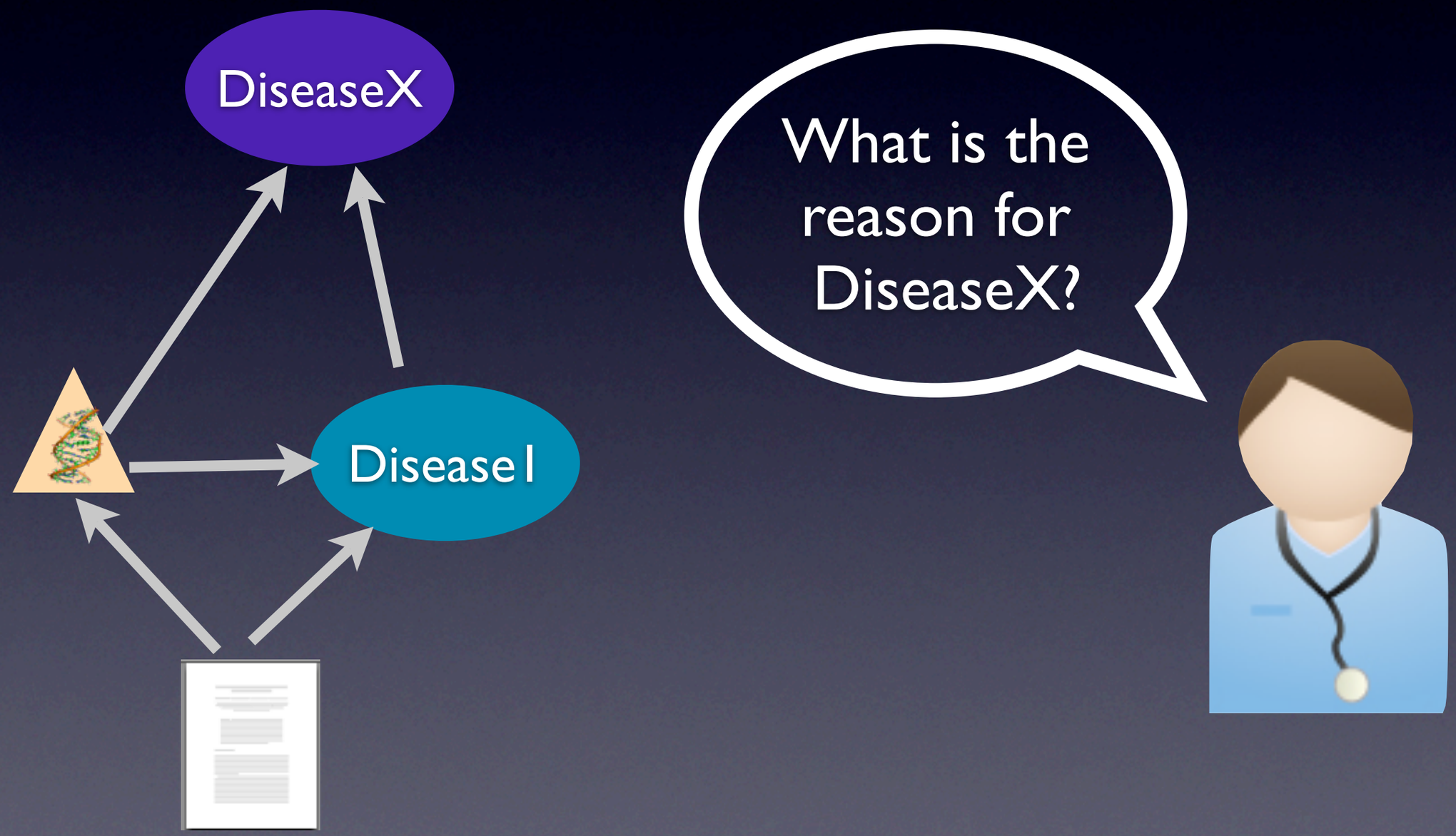

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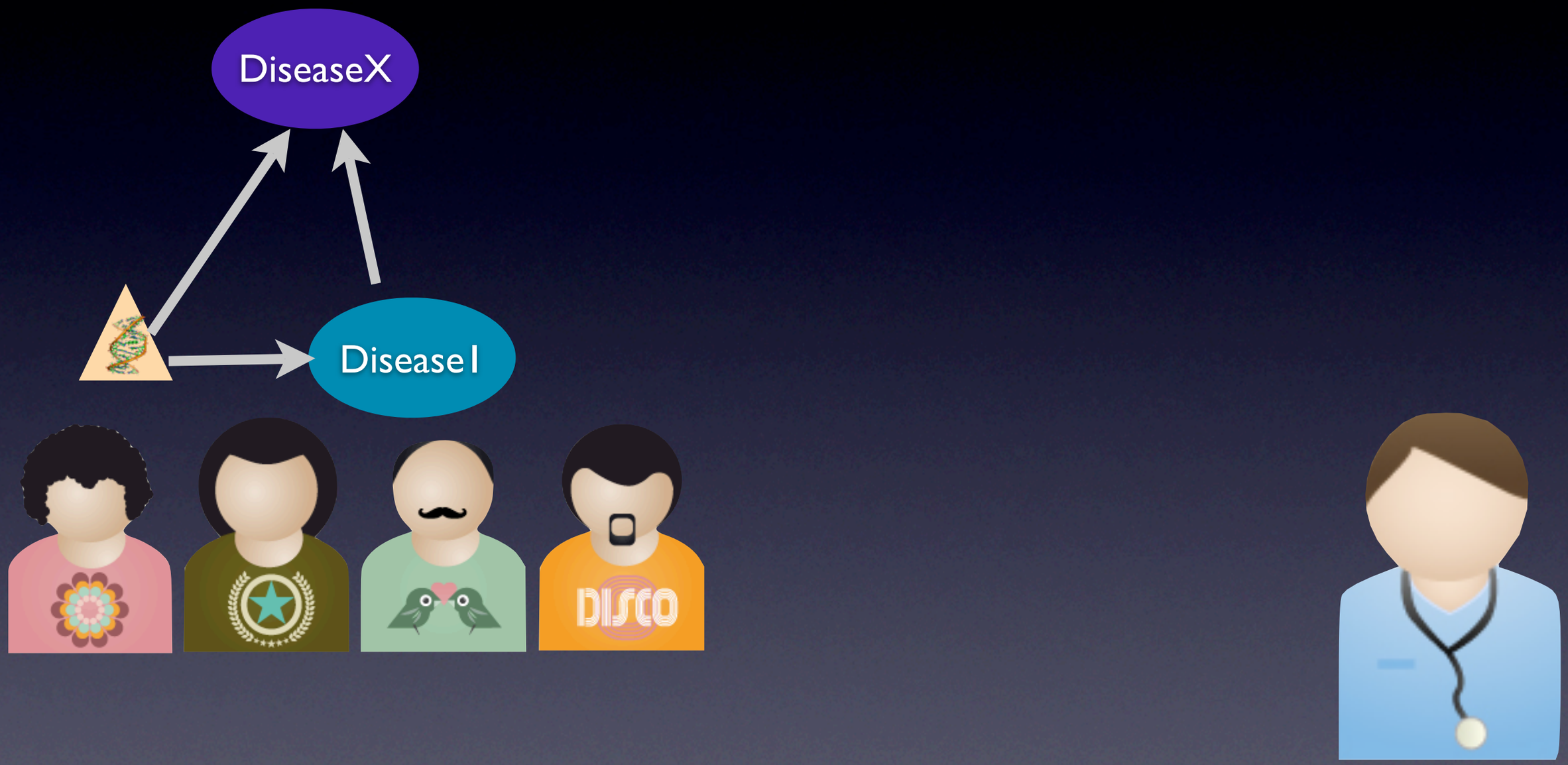

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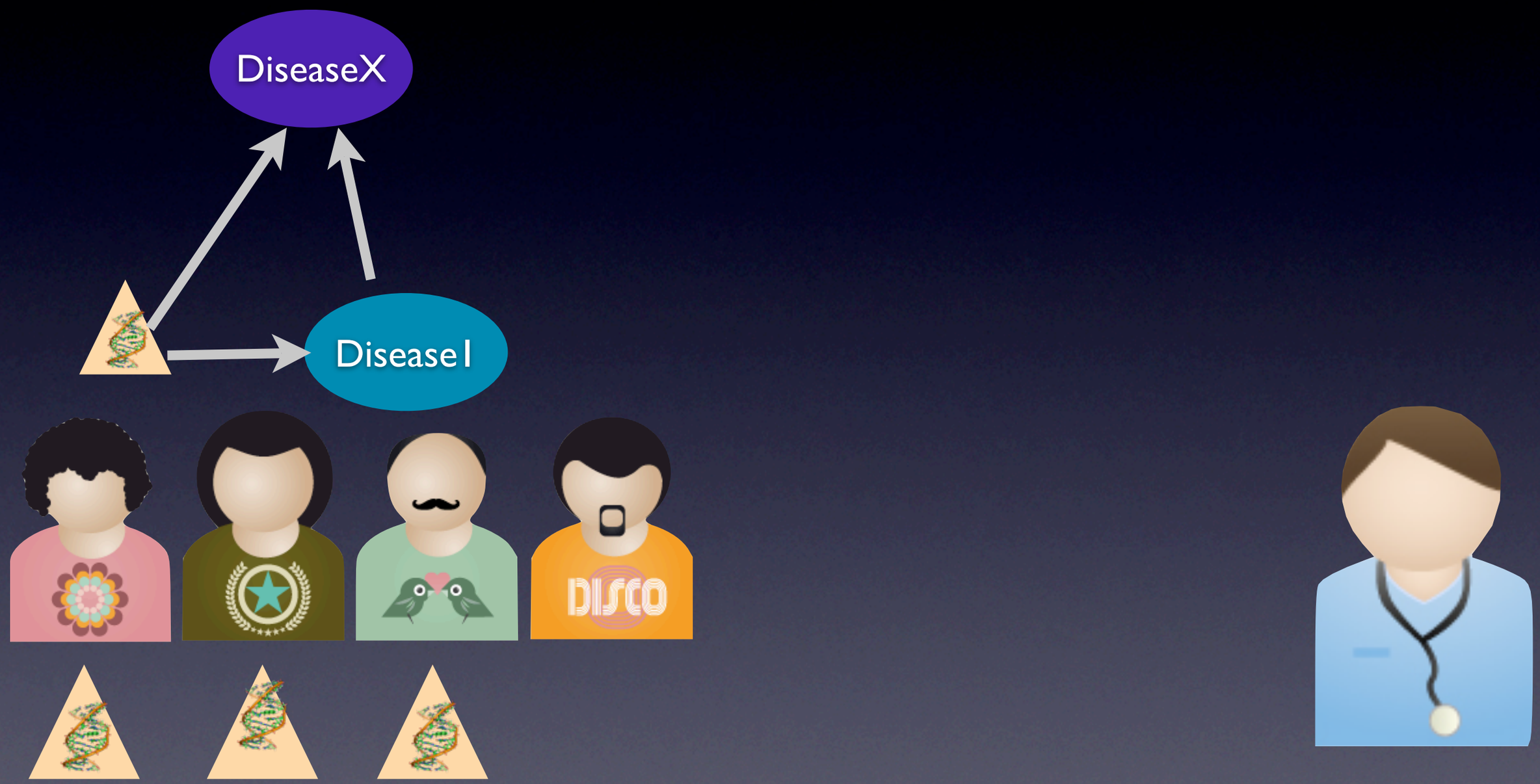

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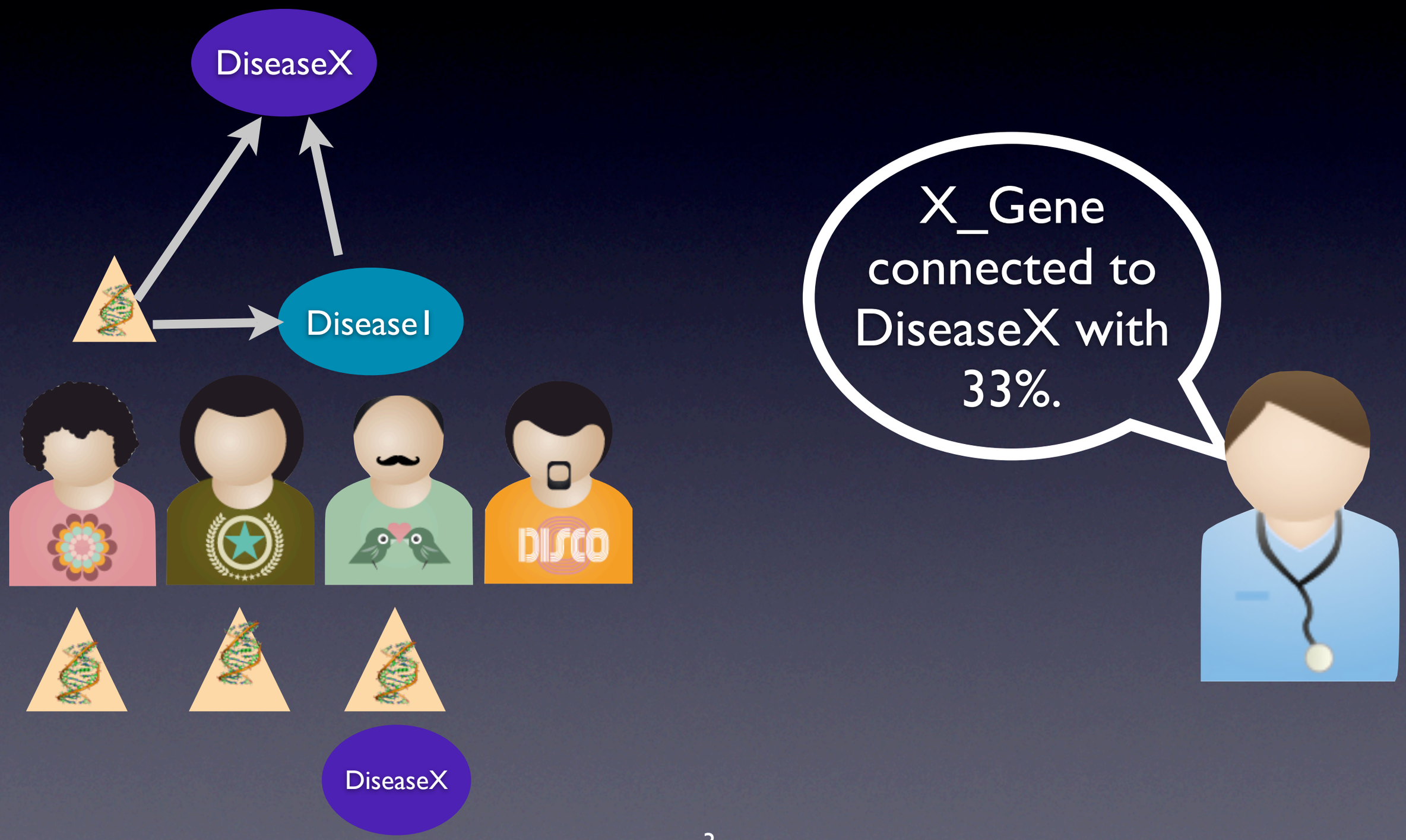
DiseaseX
Disease1
DiseaseX
X_Gene connected to DiseaseX with 33%.

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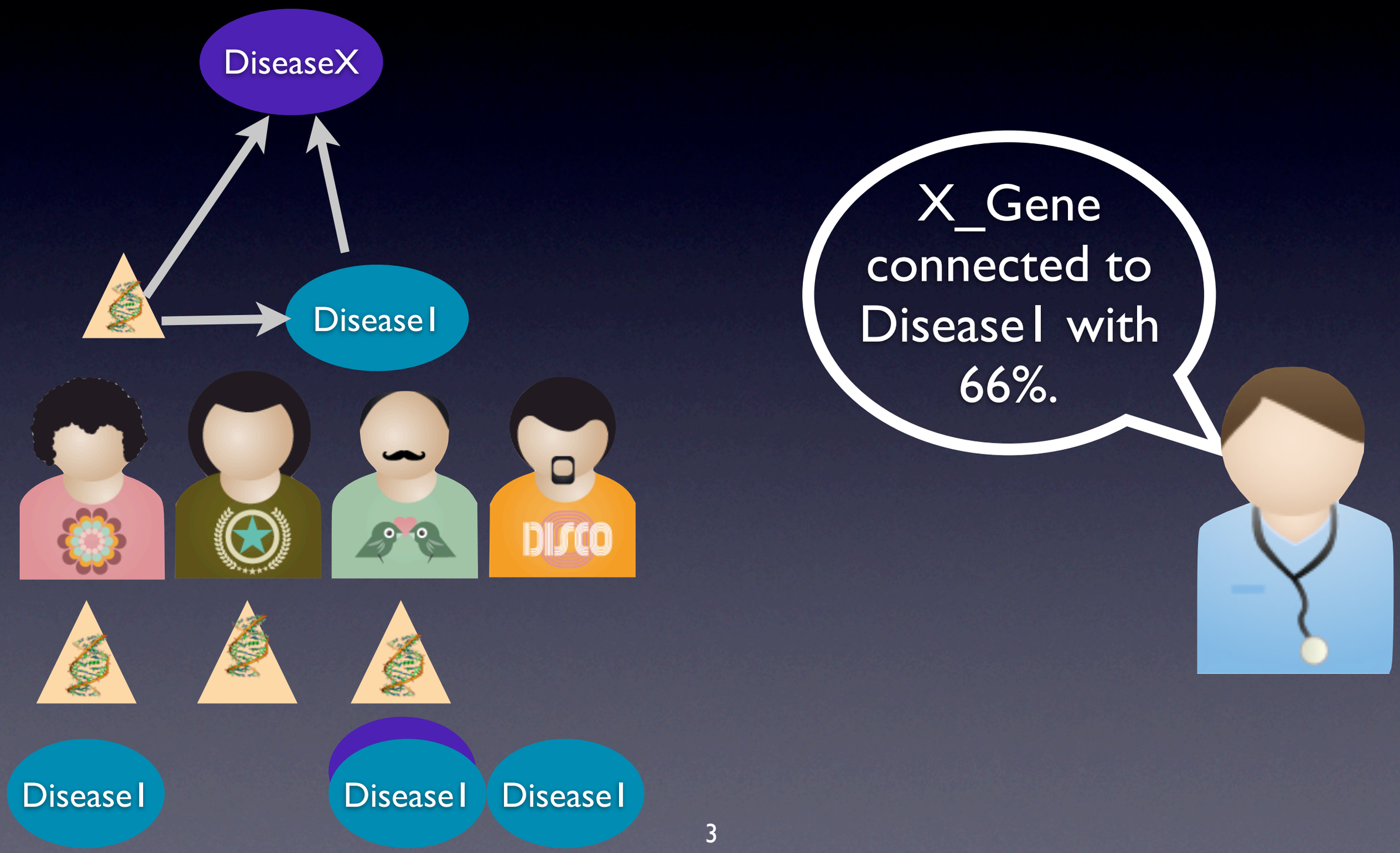
DiseaseX
Disease1
Disease1
Disease1
Disease1
X_Gene connected to Disease1 with 66%.

The Situation

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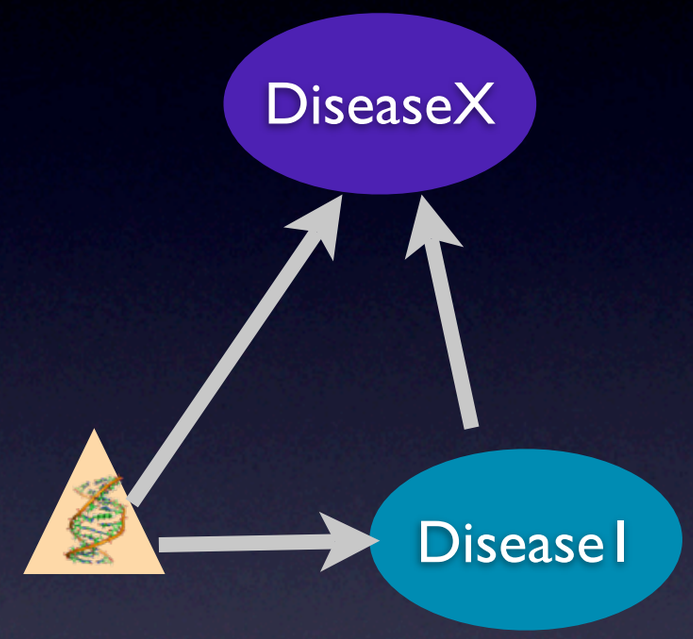
- Domain knowledge



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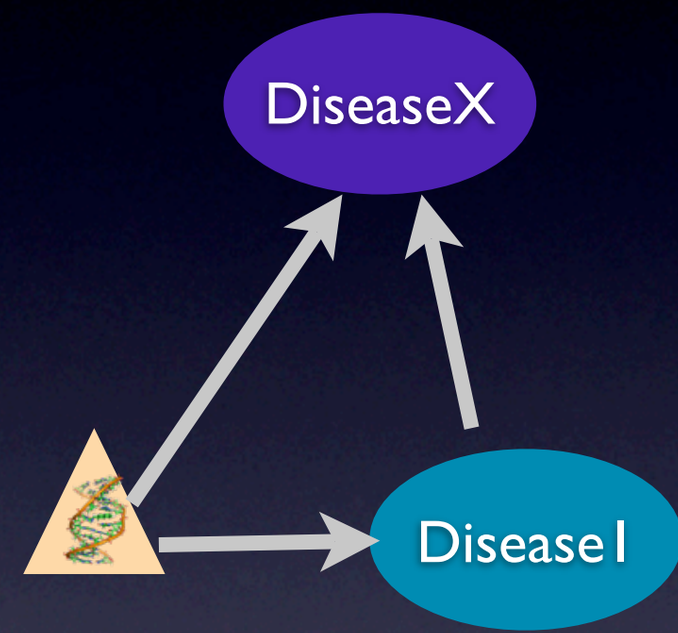

- Examples with probabilities

0.33 

0.66 

The Situation

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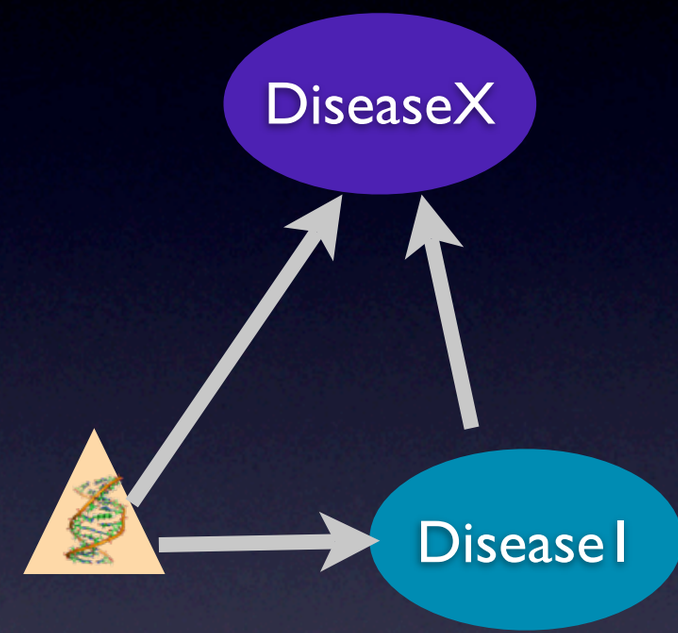


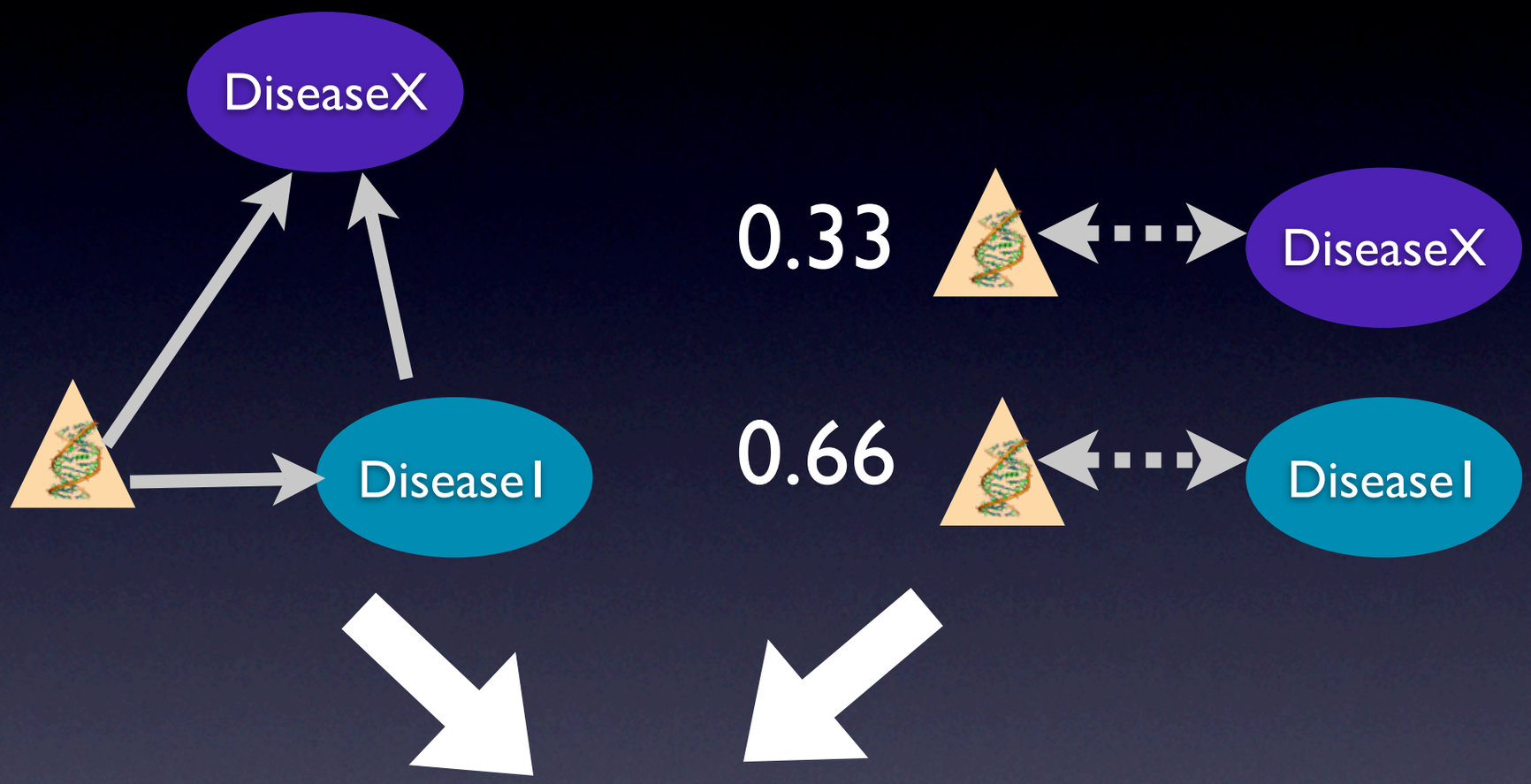
- Examples with probabilities

0.33 

0.66 

- Uncertainty how to explain the examples

A Solution



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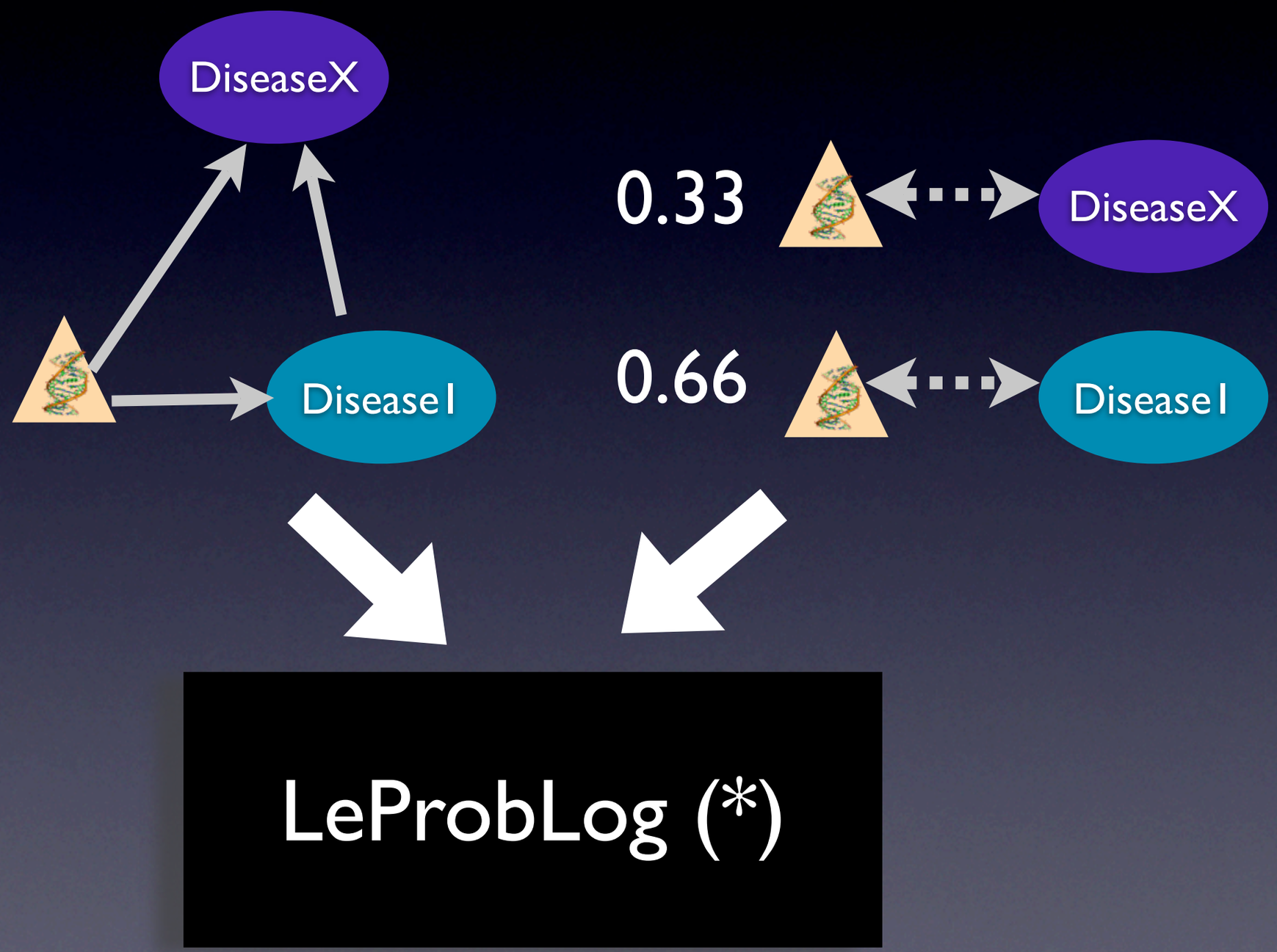
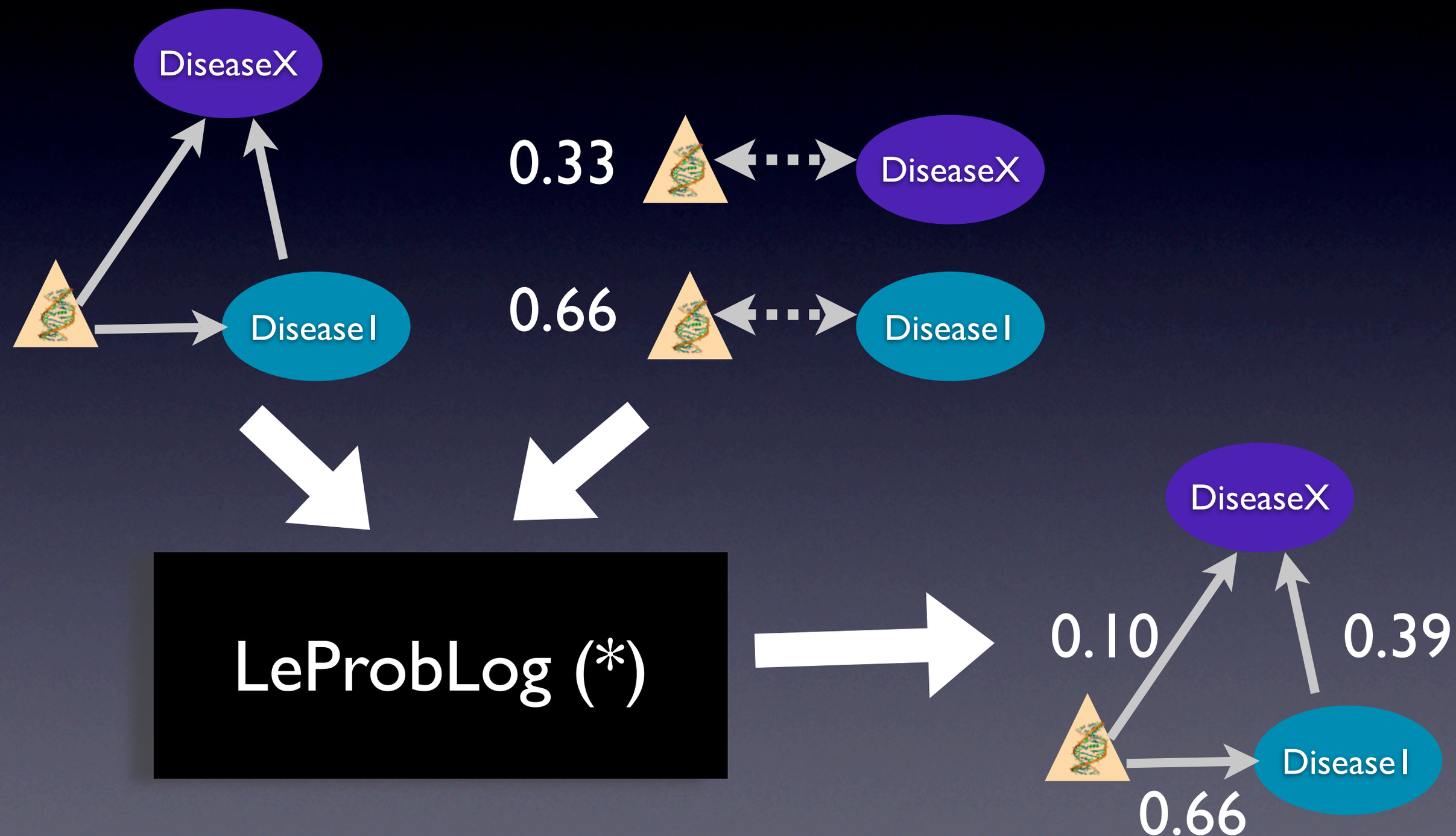


(*) Least Square Parameter Estimation for ProbLog

A Solution

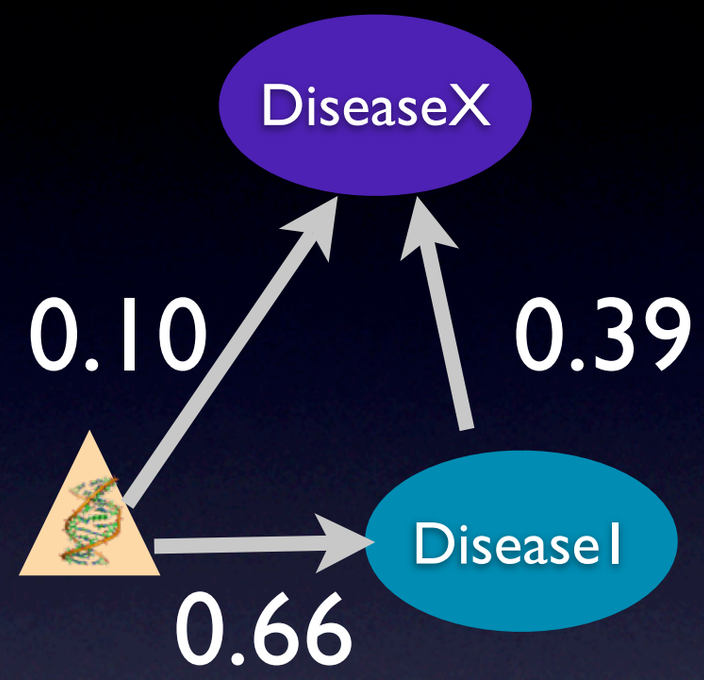


(*) Least Square Parameter Estimation for ProbLog

Outline

- Motivation
- ProbLog
- Parameter Learning for ProbLog
- Experiments

ProbLog

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path(X,Y) :- edge(X,Y)
path(X,Y) :- edge(X,Z), path(Z,Y)
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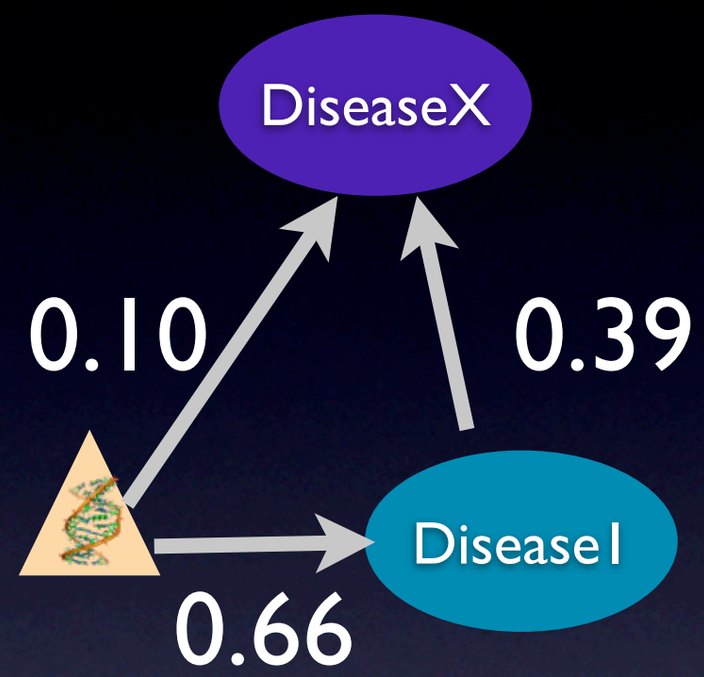
ProbLog

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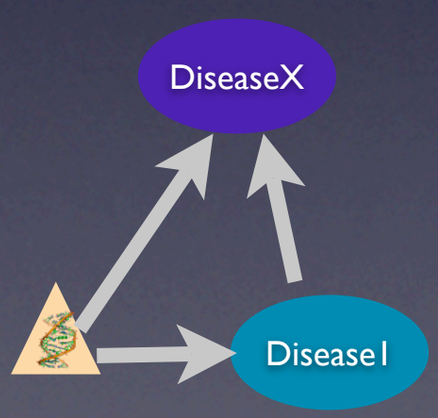
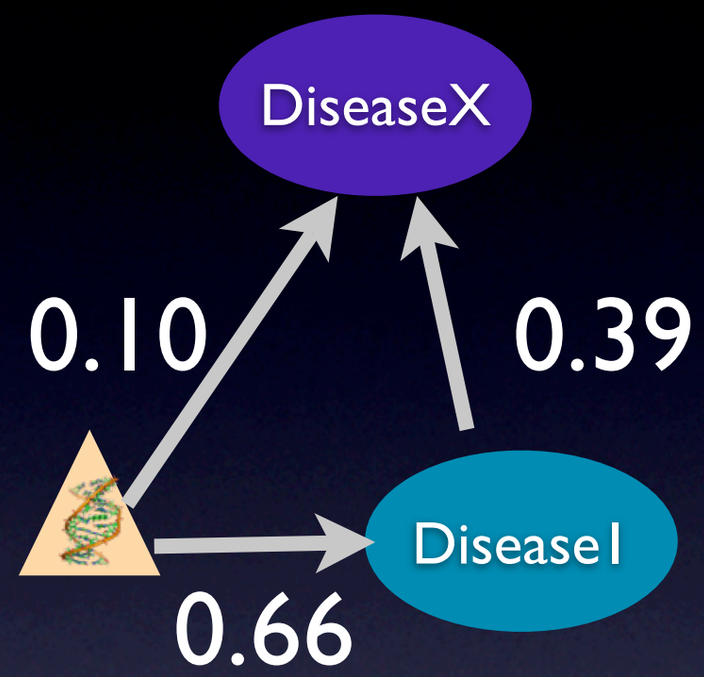


ProbLog

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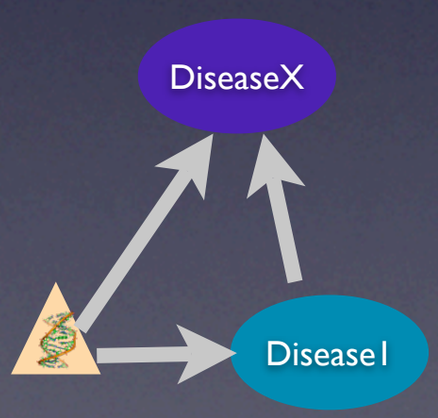
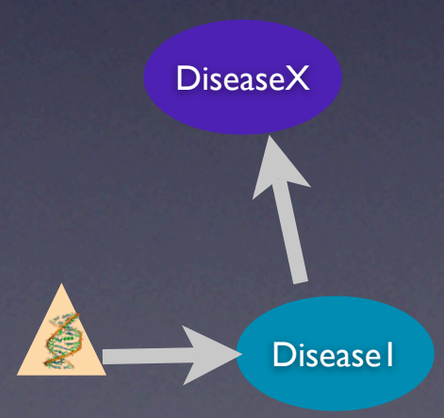
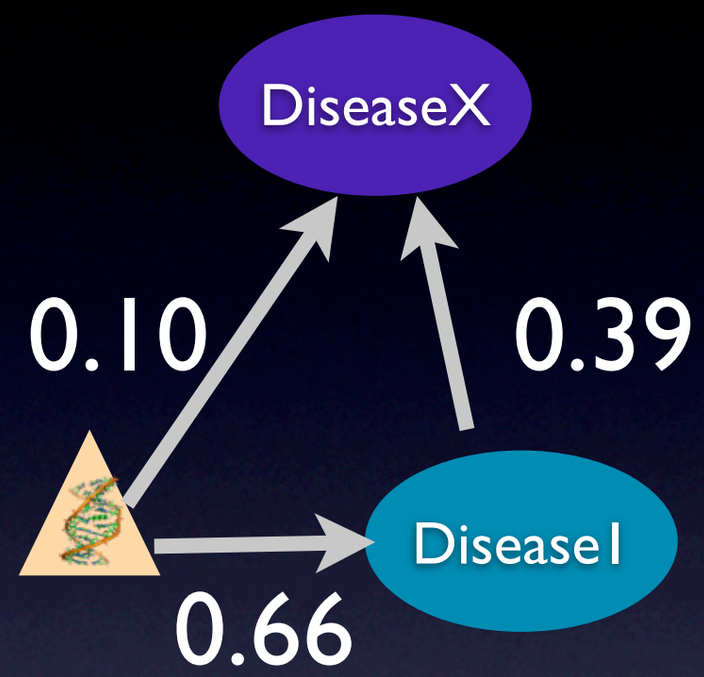


p=(1-0.10) * 0.66 * 0.39



ProbLog

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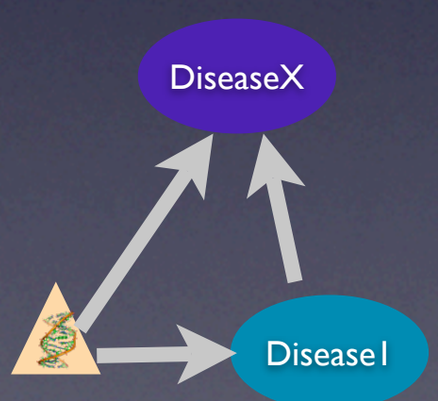

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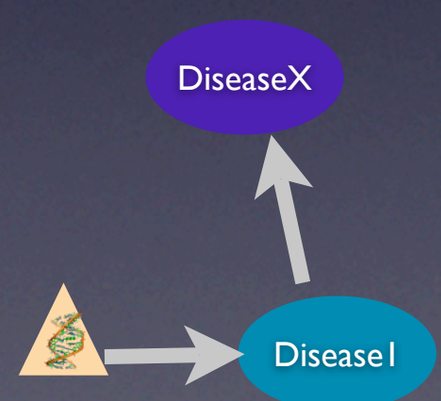

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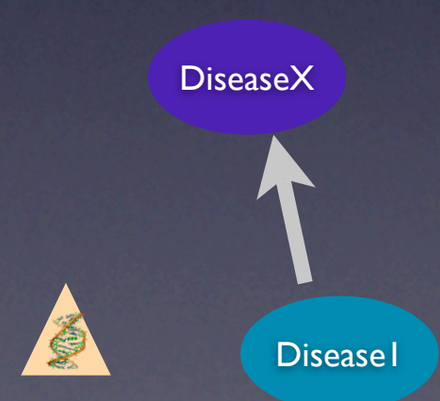

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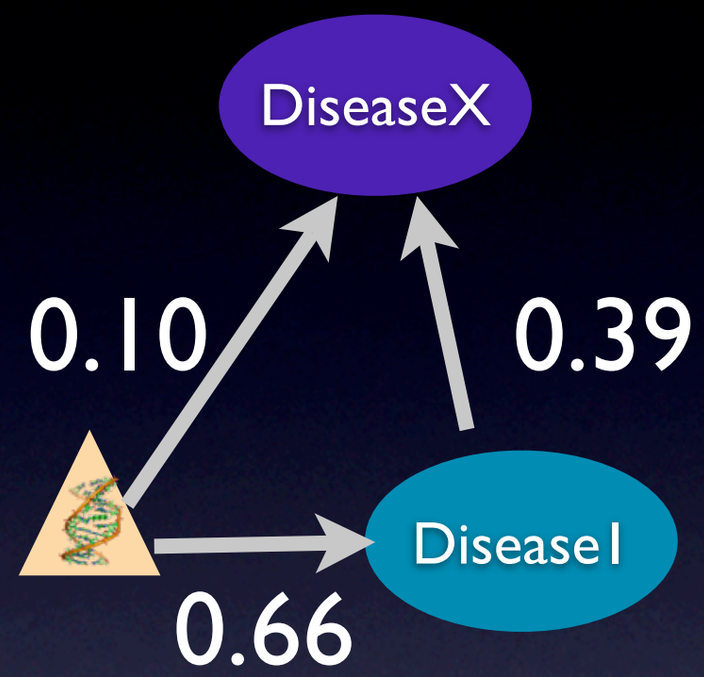


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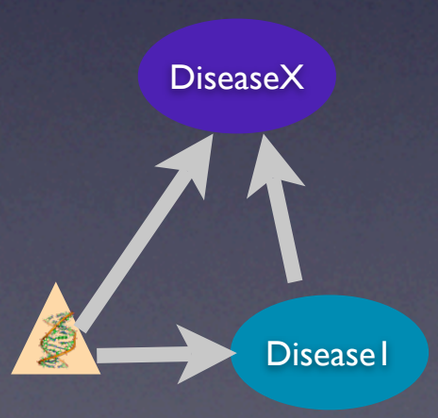

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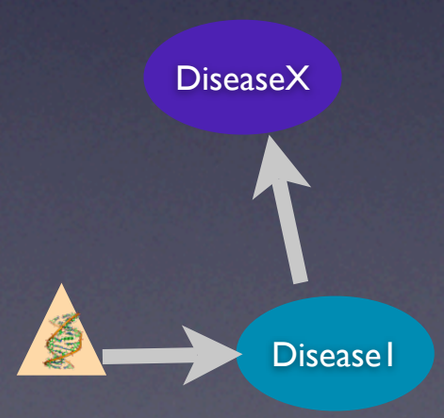

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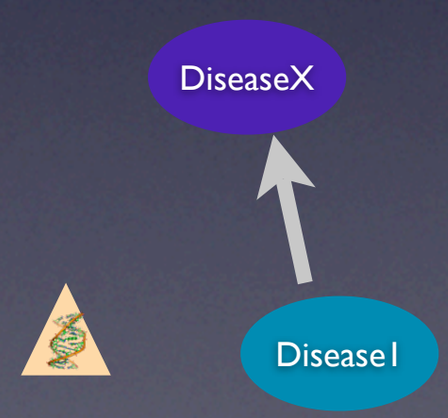

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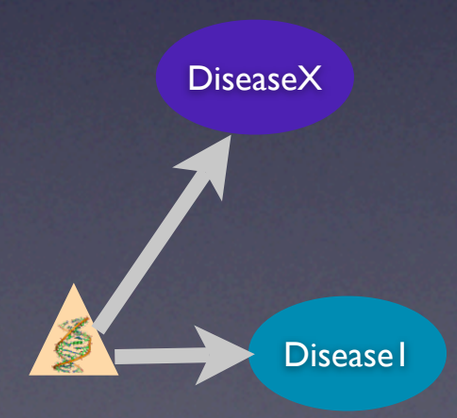

...

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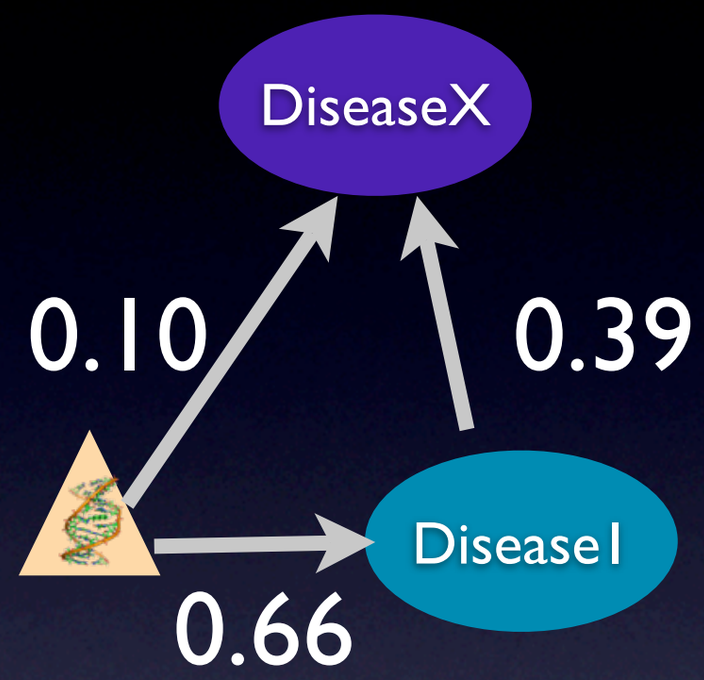

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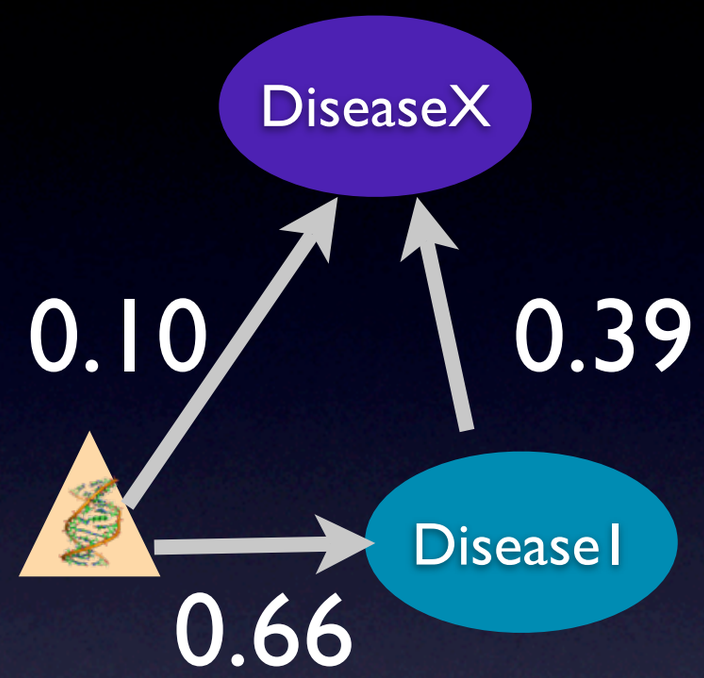
P(path('x_gene', 'DiseaseX'))

ProbLog



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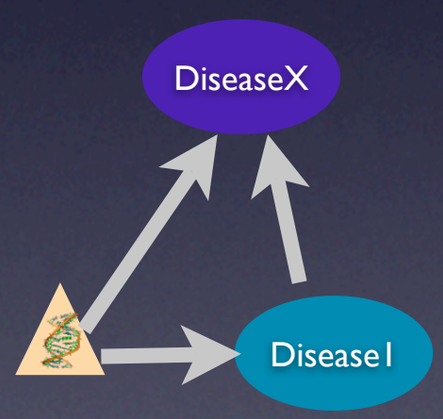

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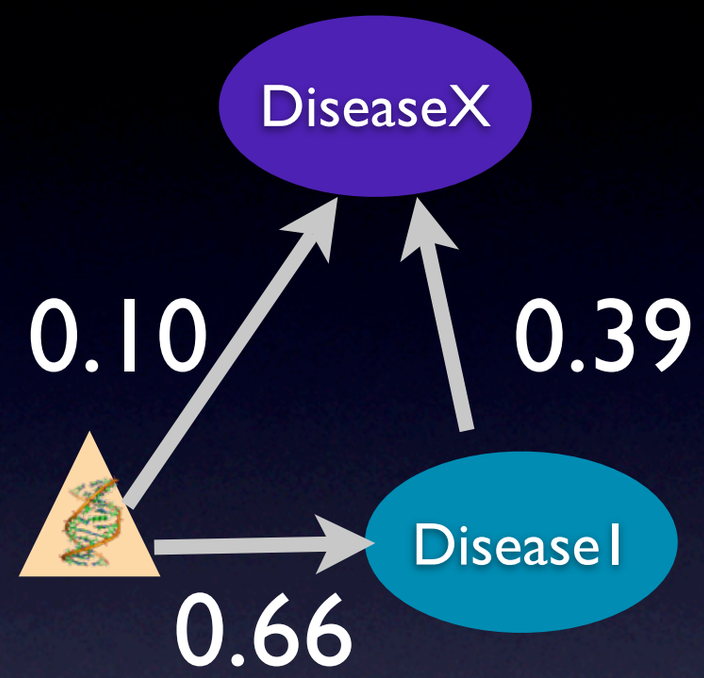

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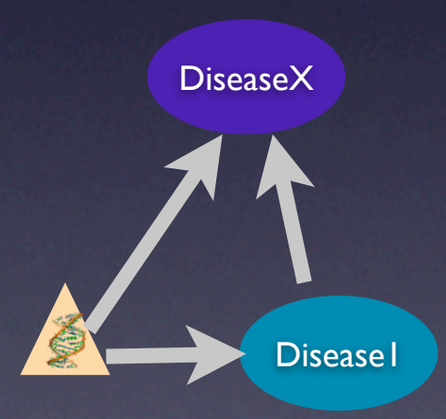

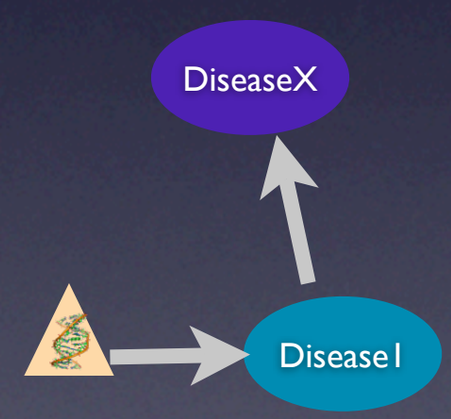

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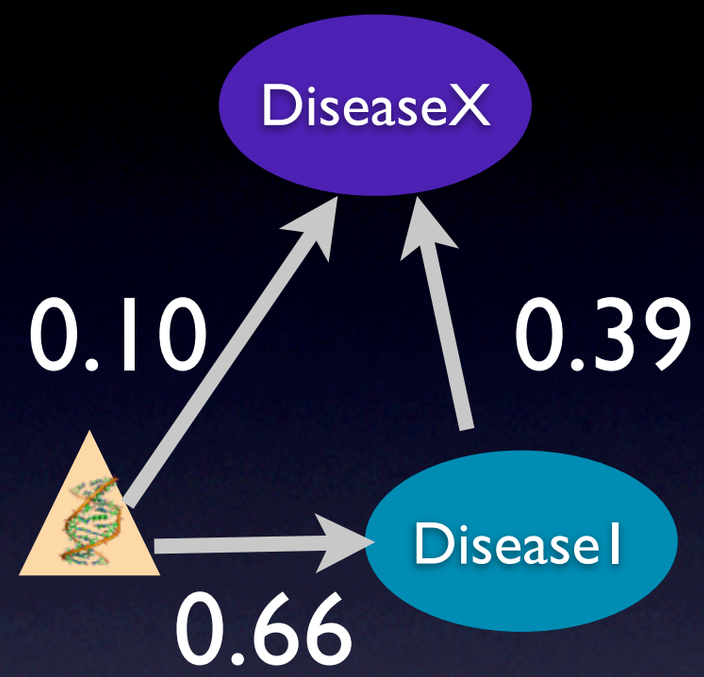

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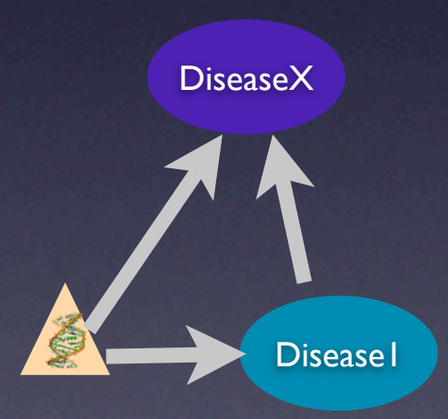

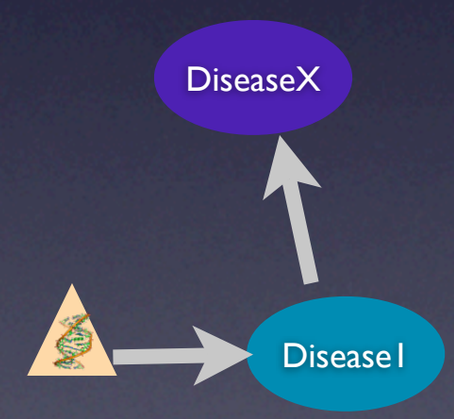

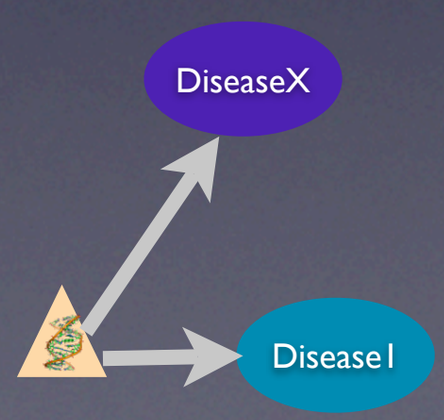

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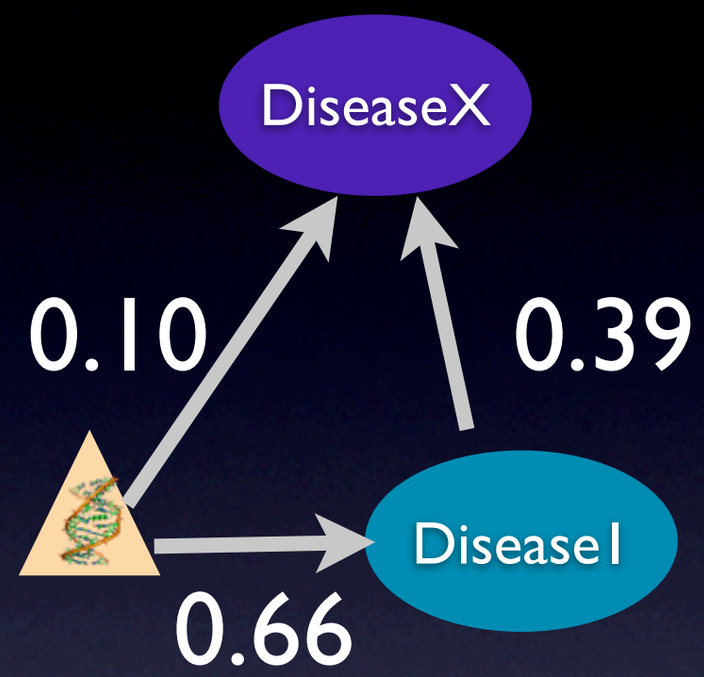

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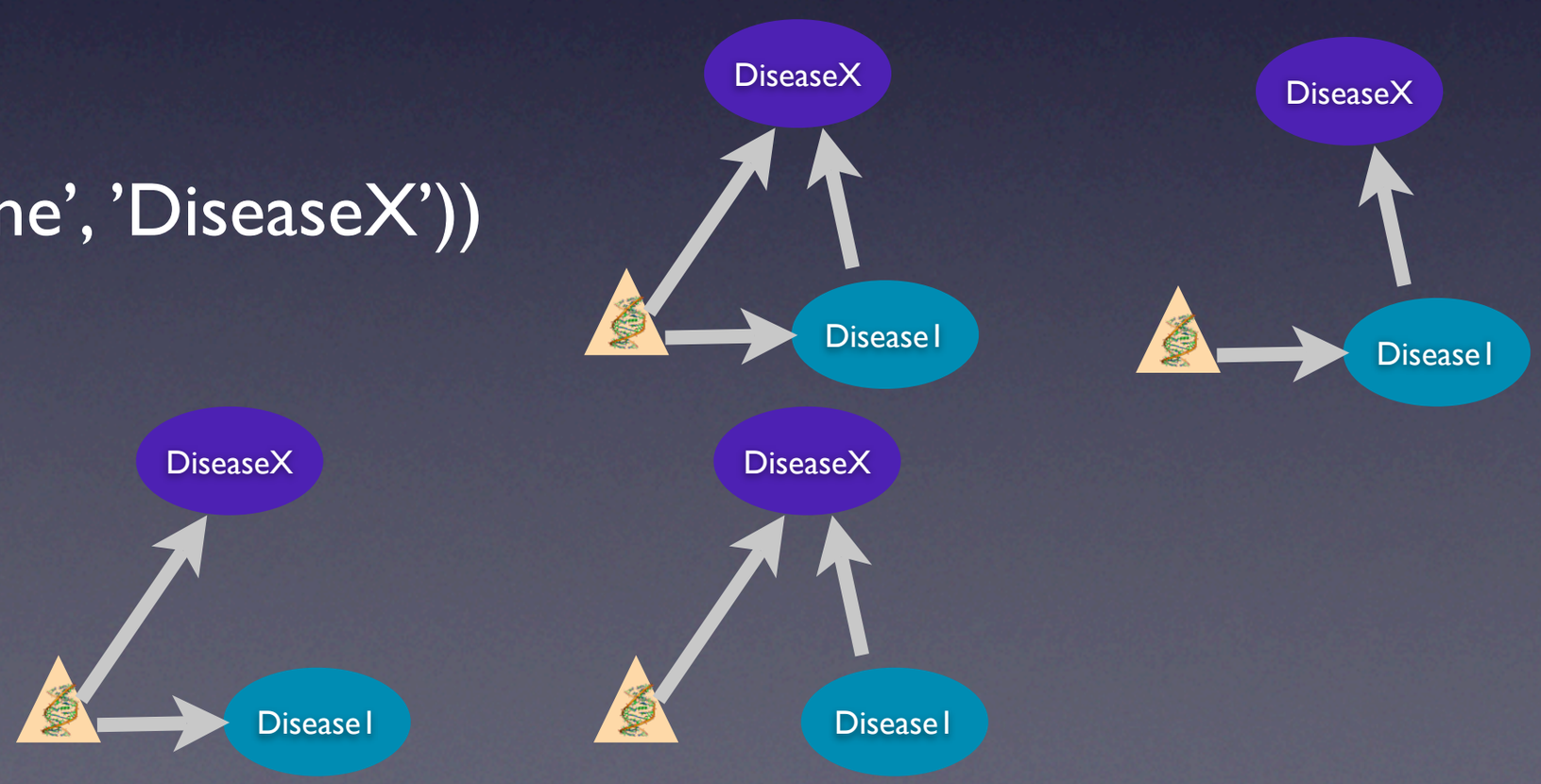

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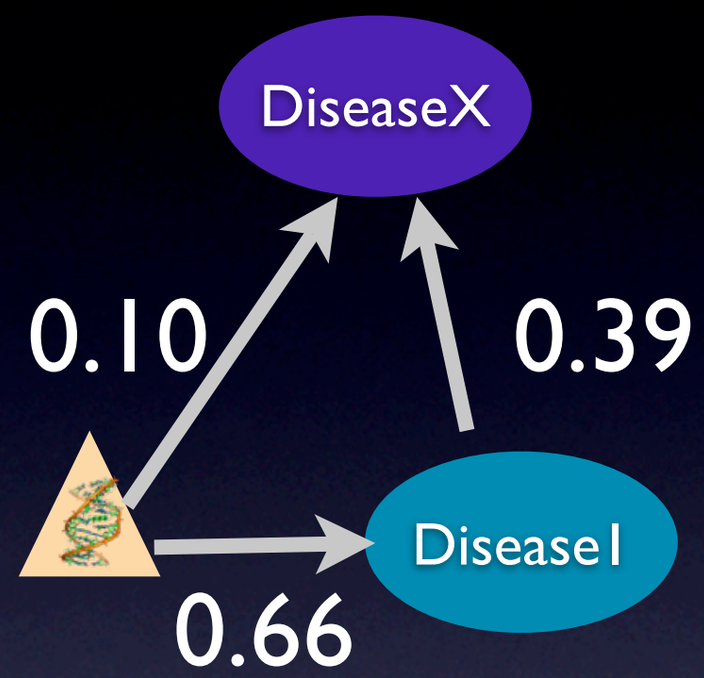

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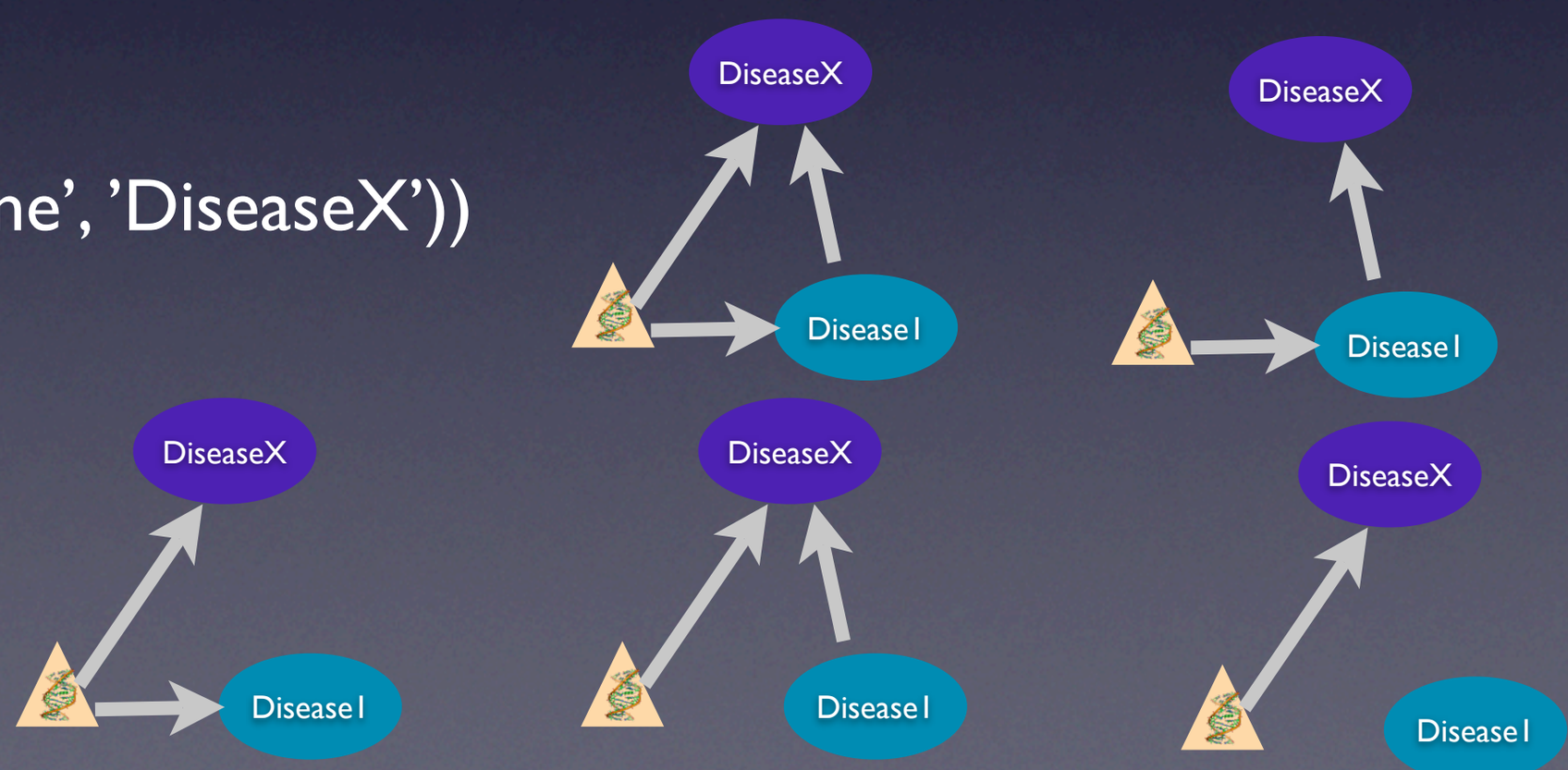

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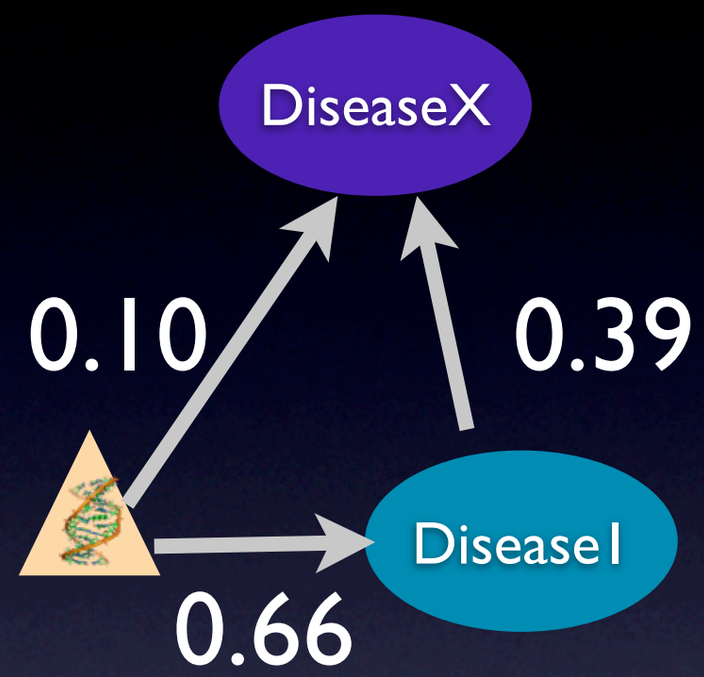

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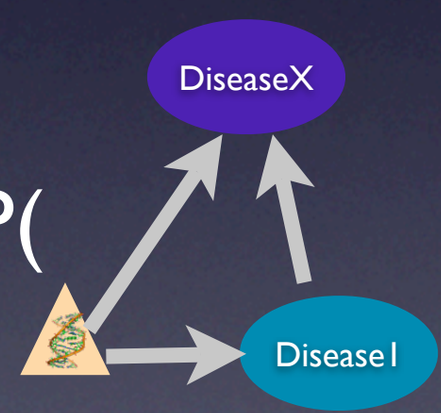
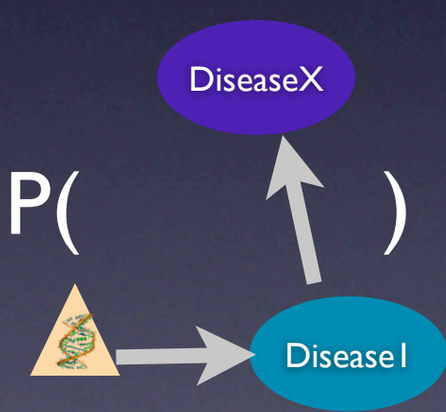
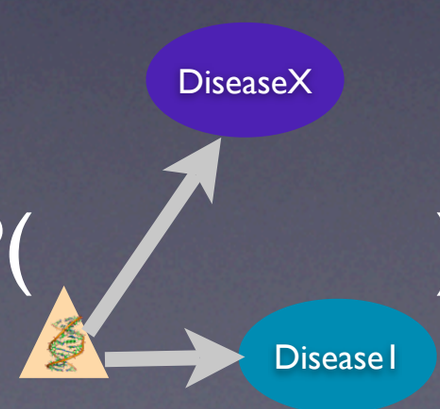
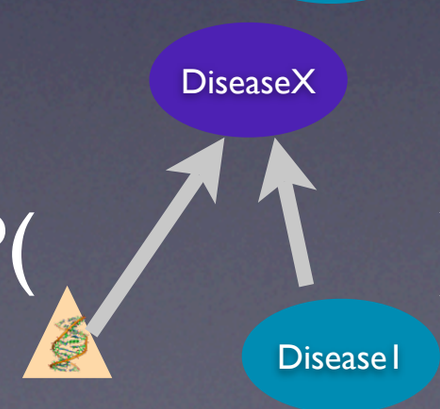
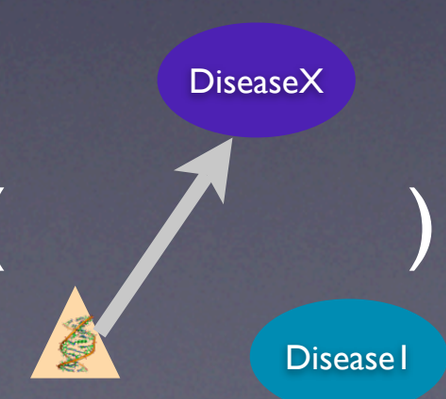
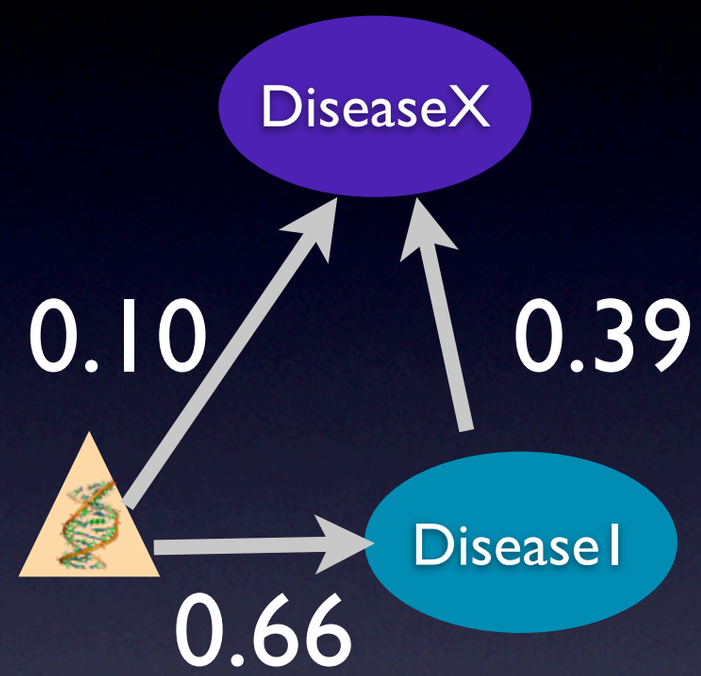
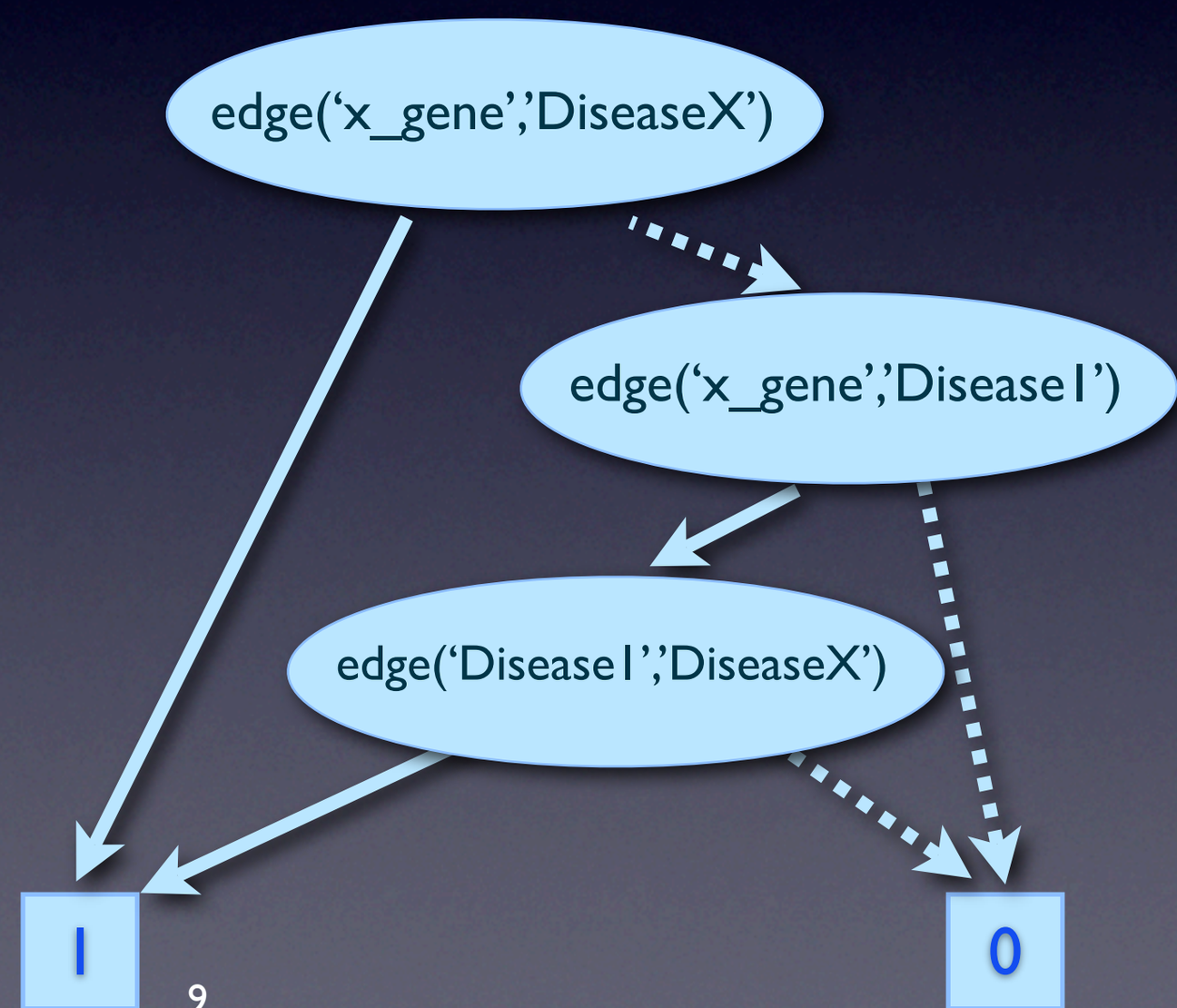
P(path('x_gene', 'DiseaseX'))=P() + P() +

P() + P() + P()

Calculating Probabilities



P_s('x_gene', 'DiseaseX'|L)=?



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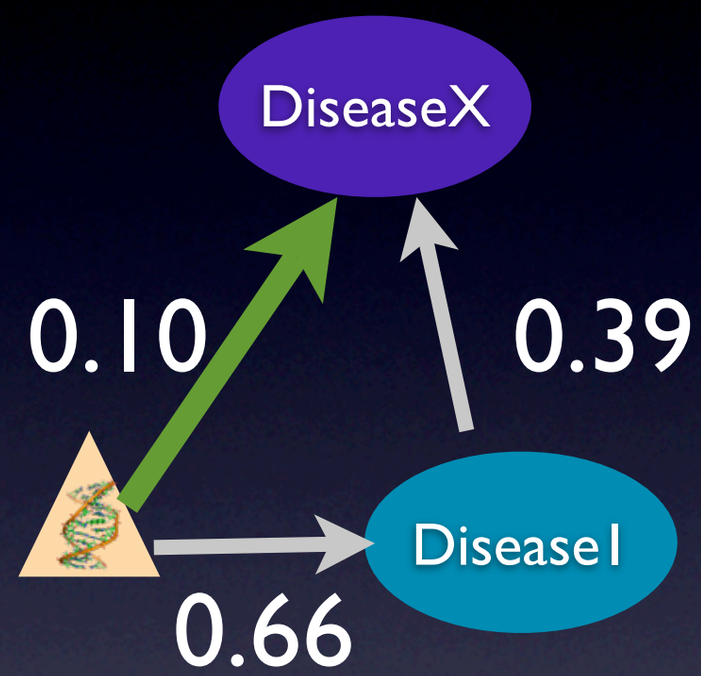

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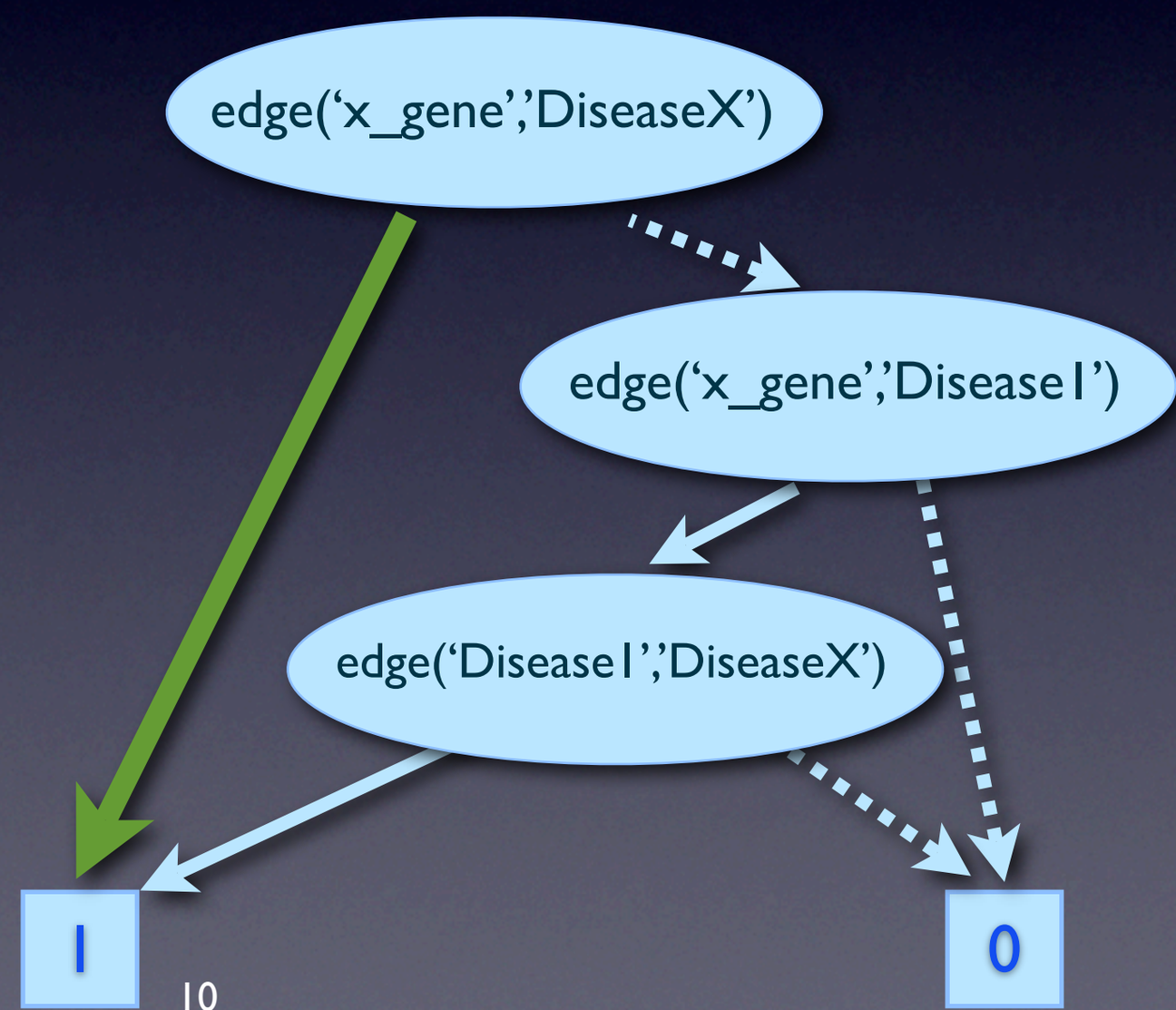
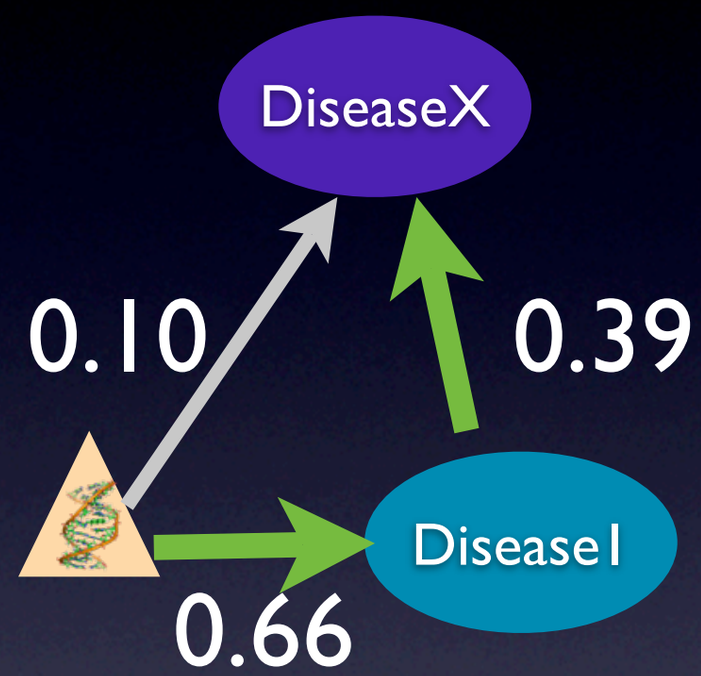
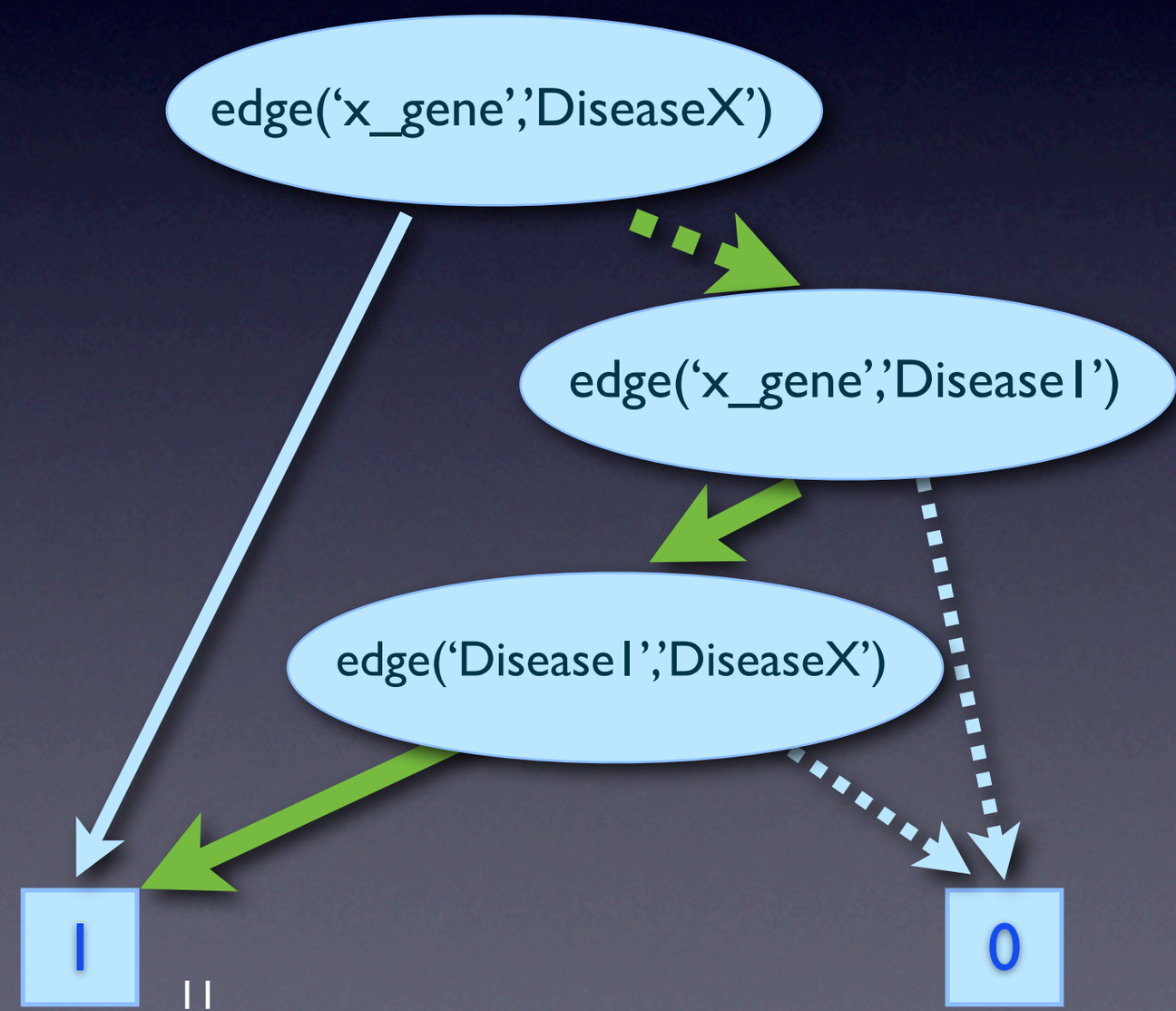


Calculating Probabilities



P_s('x_gene', 'DiseaseX'|L)=?



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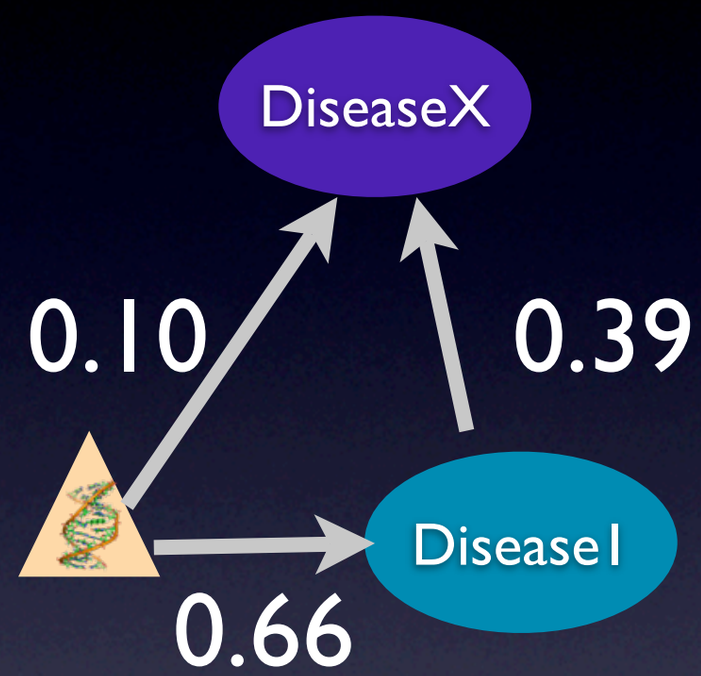

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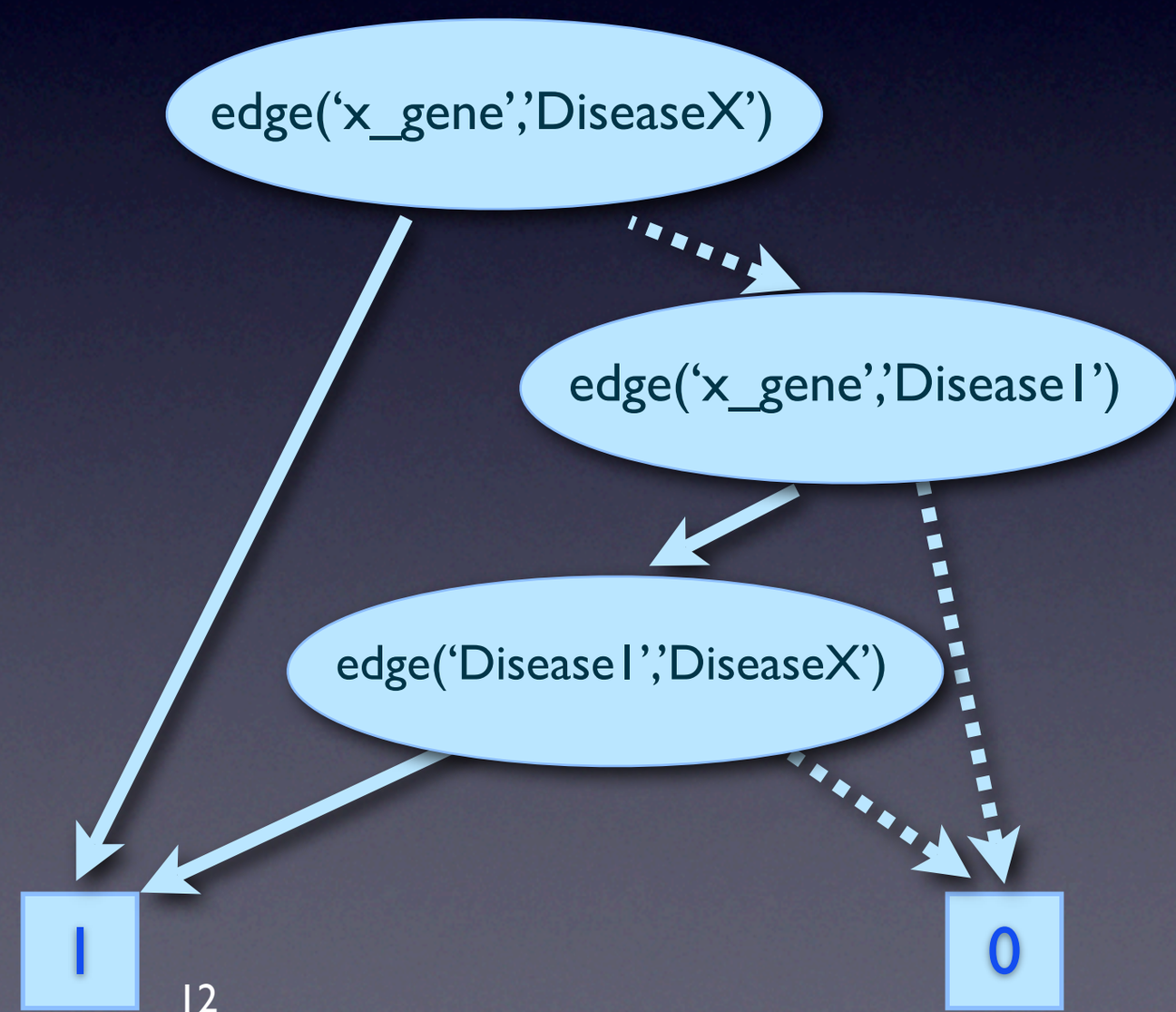

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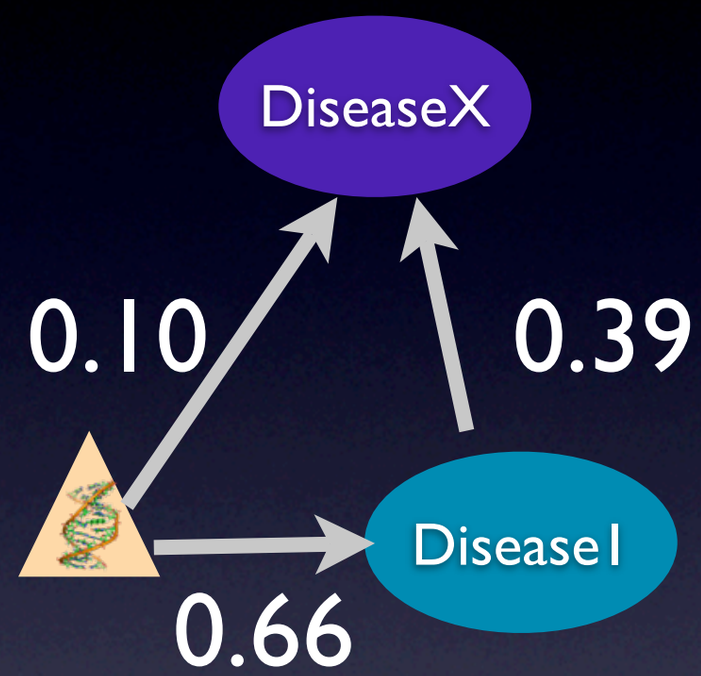

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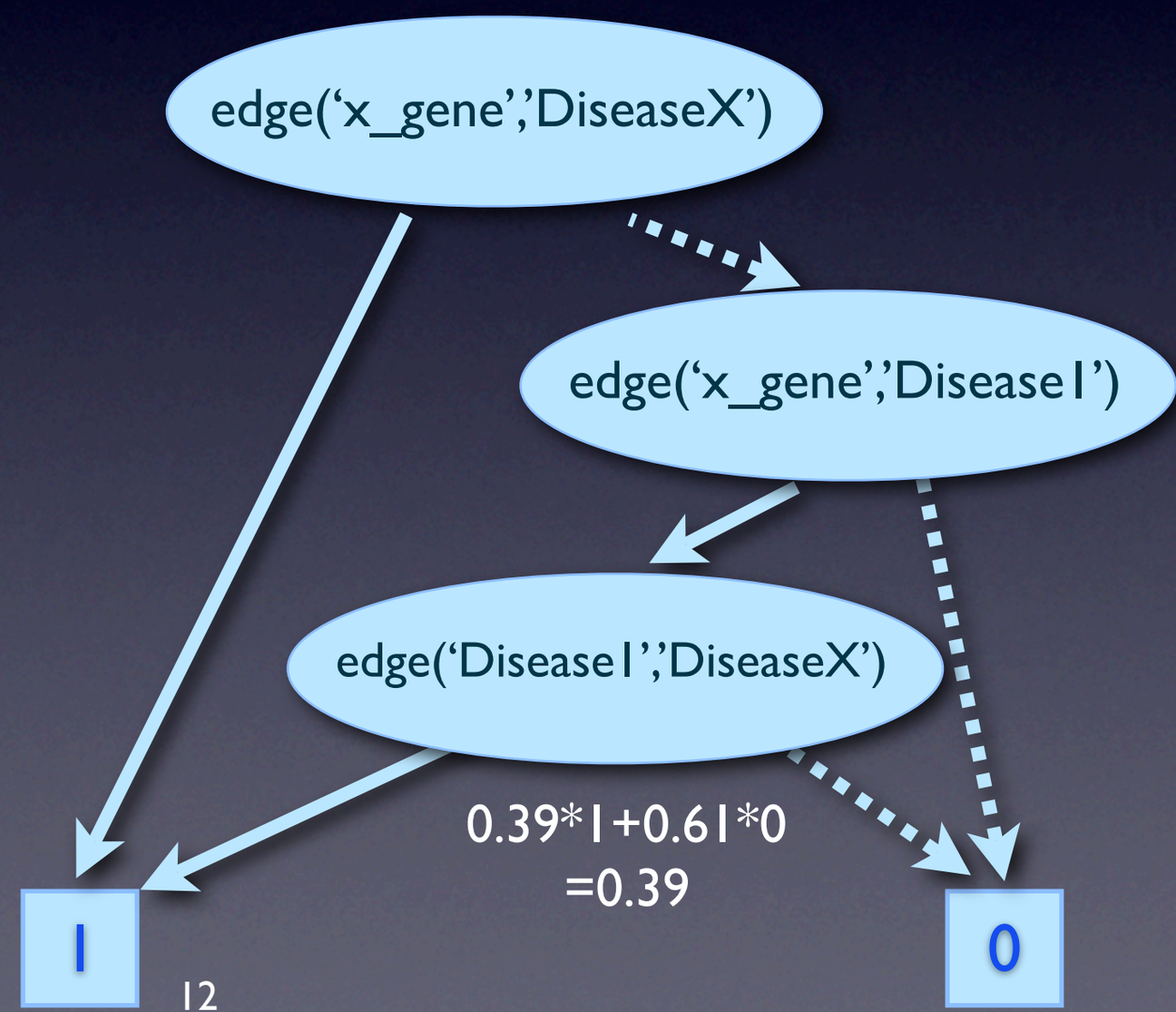

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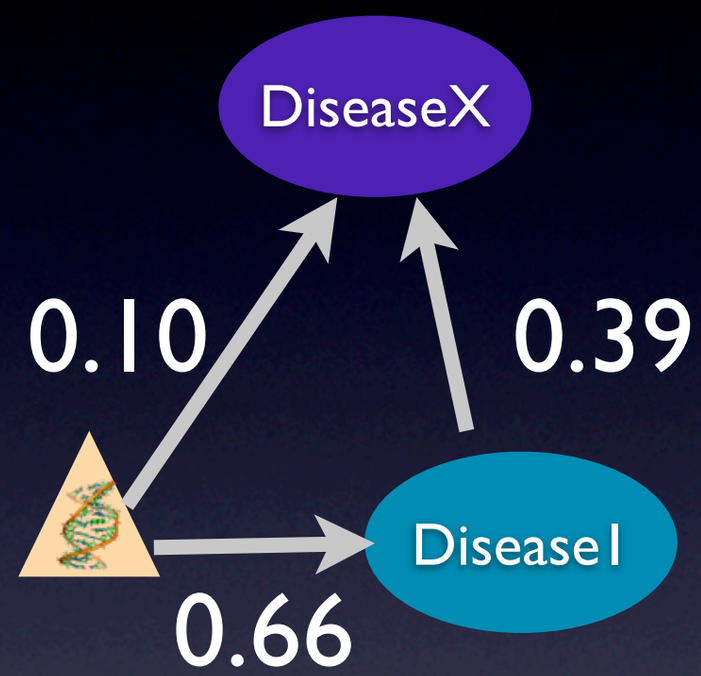

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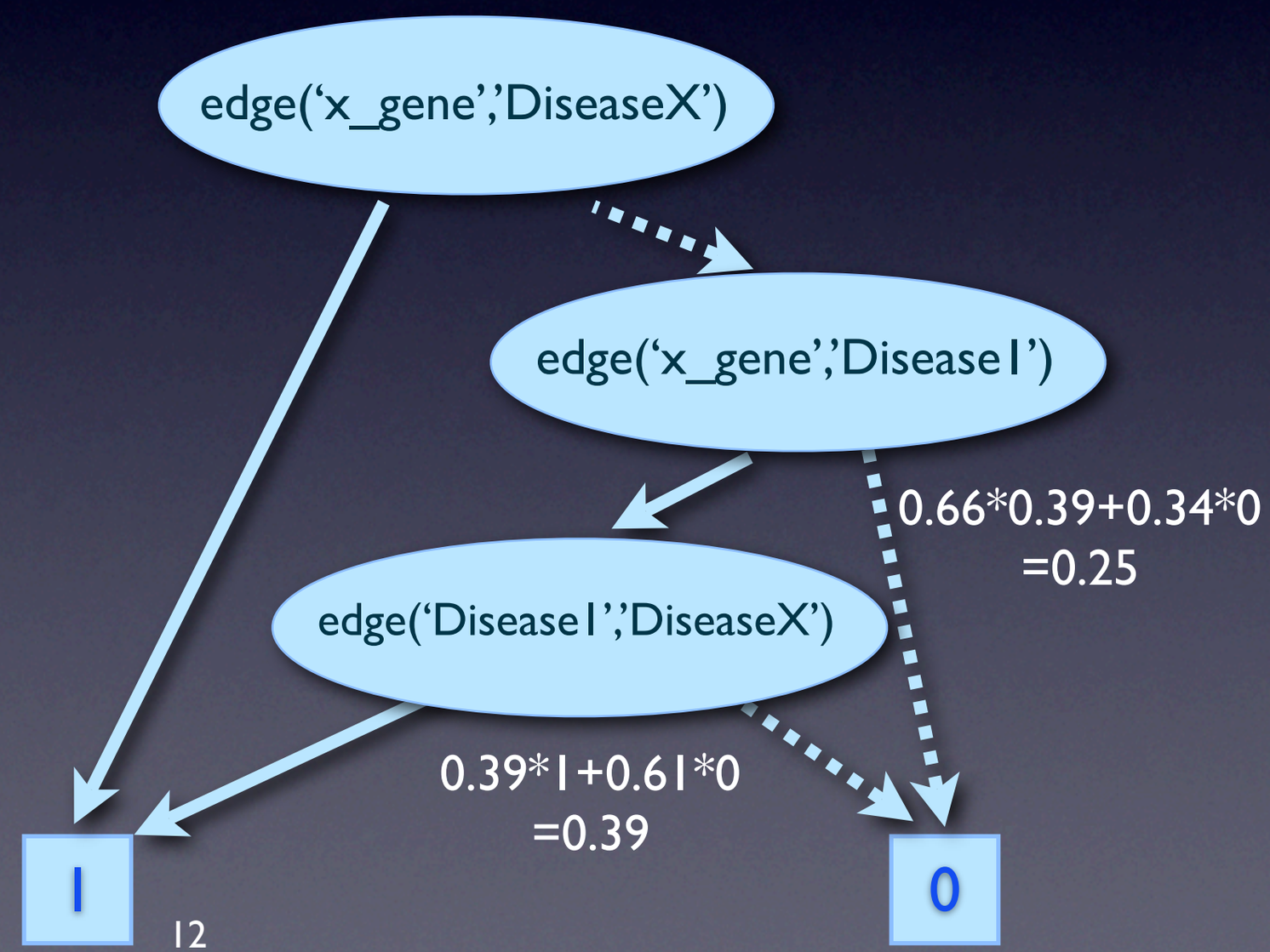

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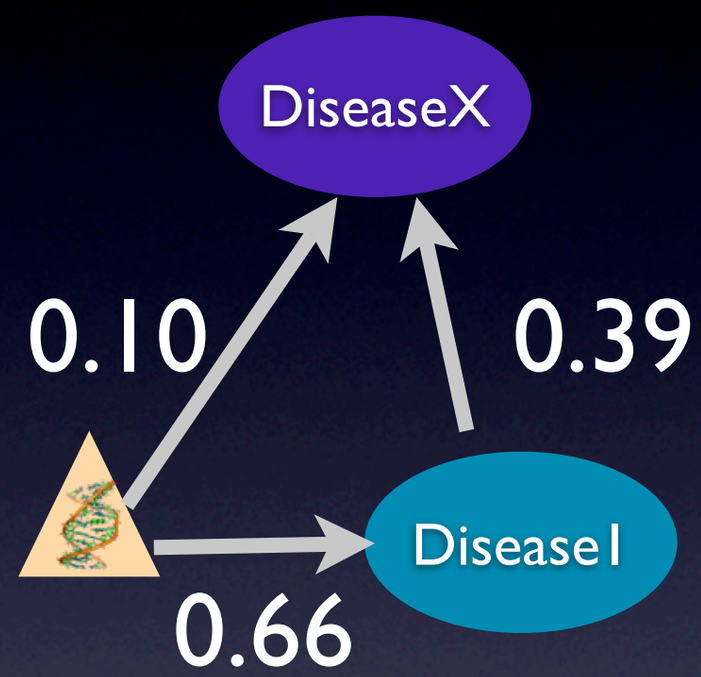

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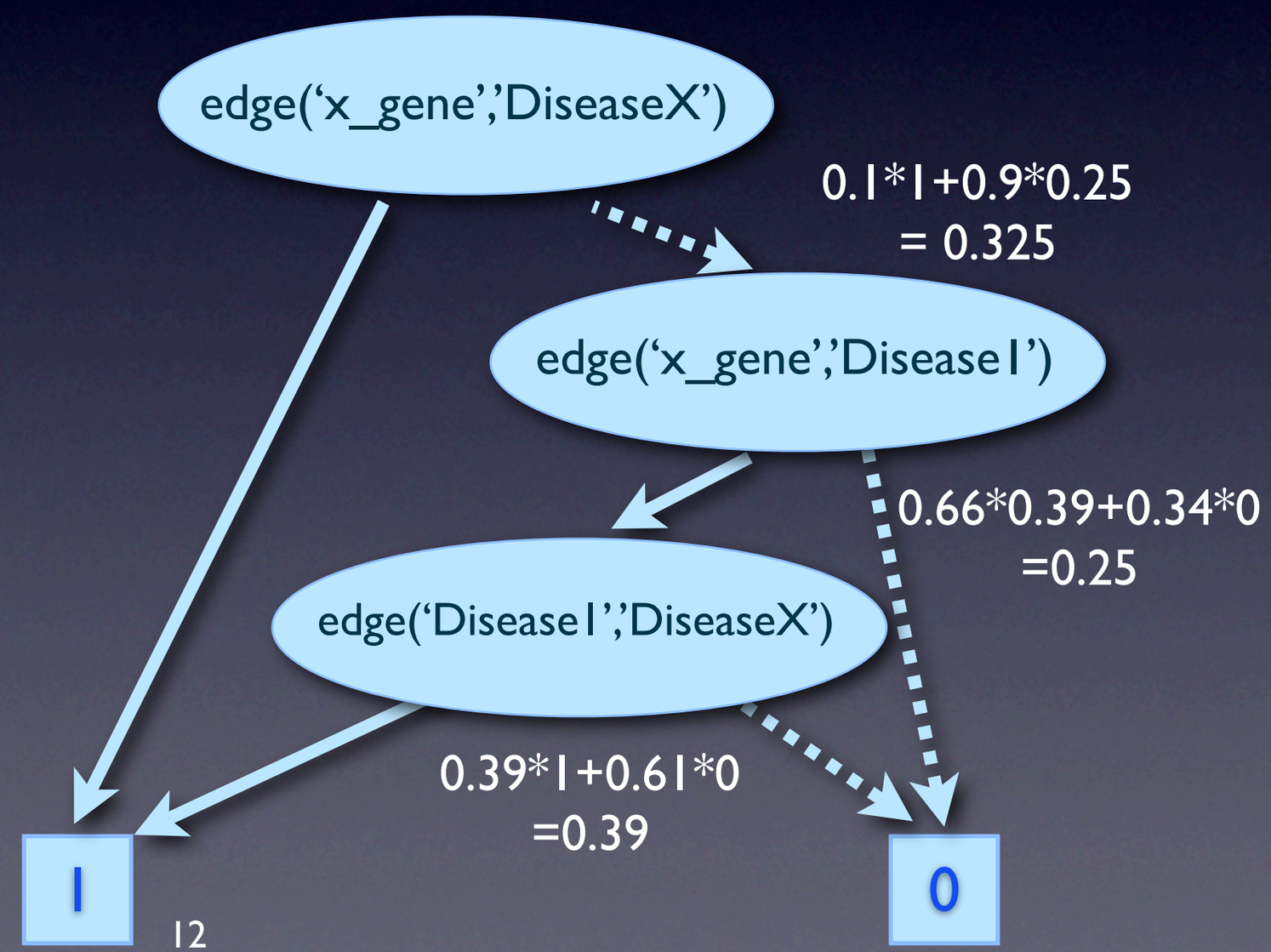

Parameter Learning

?? :: edge(‘x_gene’, ’DiseaseX’)
?? :: edge(‘x_gene’, ’Disease1’)
?? :: edge(‘Disease1’, ’x_gene’)

path(X,Y) :- edge(X,Y)
path(X,Y) :- edge(X,Z), path(Z,Y)

Parameter Learning

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0.33 :: path(‘x_gene’, ’DiseaseX’)
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path(X,Y) :- edge(X,Z), path(Z,Y)

P_s(path(‘x_gene’, ’DiseaseX’) |L) <=> 0.33 :: path(‘x_gene’, ’DiseaseX’)
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$$MSE(T) = \frac{1}{K} \sum_{1 \leq i \leq K} \left(P_s(q_i|T) - \tilde{p}_i \right)^2$$

Gradient Descent

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- Init probabilities randomly

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    - find proofs for queries and build BDDs
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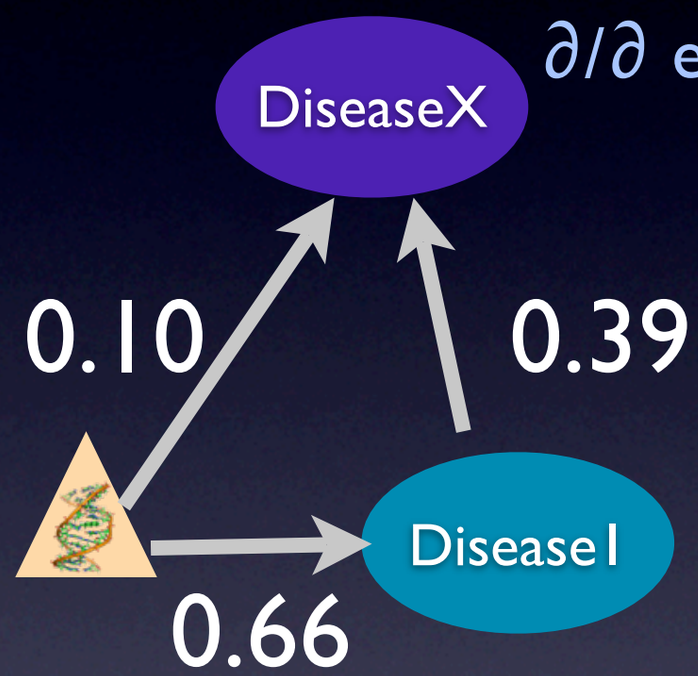
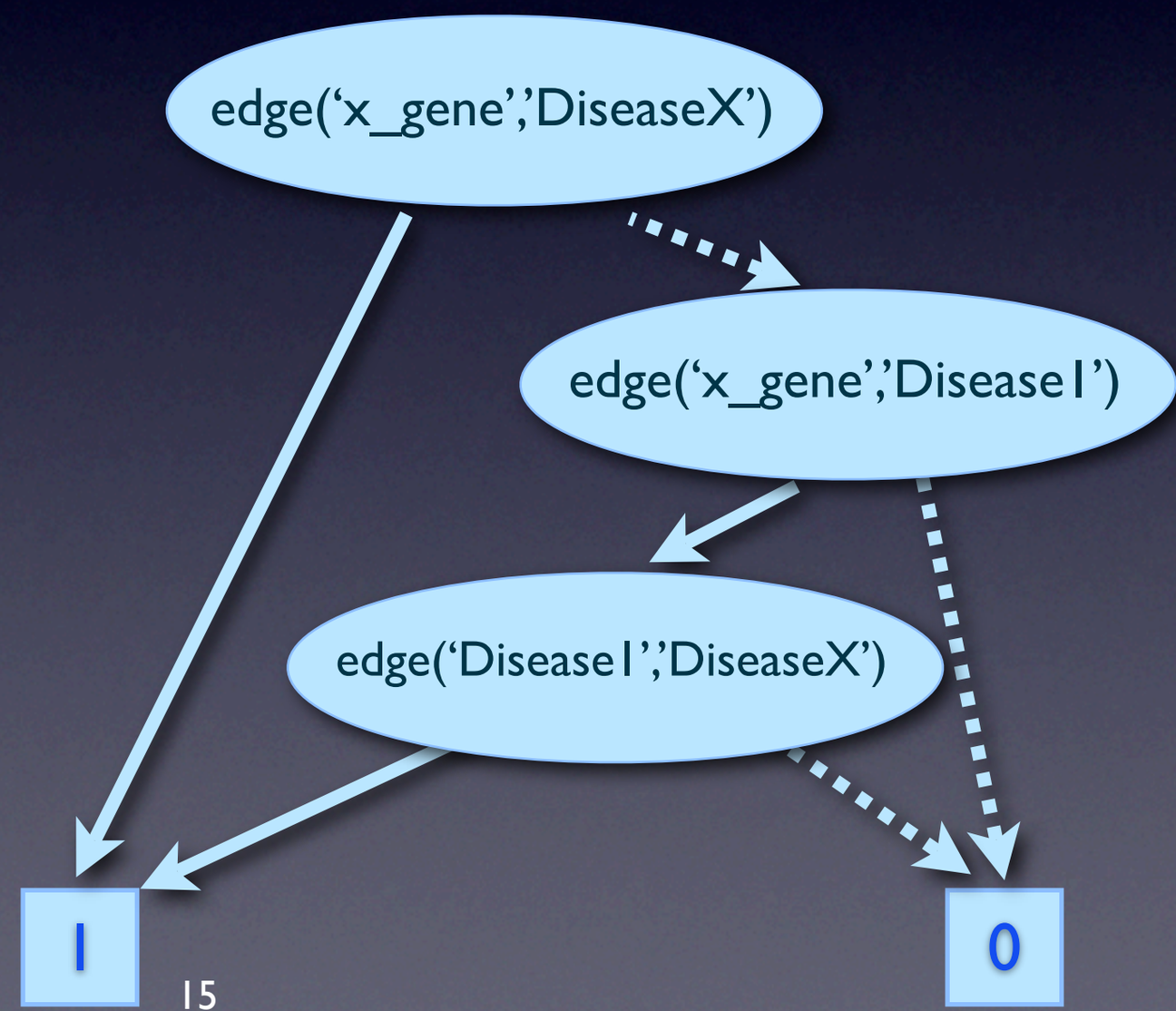
    - add gradient
- return probabilities

How to calculate the Gradient of the MSE?

∂/∂ edge('x_gene','Disease1') P_s(path('x_gene', 'DiseaseX') |L)





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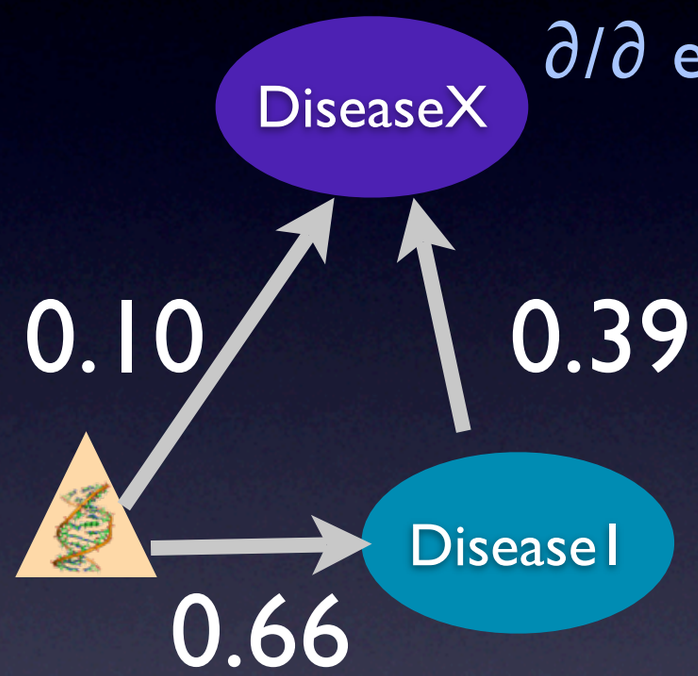

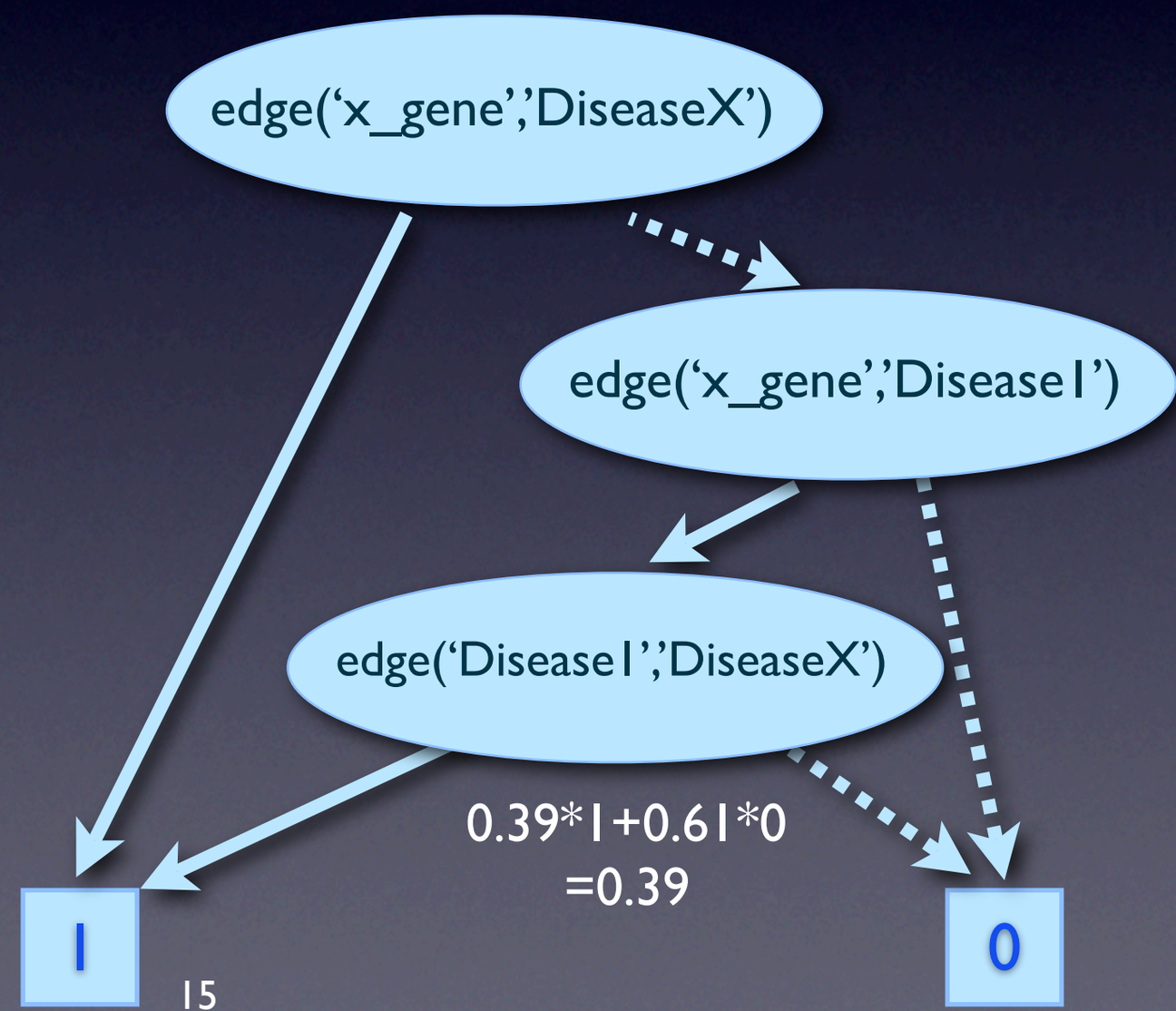

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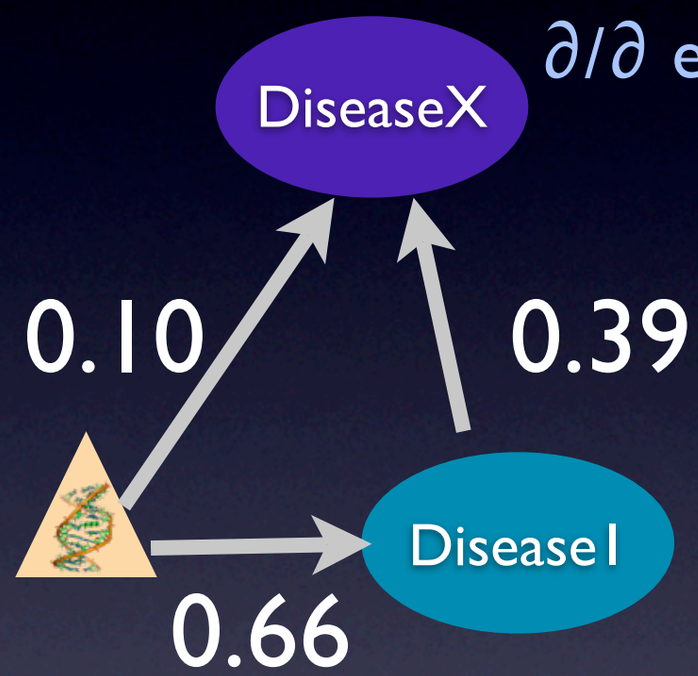

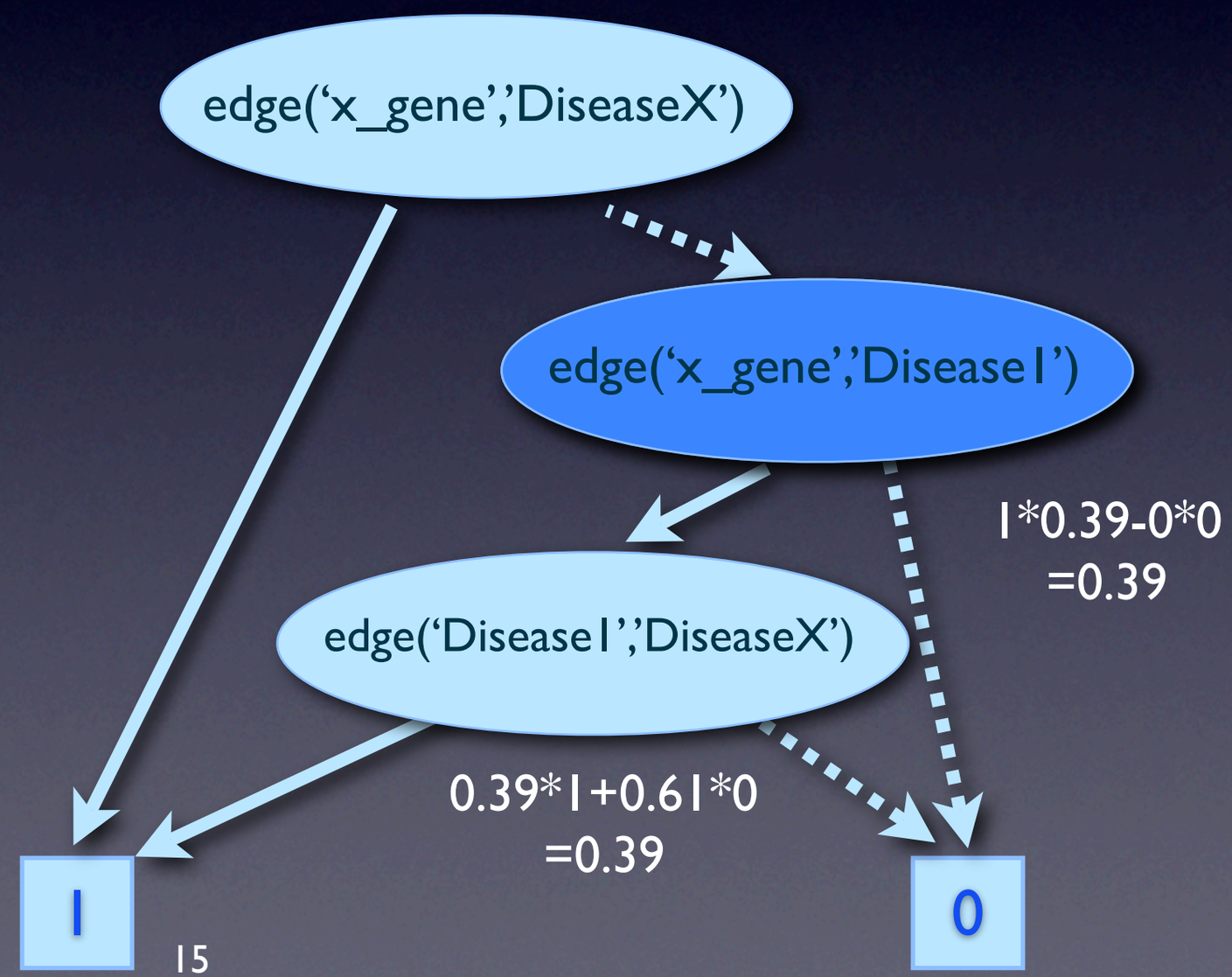

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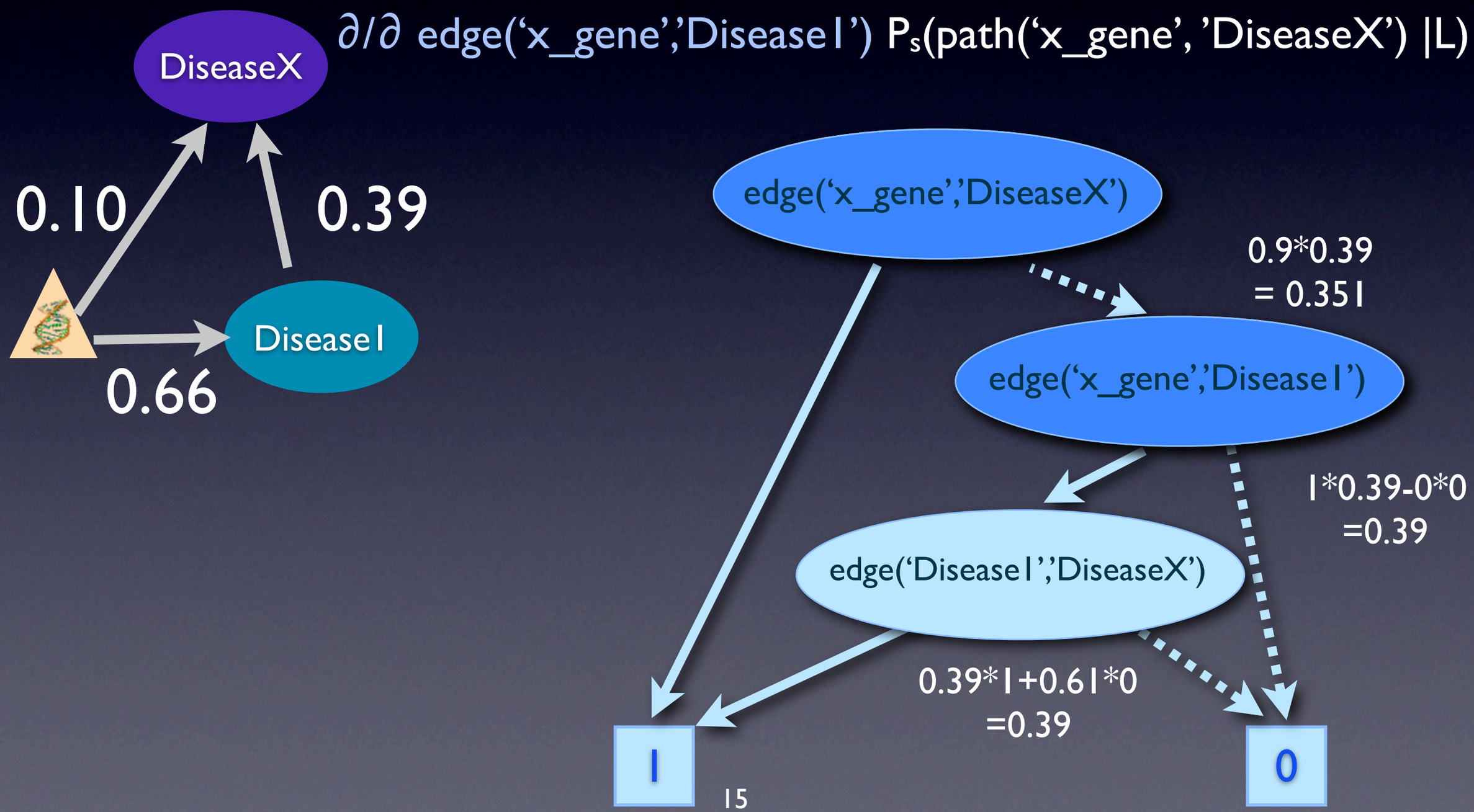

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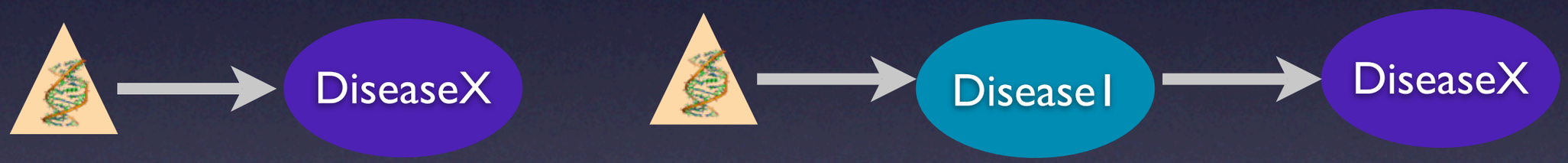

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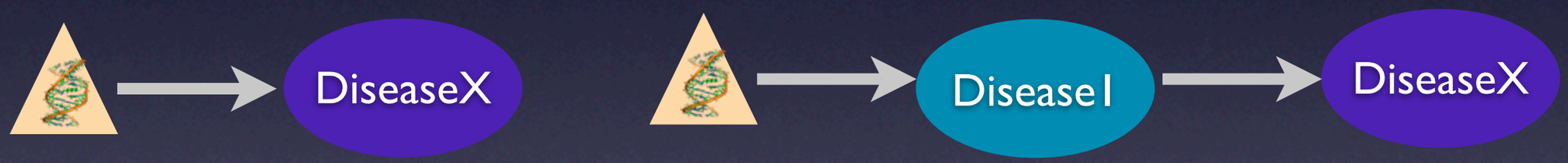

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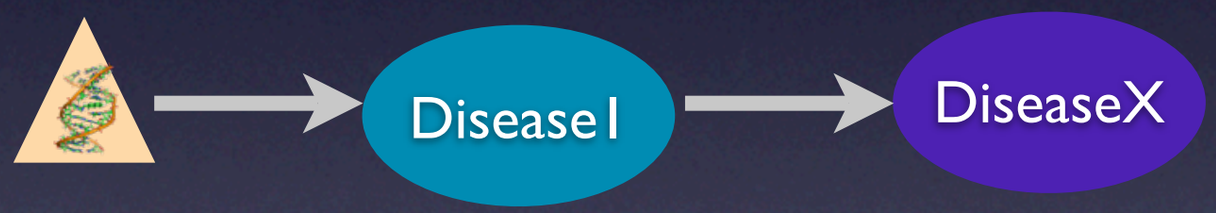

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Proofs are Queries

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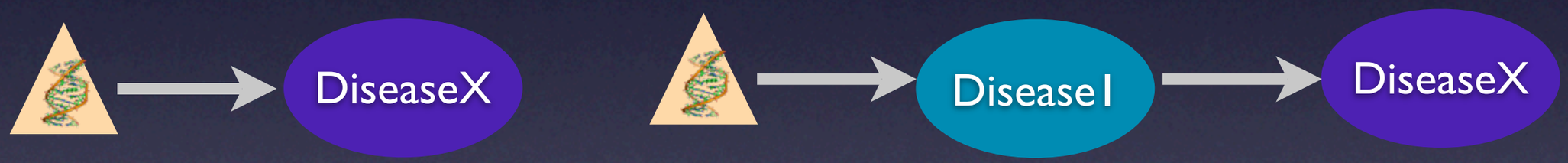

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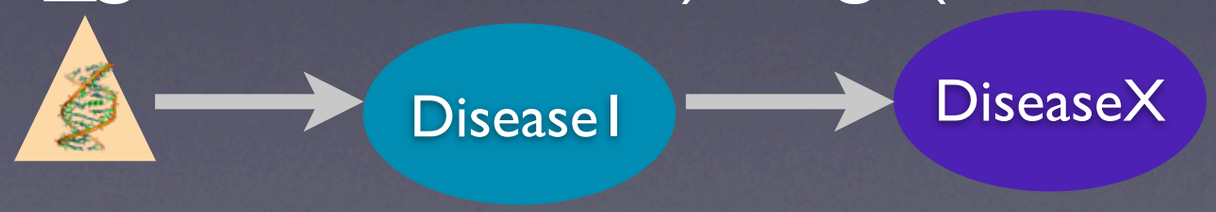
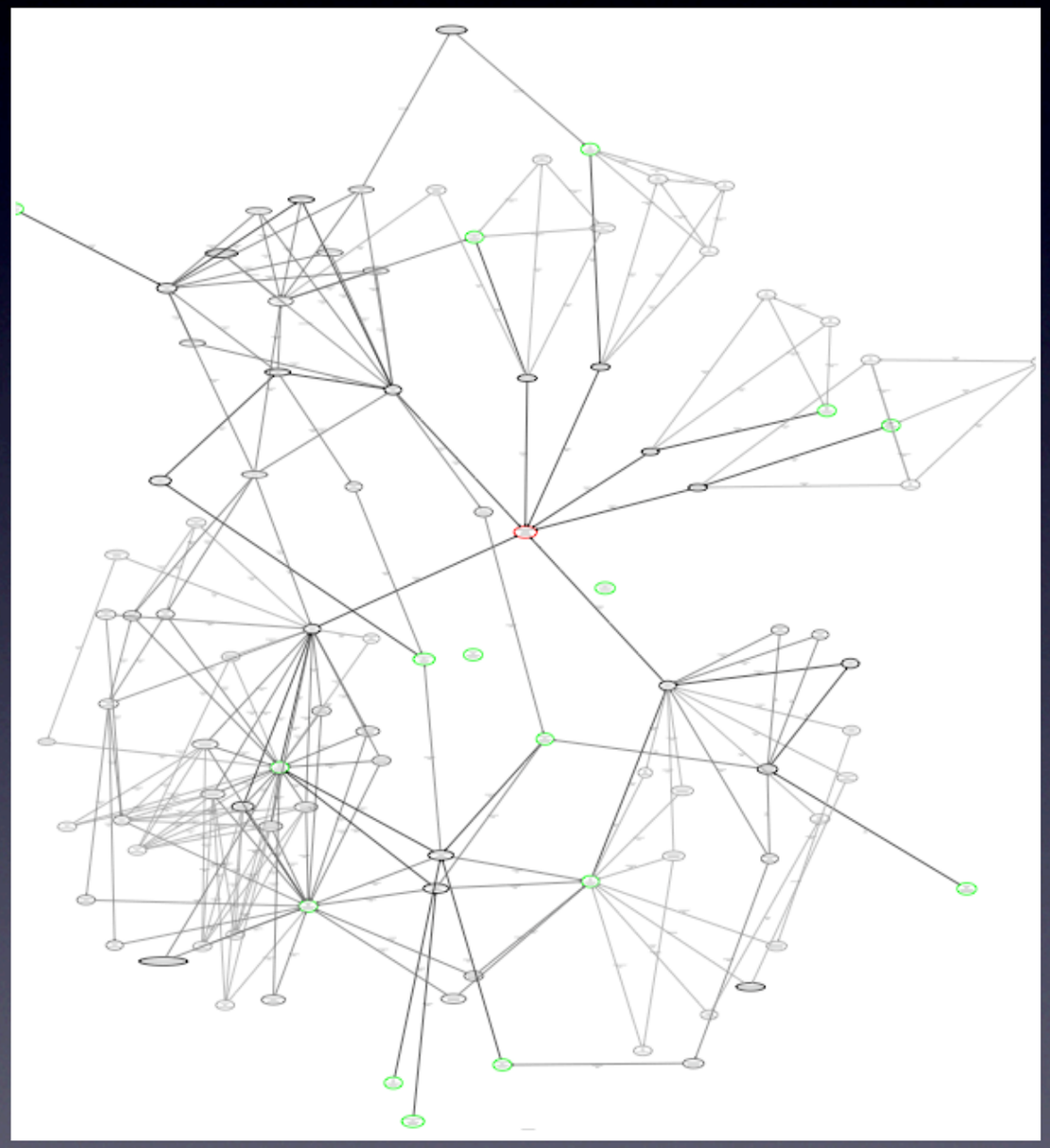
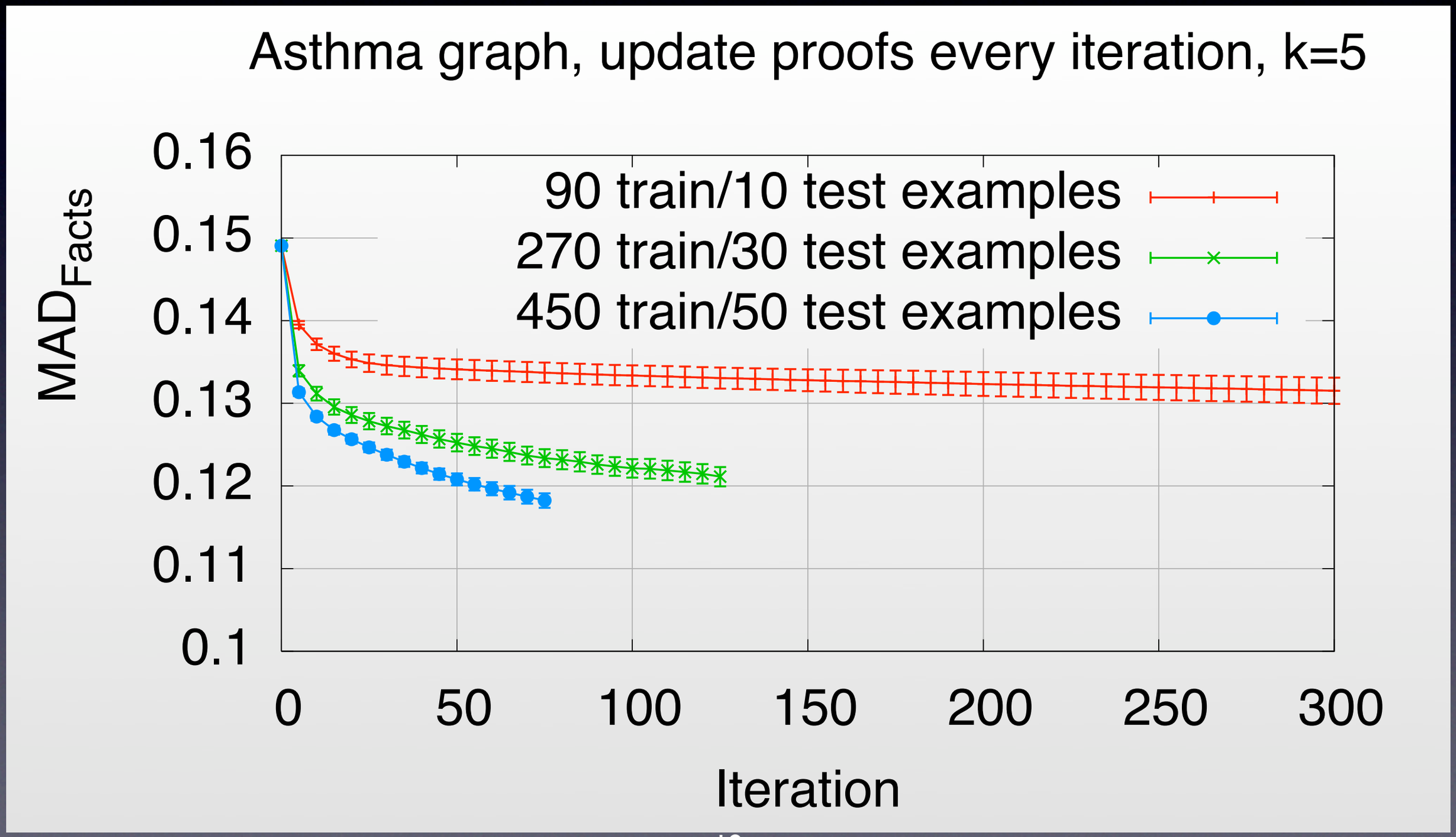


Experiments

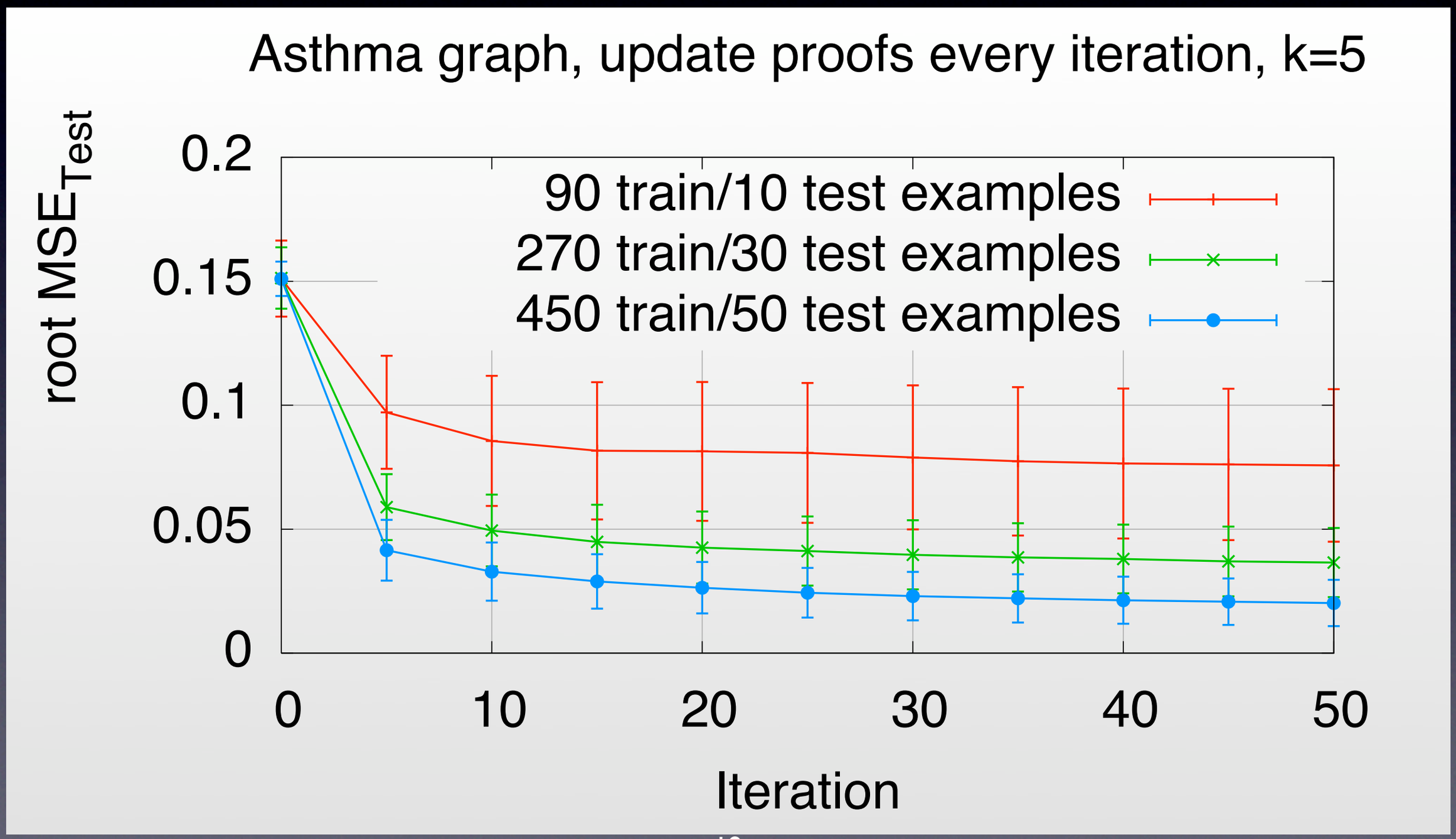
- subgraph from the BIOMINE database around asthma genes
- 127 nodes, 241 edges
- sampled 500 random node pairs
- calculated P(path(X,Y))
- 10-fold cv



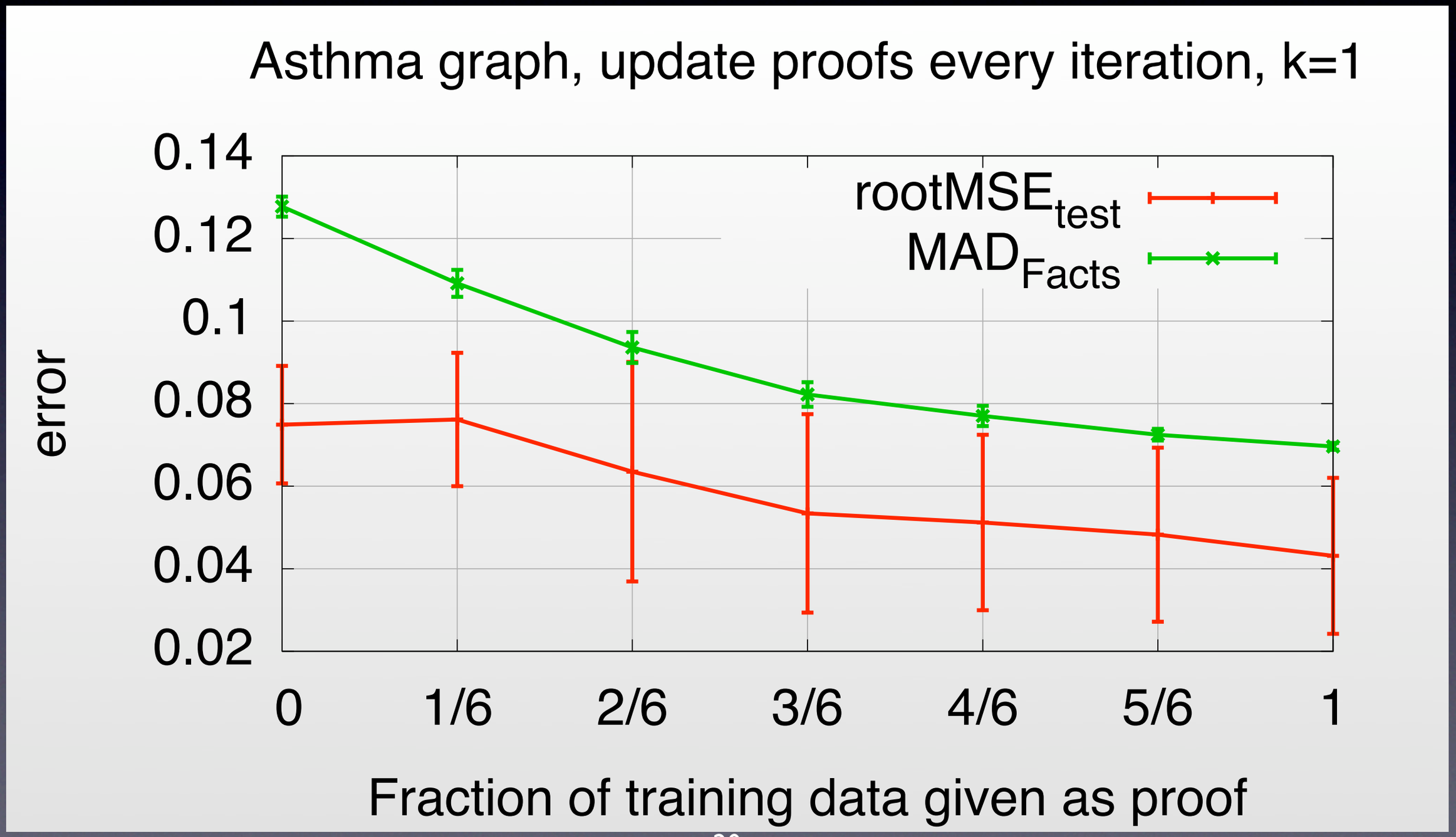
Recovering Probabilities



Reducing Test Error



Using Proofs



Summary

- it works
- it can naturally deal with proofs
- it is efficient due to the BDDs
- applicable for any prob. database where gradient of queries can be calculated

Questions?

More Details: See our ECML 2008 paper