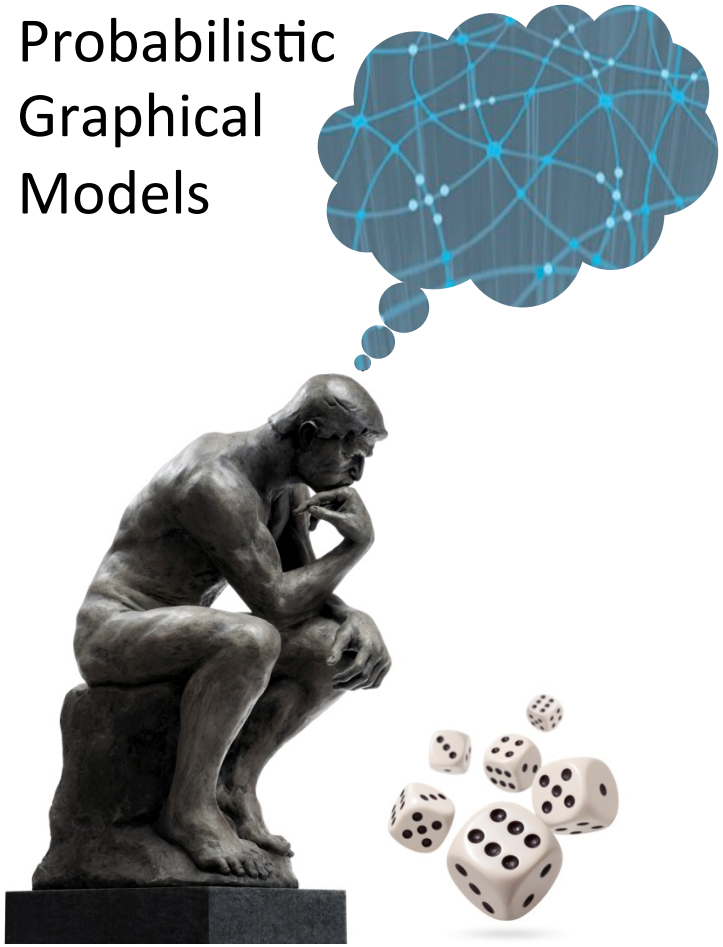
Probabilistic Graphical Models

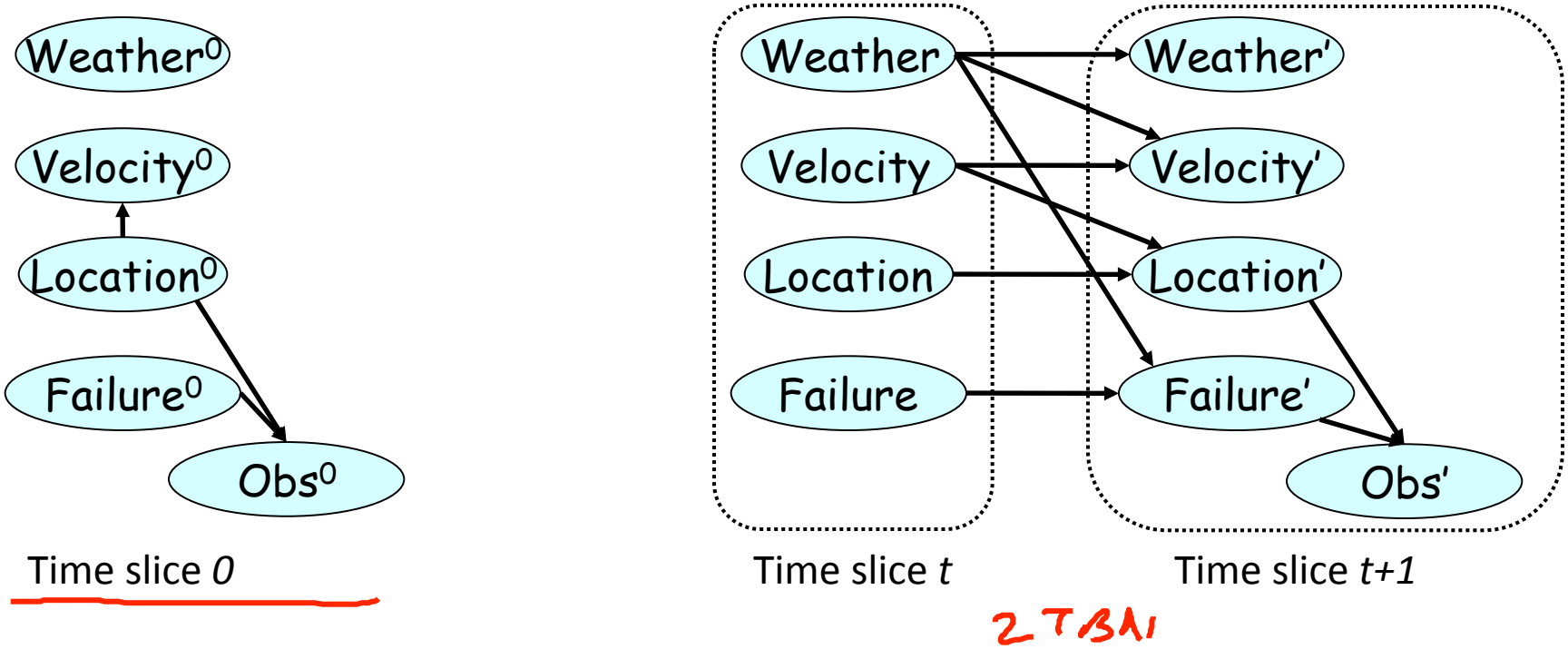


Inference

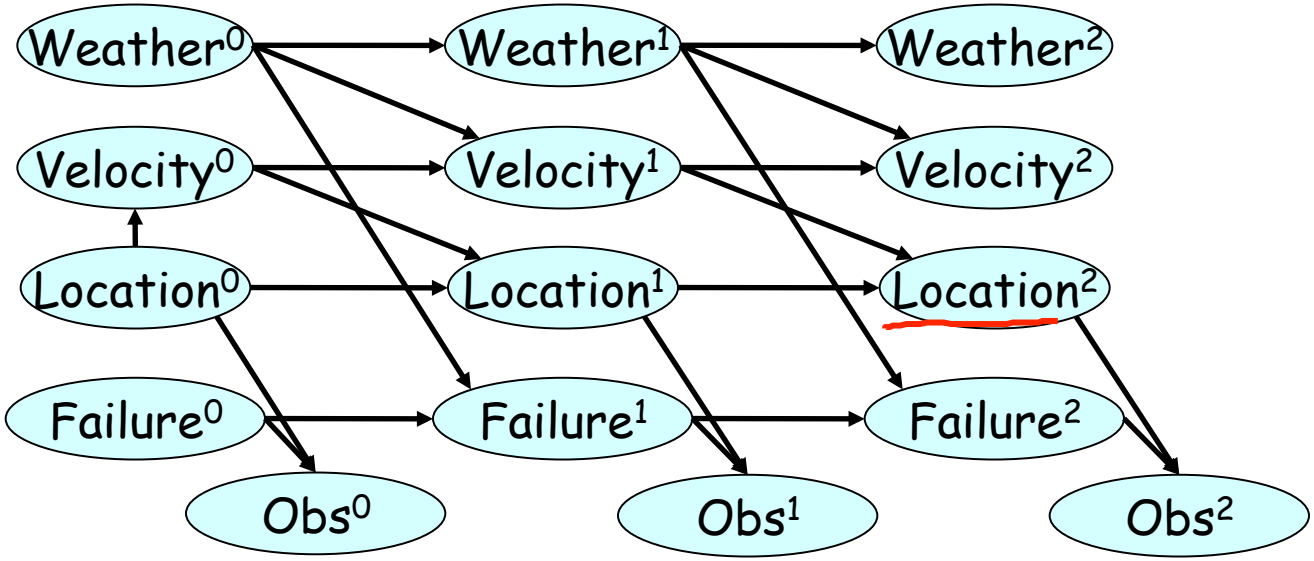
Sampling Methods

Inference In Template Models

DBN Template Specification



Ground Bayesian Network



Can unroll DBN for given trajectory
and run inference over ground network

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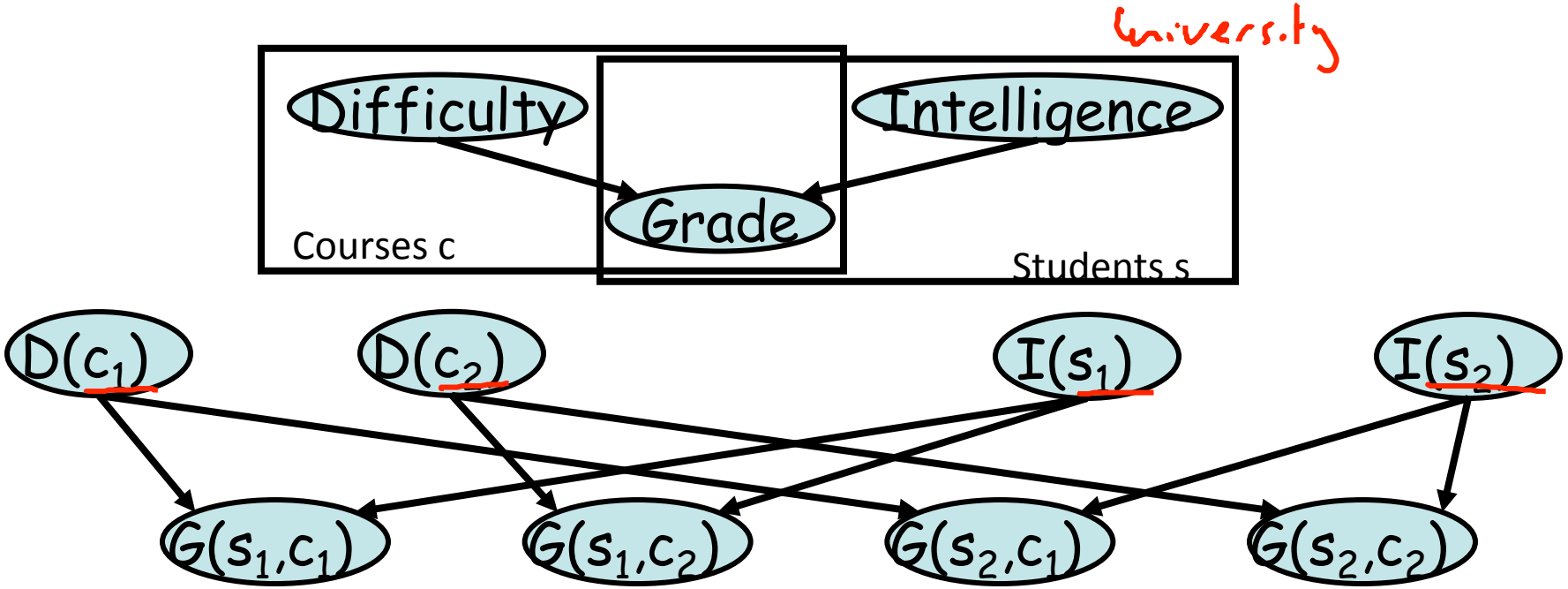
Plate Model



Can unroll plate model for given set of objects and run inference over ground network

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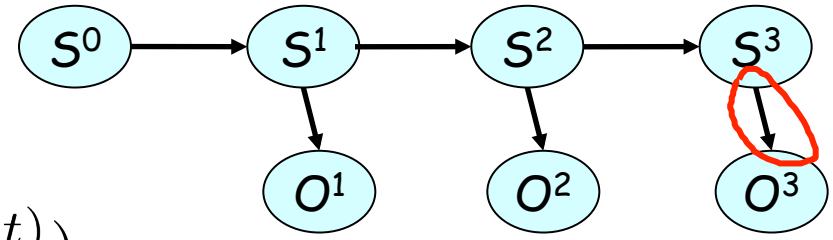
Belief State Tracking



$$\sigma^{(t)}(S^{(t)}) = P(S^{(t)} \mid o^{(1:t)})$$

$$\sigma^{(t+1)}(S^{(t+1)}) \stackrel{\Delta}{=} P(S^{(t+1)} \mid o^{(1:t)})$$

$$= \sum_{S^{(t)}} P(S^{(t+1)} \mid S^{(t)}, o^{(1:t)}) P(S^{(t)} \mid o^{(1:t)})$$

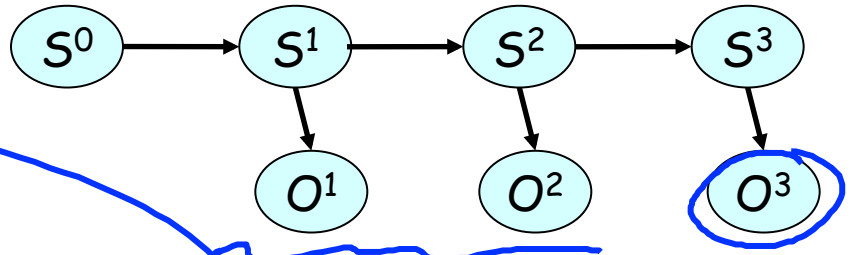
$$= \sum_{S^{(t)}} P(S^{(t+1)} \mid S^{(t)}) \sigma^{(t)}(S^{(t)})$$

transition model

Belief State Tracking

$$\sigma^{(t)}(S^{(t)}) = P(S^{(t)} \mid \boldsymbol{o}^{(1:t)})$$

$$\sigma^{(\cdot t+1)}(S^{(t+1)}) \stackrel{\Delta}{=} P(S^{(t+1)} \mid o^{(1:t)})$$



$$\sigma^{(t+1)}(S^{(t+1)}) = P(S^{(t+1)} \mid o^{(1:t)}, o^{(t+1)})$$

$$= \frac{P(o^{(t+1)} \mid S^{(t+1)}, o^{(1:t)}) P(S^{(t+1)} \mid o^{(1:t)})}{P(o^{(t+1)} \mid o^{(1:t)})}$$

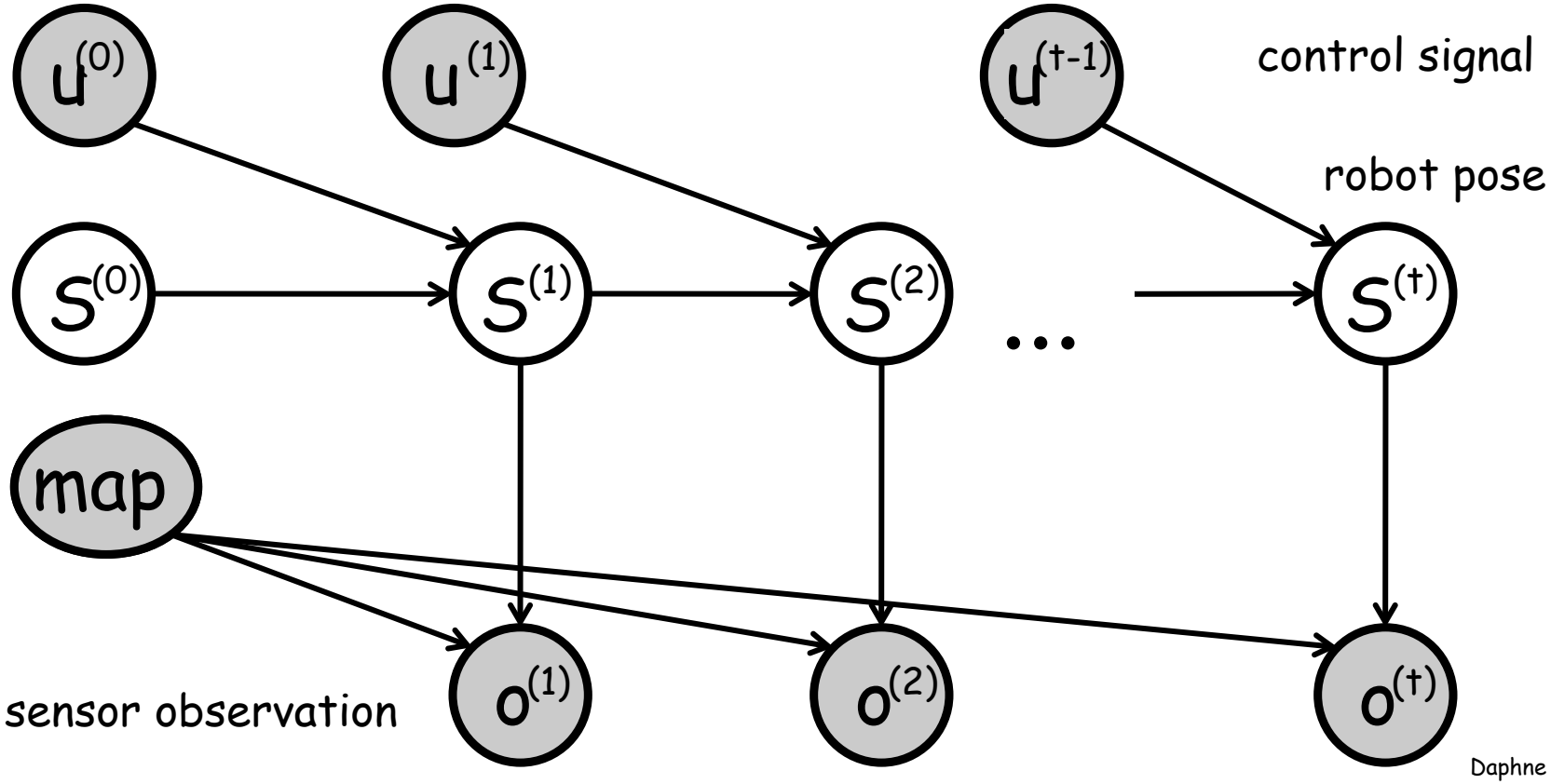
observation

$$= \frac{P(o^{(t+1)} \mid S^{(t+1)}) \sigma^{(\cdot t+1)}(S^{(t+1)})}{P(o^{(t+1)} \mid o^{(1:t)})}$$

numerator + normalizing

normalizing constant

Robot Localization



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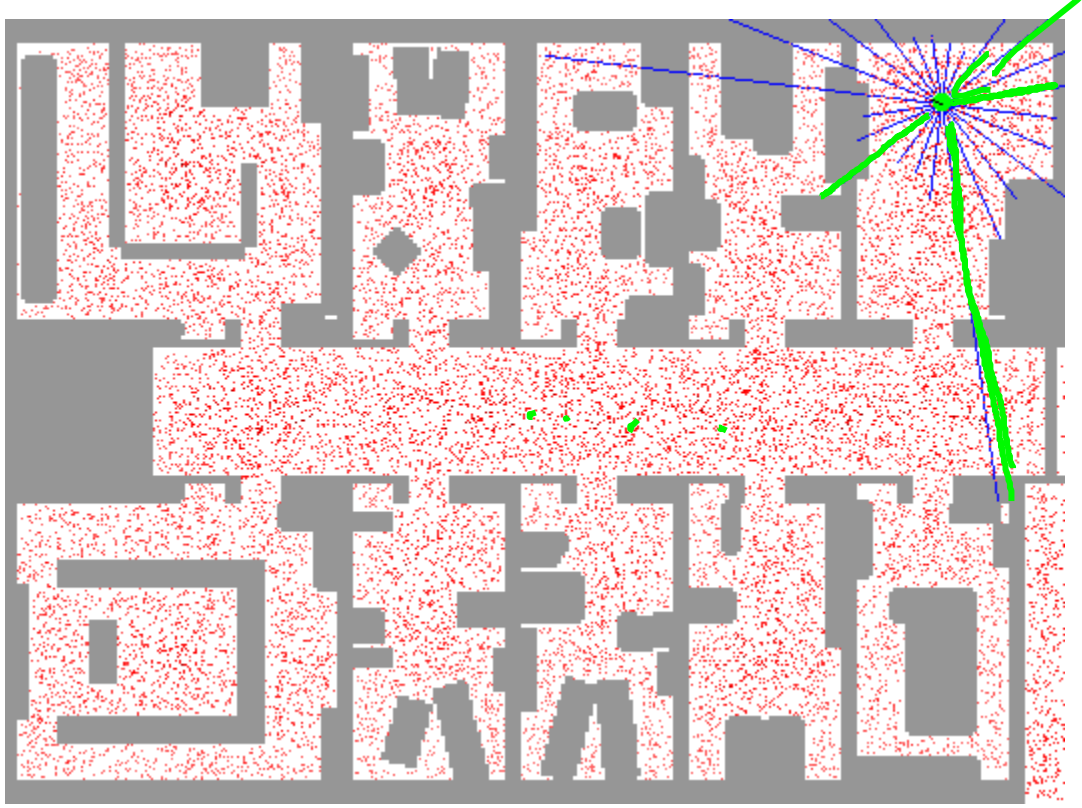
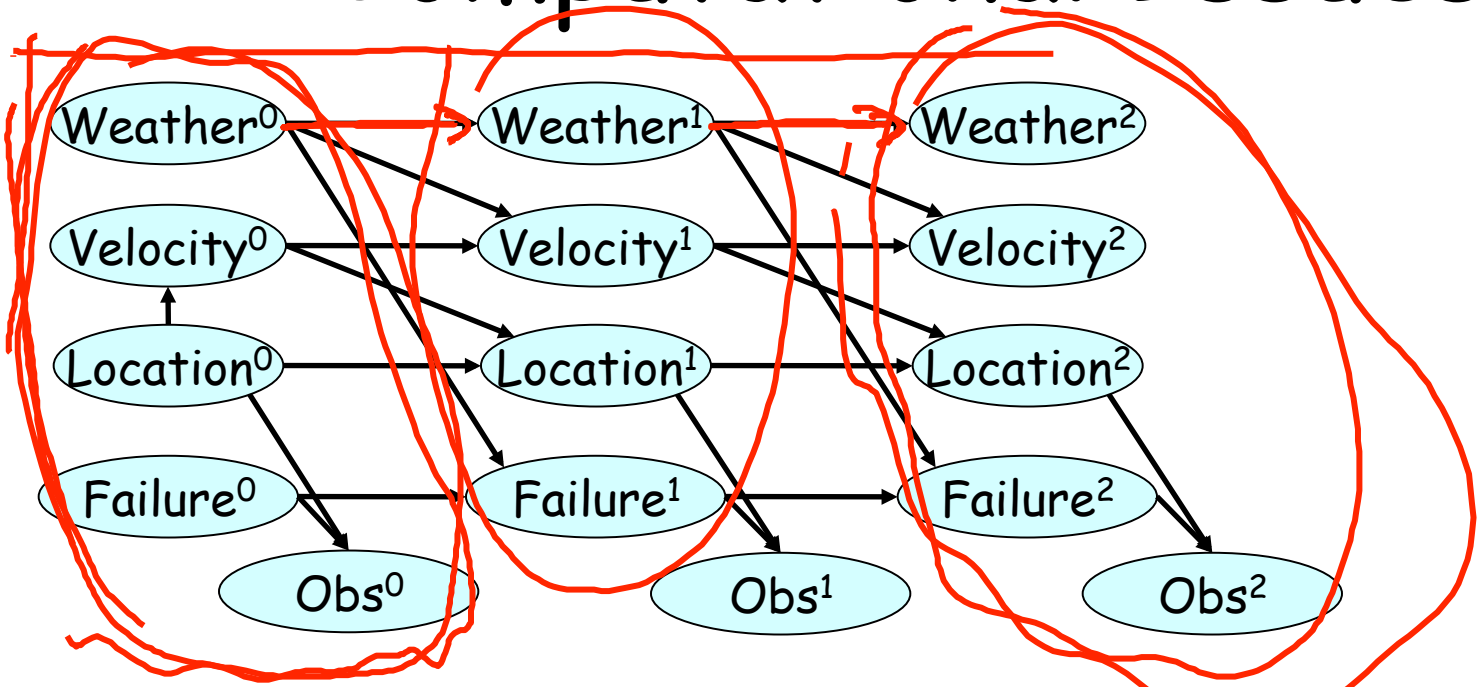
Robot Localization



Fox, Burgard, Thrun

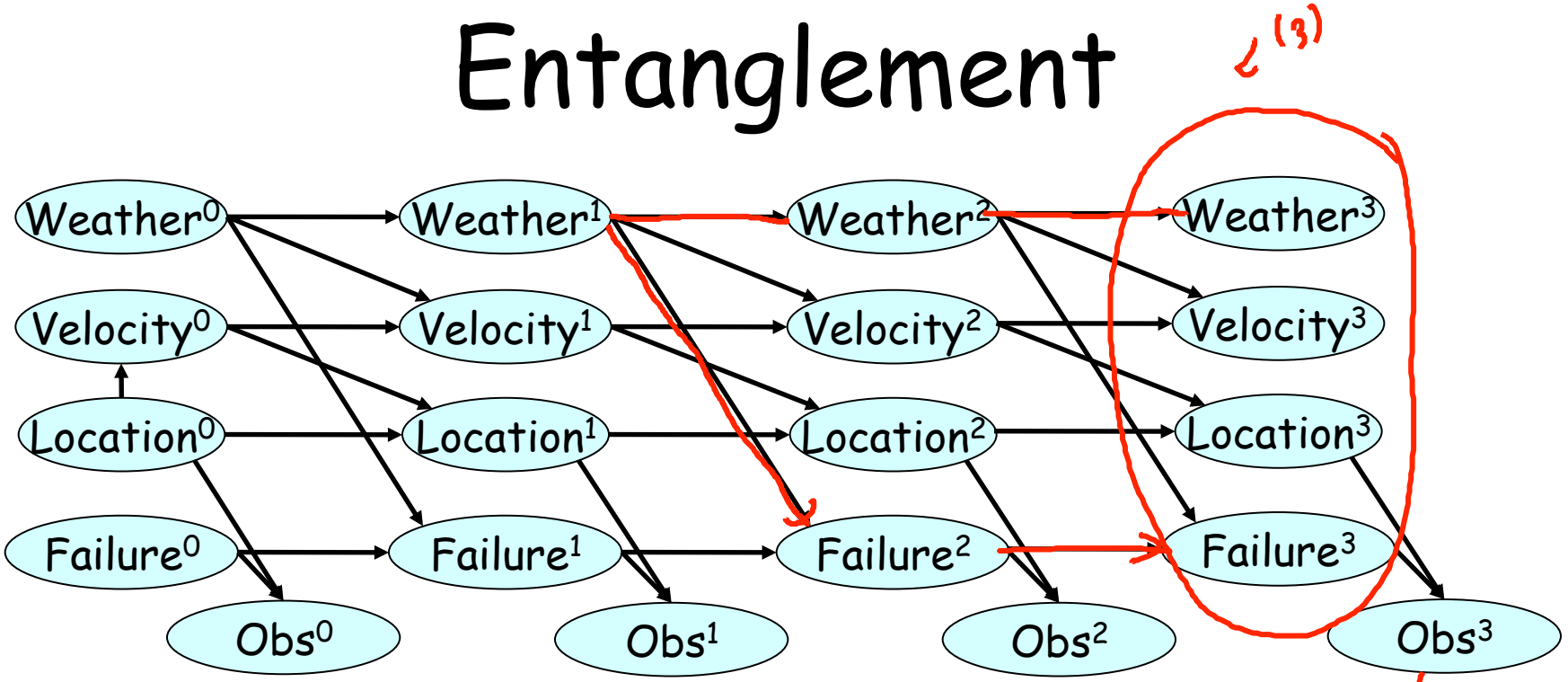
Computational Issues



Minimal sepset must separate future from past

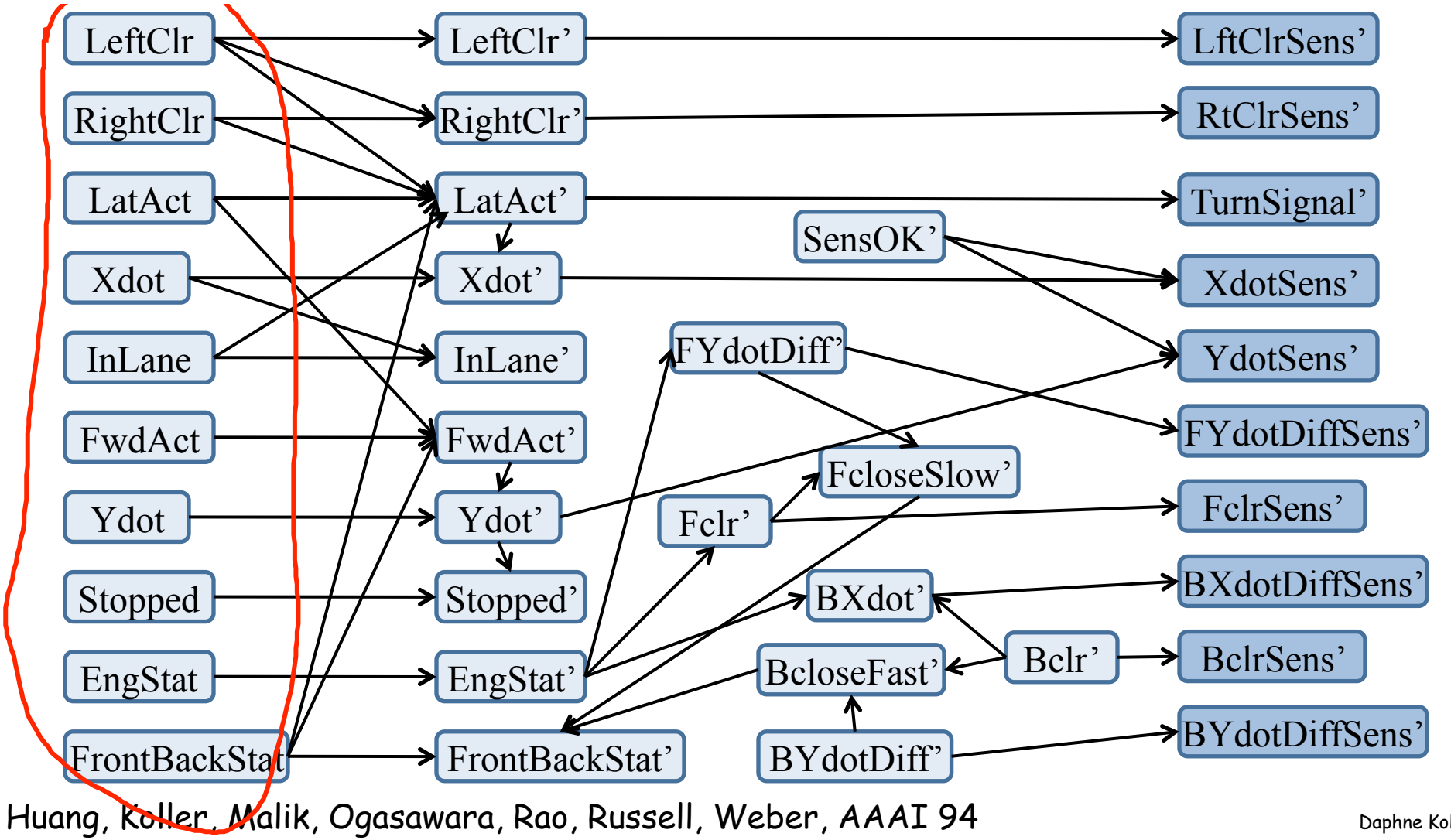
⇨ must involve at least all of the persistent variables

Entanglement

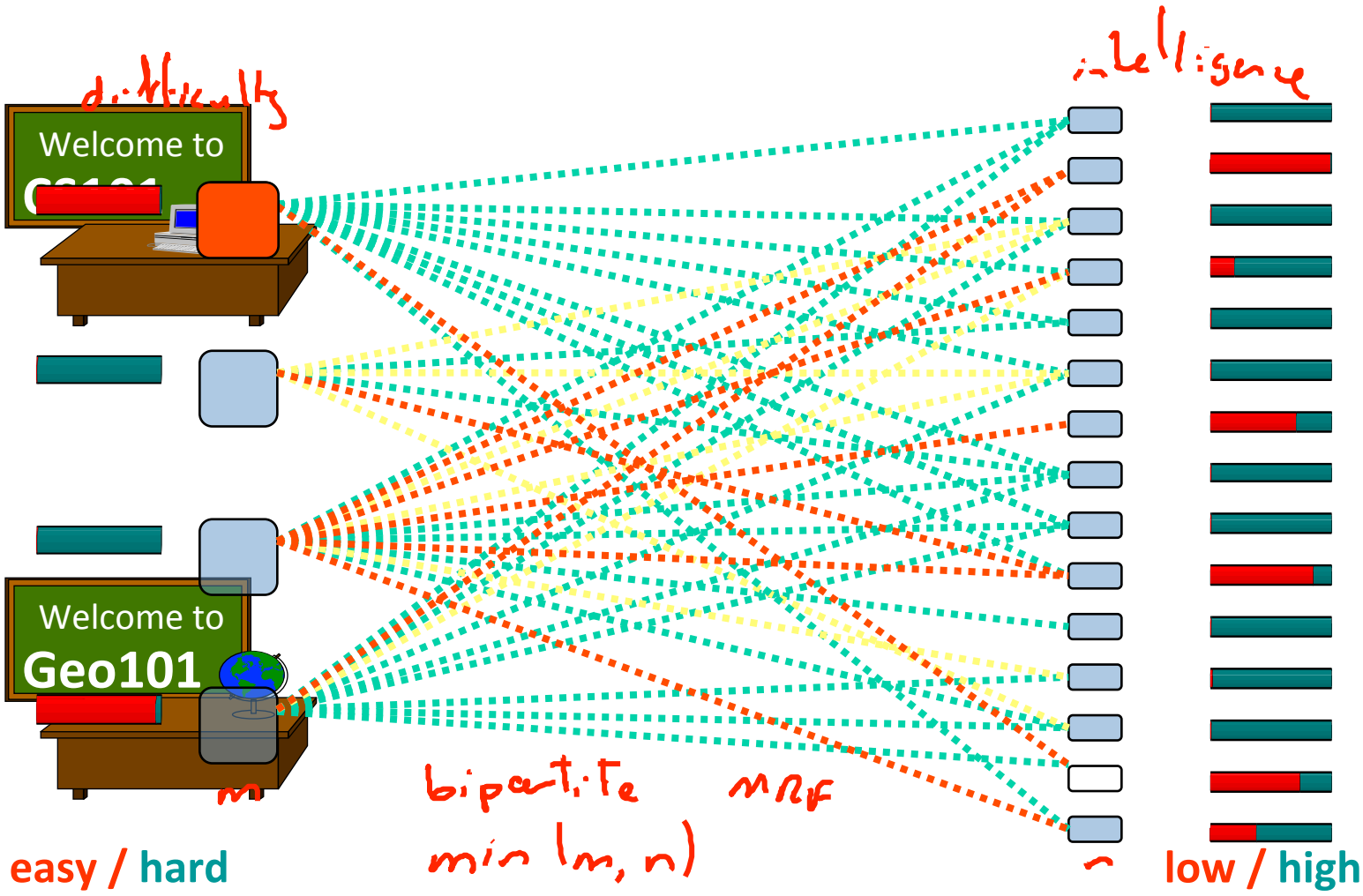


exact belief state is fully correlated in most cases

no conditional independencies



Huang, Koller, Malik, Ogasawara, Rao, Russell, Weber, AAAI 94



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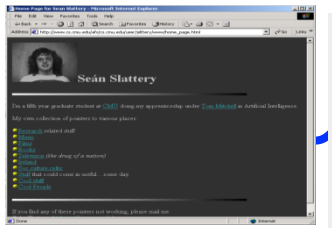
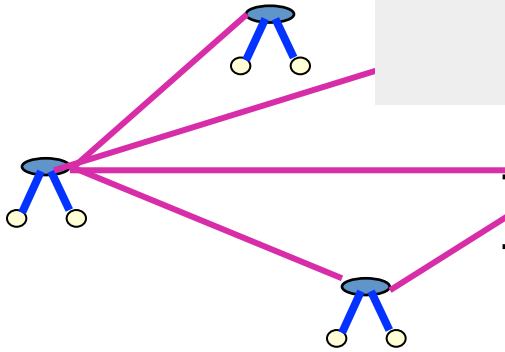
(Craven et al, Proc AAAI98; Tasker et al, UAI2002)

Collective Webpage Classification





From-Page

Category

$Word_1$ . .

To-Page

Category

$Word_N$

Classify all pages *collectively*,

maximizing the *joint* label probability

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Summary

- Inference in template and temporal models can be done by unrolling the ground network and using standard methods
- Temporal models also raise new inference tasks, such as real-time tracking, which require that we adapt our methods
- Moreover, ground network is often large and densely connected, requiring careful algorithm design and use of approximate methods