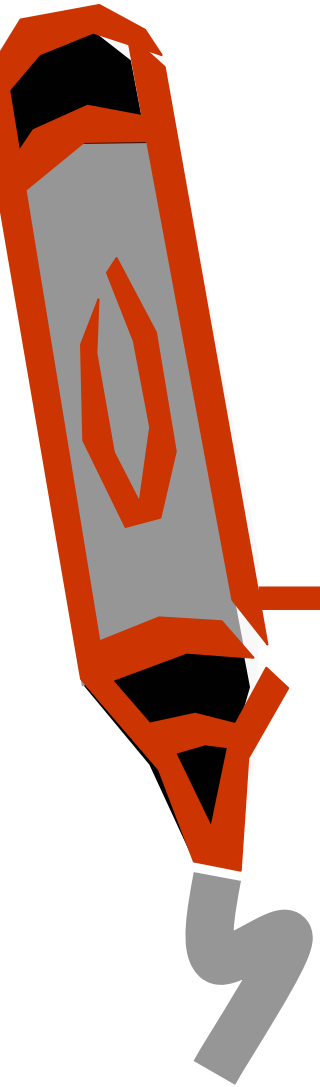

Inference Networks for IR

some slides courtesy James Allan@umass

background statistics

- random variables X,Y and density functions
- conditional probability $\mathbf{P}[X|Y]$

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	red	blue	green	
square	0.25	0.10	0.21	
round	0.17	0.04	0.23	

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	red	blue	green	
square	0.25	0.10	0.21	0.56
round	0.17	0.04	0.23	0.44
	0.42	0.14	0.44	

estimating relevance

-query:
China response to the Asian economic crisis

judge1 : **China**
judge2 : **response**
judge3 : **Asian economy**
judge4 : **economic crisis**

rate the likelyhood that next 3 documents will be judged relevant; assign for each doc a number between

0=certain not relevant
10=certain relevant

Dutch not badly hit by Asian flu-Wijers

(05:22 a.m. Feb 28, 1998 Eastern) HONG KONG, Feb 28 (Reuters)

The Netherlands was not expected to suffer badly from Asia's financial flu as its accumulated investments were small, compared to Dutch investments in the US, said Minister of Economic Affairs Hans Wijers on Saturday. ''In terms of foreign direct Dutch investment, although we are in many countries a major investor, if you look at accumulated investments here, for example compared to what we have done in the United States, it's still relatively small,'' Wijers said at a press briefing. He said the Netherlands did not expect too many negative effects as long as Japan's economy was not hit too hard. Many Asian economies have slumped following a sharp devaluation in their currencies. In Hong Kong, Wijers held talks with Chief Executive Tung Chee-hwa and Financial Secretary Donald Tsang. Wijers said he was impressed with the Hong Kong government's commitment to hold the currency's peg at its present value of HK$7.8 to one US dollar. Wijers was concluding a week-long tour of Beijing, Shanghai, Guangzhou and Hong Kong accompanied by representatives from 61 Dutch companies. He met China's trade minister Wu Yi and other senior officials. By the time they reached Hong Kong, the delegation had clinched deals with China worth a total of US$250 million, Wijers said. ''I promised Madame Wu Yi support in solving the problem of access to European Union markets,'' Wijers said. Wu Yi promised Dutch companies support in reducing the trade gap between China and the Netherlands, he said. China's exports to the Netherlands are much higher than its imports from that country, Wijers noted. The Dutch minister said his country supported China's wish to enter the World Trade Organisation.

China Plans $32.5 Billion Bond Issue for Banks

(06:52 a.m. Mar 02, 1998 Eastern , By Paul Eckert) BEIJING (Reuters)

China's boldest move yet to avert an Asian-style financial crisis, a $32.5 billion bond issue to recapitalize state banks, will serve as a vital crutch for the debt-laden institutions, bankers say. The size of the ''special bond'' issue -- which was approved by a parliamentary committee on Saturday -- was more than double that predicted by financial analysts and greater than the total announced figure for 1998 government bond issues. ''The issue is expected to greatly help the banks write off their bad loans as the capital will be injected without the banks paying interest,'' said a Shanghai-based banker with the Industrial and Commercial Bank of China. Announcing its decision, the Standing Committee of the National People's Congress said the 270-billion-yuan ($32.5 billion) bond sale was ''very necessary to raise the credibility of state-owned commercial banks and their ability to compete in international financial markets.'' China's state-owned commercial banks – the Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China and Construction Bank of China -- are technically insolvent after heavy lending to money-losing state firms. The World Bank estimates the four big banks account for more than 90 percent of China's bank assets and two-thirds of financial assets. The Shanghai banker said the infusion of cash -- repayment for years of supplementing government budget outlays with so-called ''policy loans'' to inefficient state firms -- would help the banks meet international standards. ''The issue is a key step to allow state commercial banks to meet the minimum capital adequacy ratio of 8 percent required by the Bank for International Settlements,'' said the banker, who declined to be identified.

Australia's Howard says economy looking good

(01:16 a.m. Mar 01, 1998 Eastern) SYDNEY, March 1 (Reuters)

Australian Prime Minister John Howard said on Sunday that while the Asian economic crisis would have some impact, signs for the domestic economy were good. ‘‘The portents are good for the Australian economy. Despite the troubles in Asia, the Australian economy is still powering ahead,’’ Howard told Channel Nine’s Sunday program.‘‘Later on this year, there may be some flow-through which will knock off some of that (growth), but it’s a little too early to tell.’’ He was noncommittal when asked if forecasts of an Asian-led slowing in domestic growth were an incentive to call an early election, instead of waiting until his term ends in mid-1999. ‘‘I’m not here to announce the election date ... but I will go to the polls at the right time,‘‘ Howard said. The government has cut growth forecasts for 1998/99 to 3.25 percent from 3.5 percent because of the Asian turmoil. Growth in the year to June 30, 1998, is forecast at 3.75 percent.

estimating relevance

- assume one cannot estimate $\mathbf{P}[\mathbf{rel}|d, q]$

- instead estimate $\mathbf{P}[d|\mathbf{rel}]$

-assume independence

- Bayesian probabilities

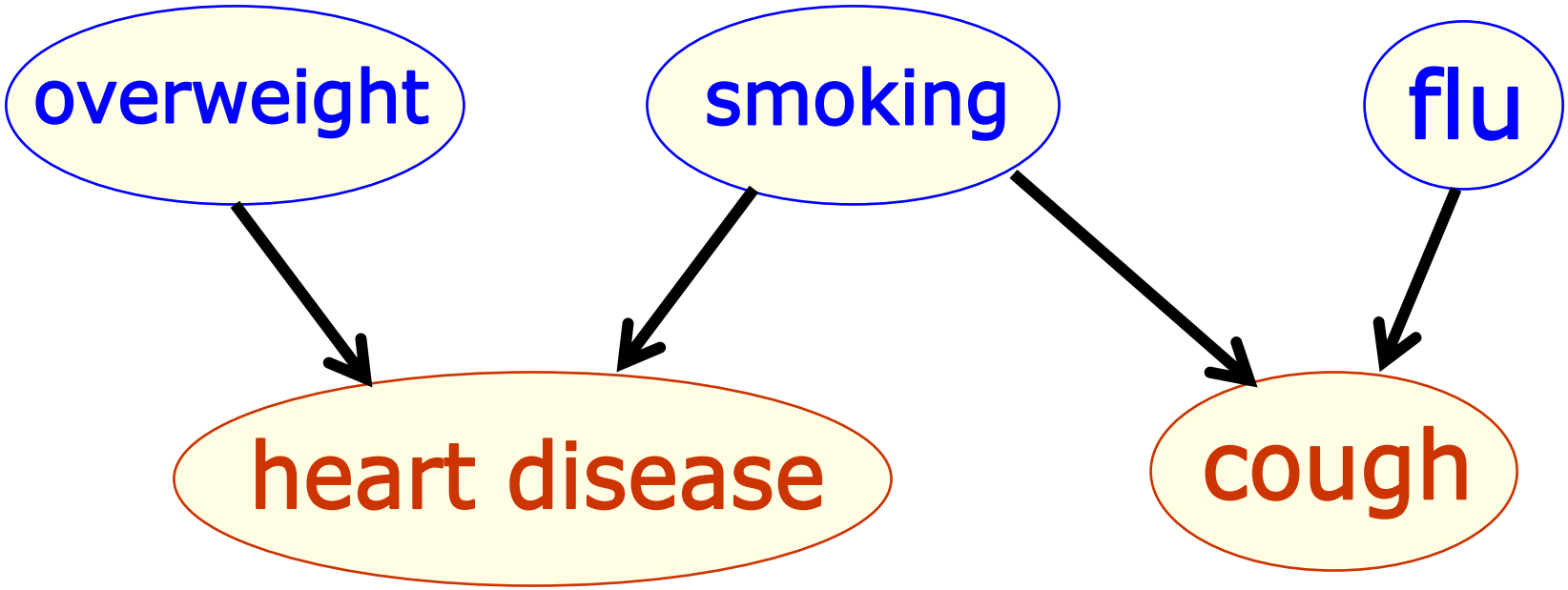
-based on expected outcomes

-estimates based on combining evidence

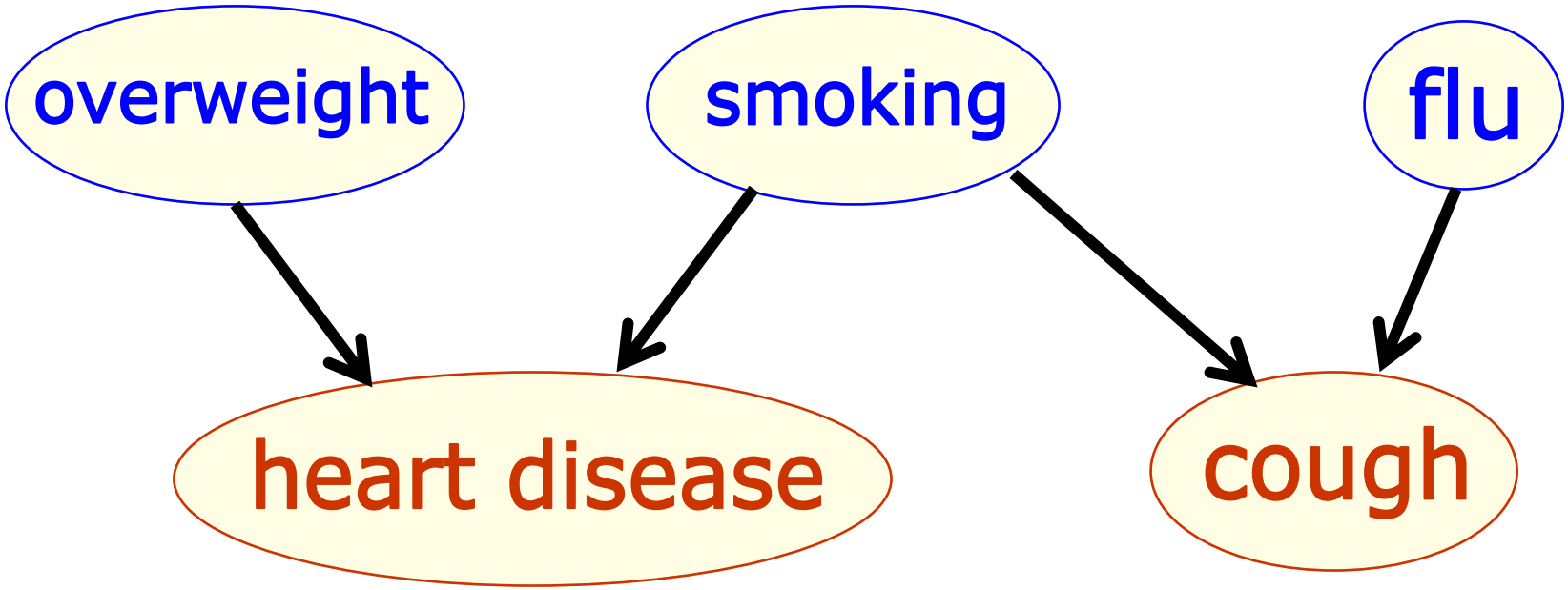
inference network

- probabilistic retrieval model
- explicitly represent inference
- combine the evidence
- generalizes other models
- focus on causality

Bayesian Networks

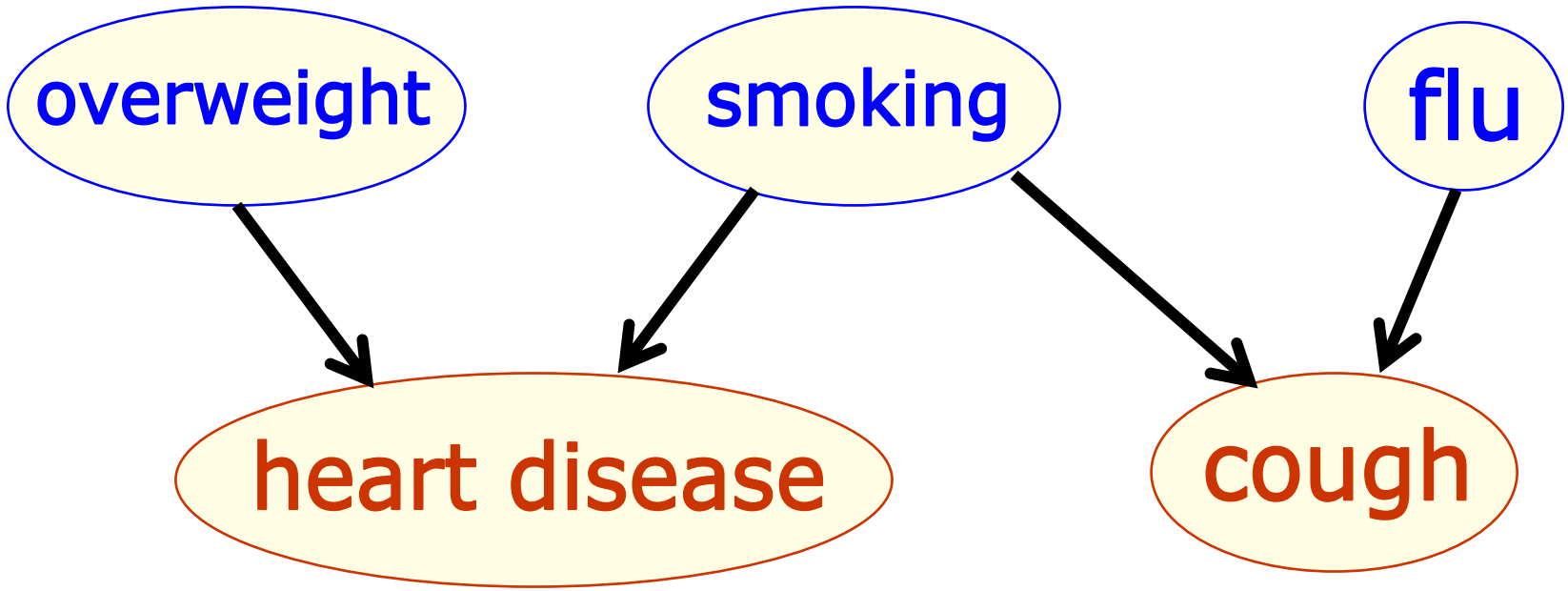


causation



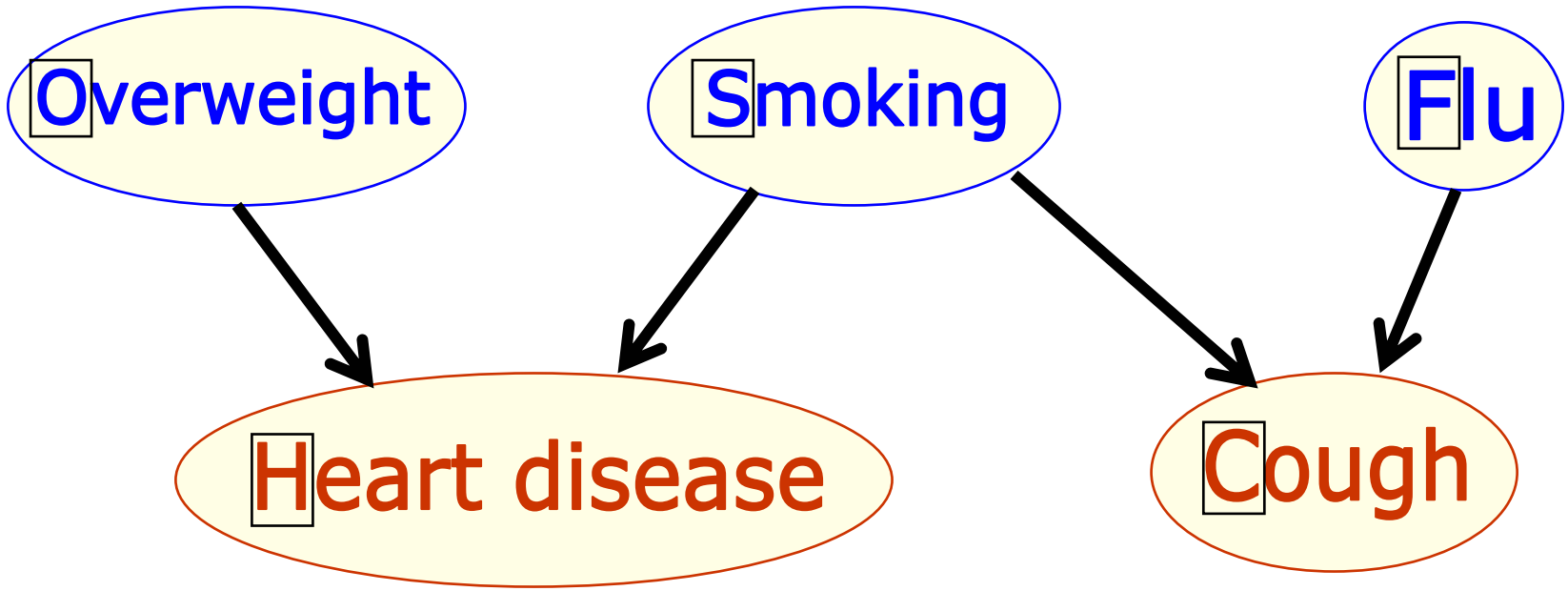
- causes and effects
- arcs represent causality
- causation does not have to be complete

Bayesian Networks



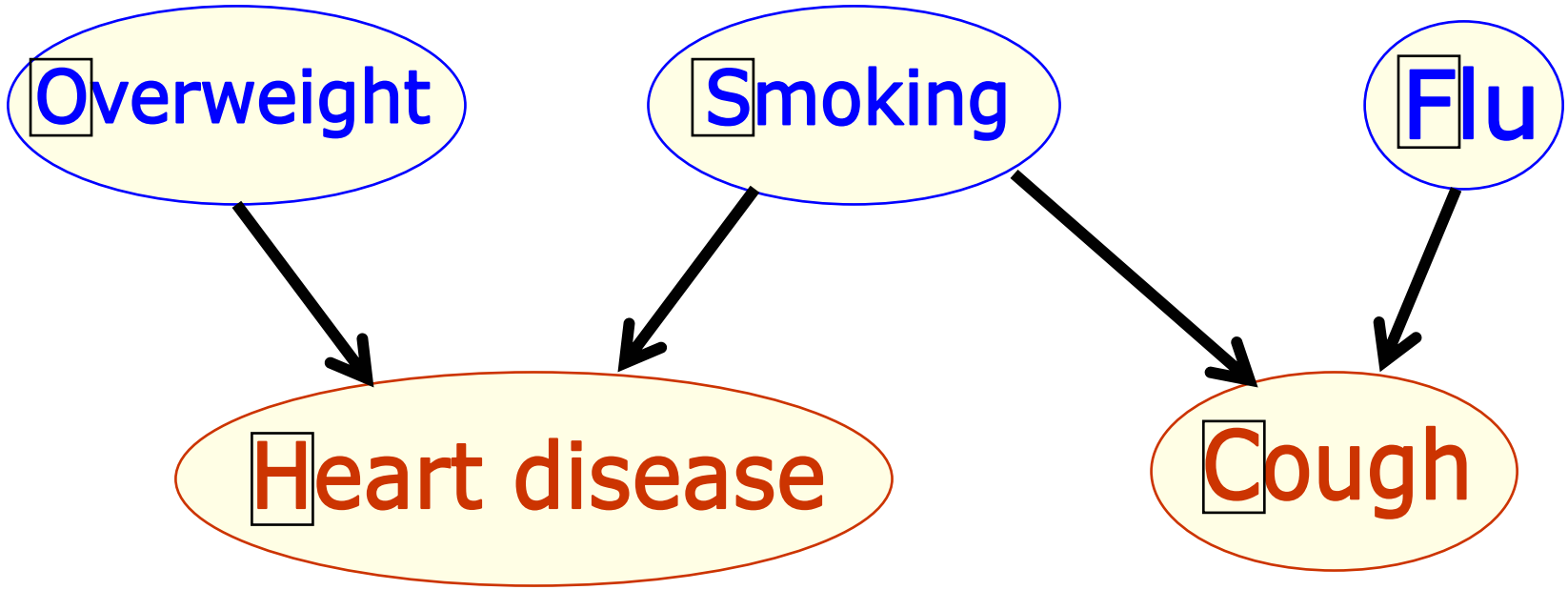
- it's a DAG = *directed acyclic* graph
- nodes = events = random variables
- edges = dependence = cond probabilities

Bayesian Networks



- joint distribution of the random variables
- problem : $\mathbf{P}[O, S, F, H, C]$ table too large

Bayesian Networks

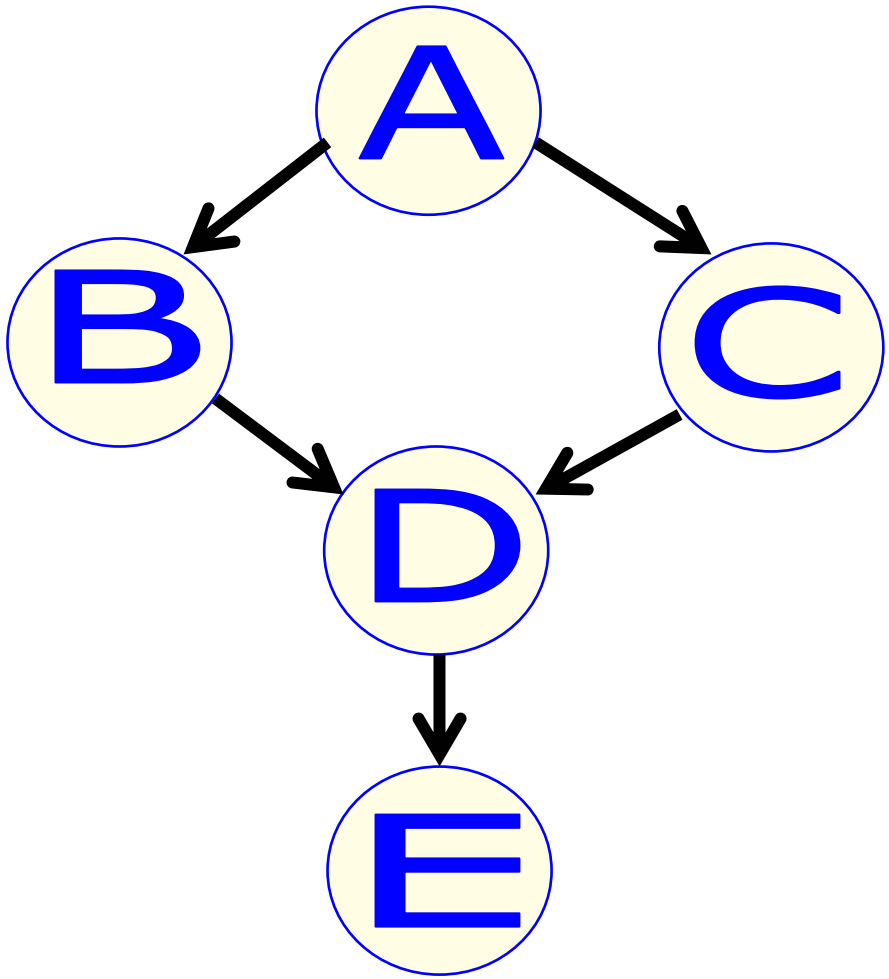


- joint distribution of the random variables
- problem : $\mathbf{P}[O, S, F, H, C]$ table too large
- solution : assume independence

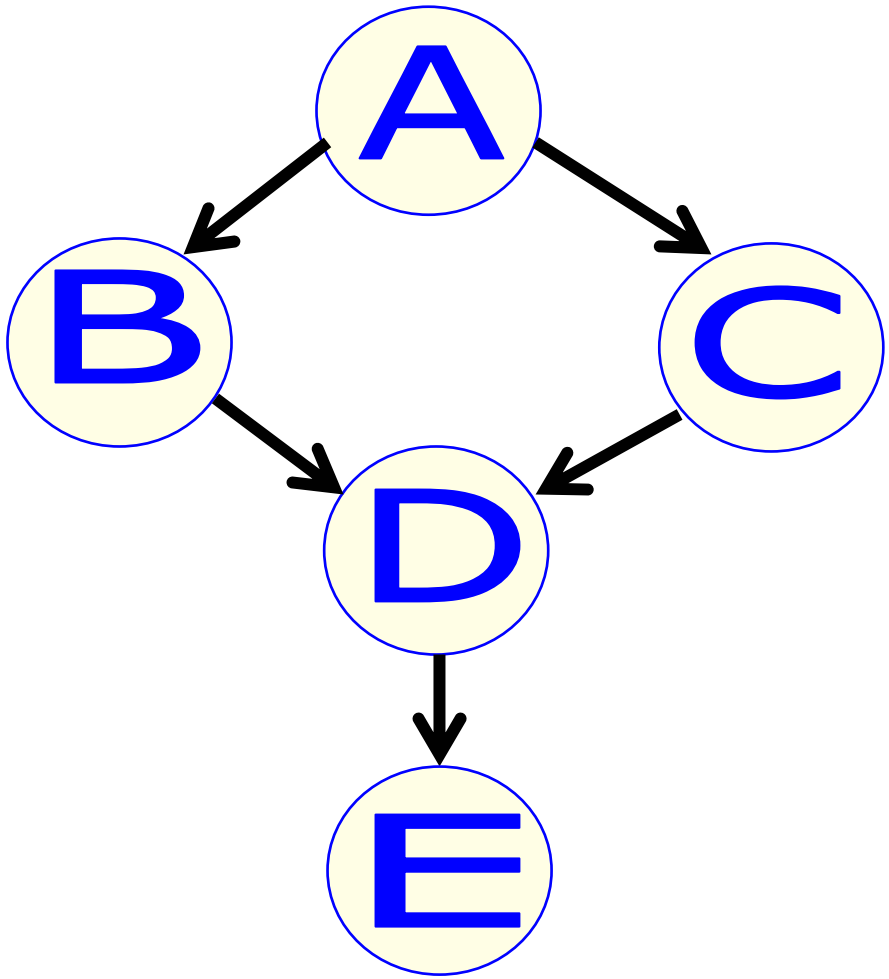
$\mathbf{P}[O, S, F, H, C] =$

$\mathbf{P}[O] \cdot \mathbf{P}[S] \cdot \mathbf{P}[F] \cdot \mathbf{P}[H|O, S] \cdot \mathbf{P}[C|S, F]$

Bayesian Networks



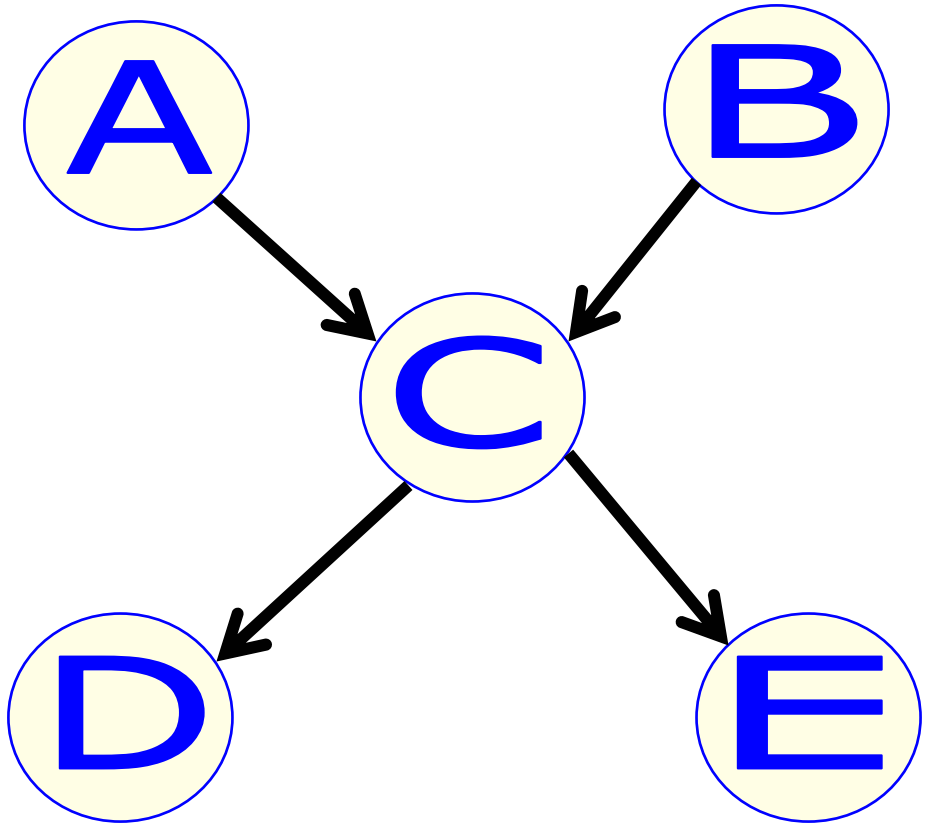
Bayesian Networks



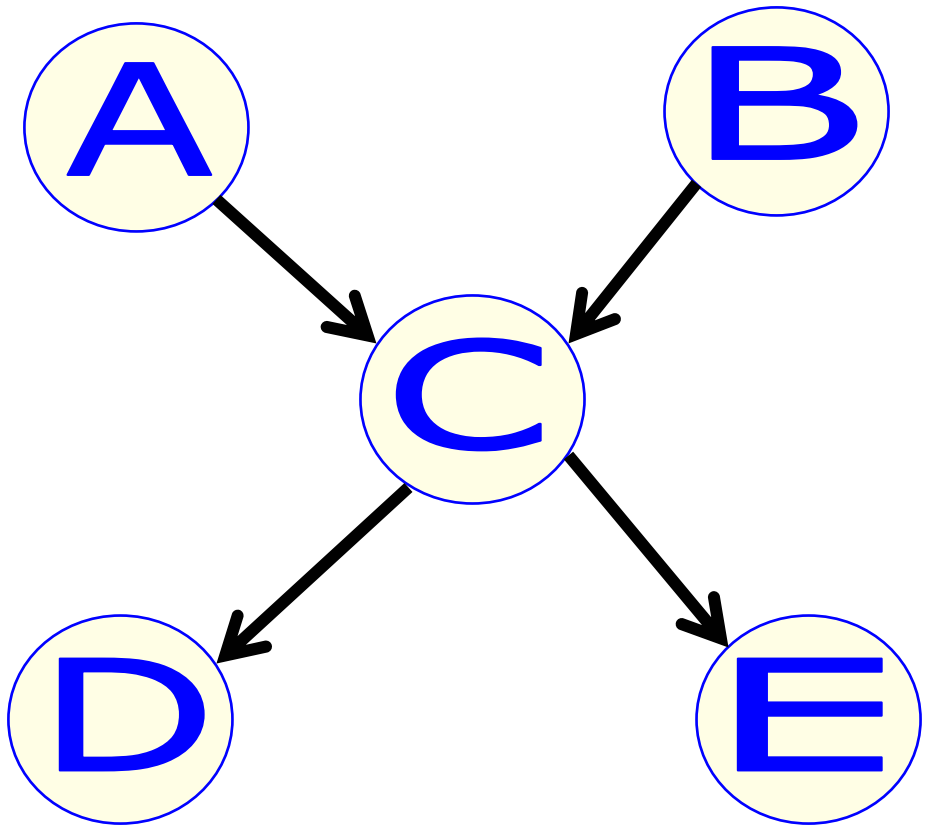
- $\mathbf{P}[A, B, C, D, E] =$

$\mathbf{P}[A] \cdot \mathbf{P}[B|A] \cdot \mathbf{P}[C|A] \cdot \mathbf{P}[D|B, C] \cdot \mathbf{P}[E|D]$

Bayesian Networks



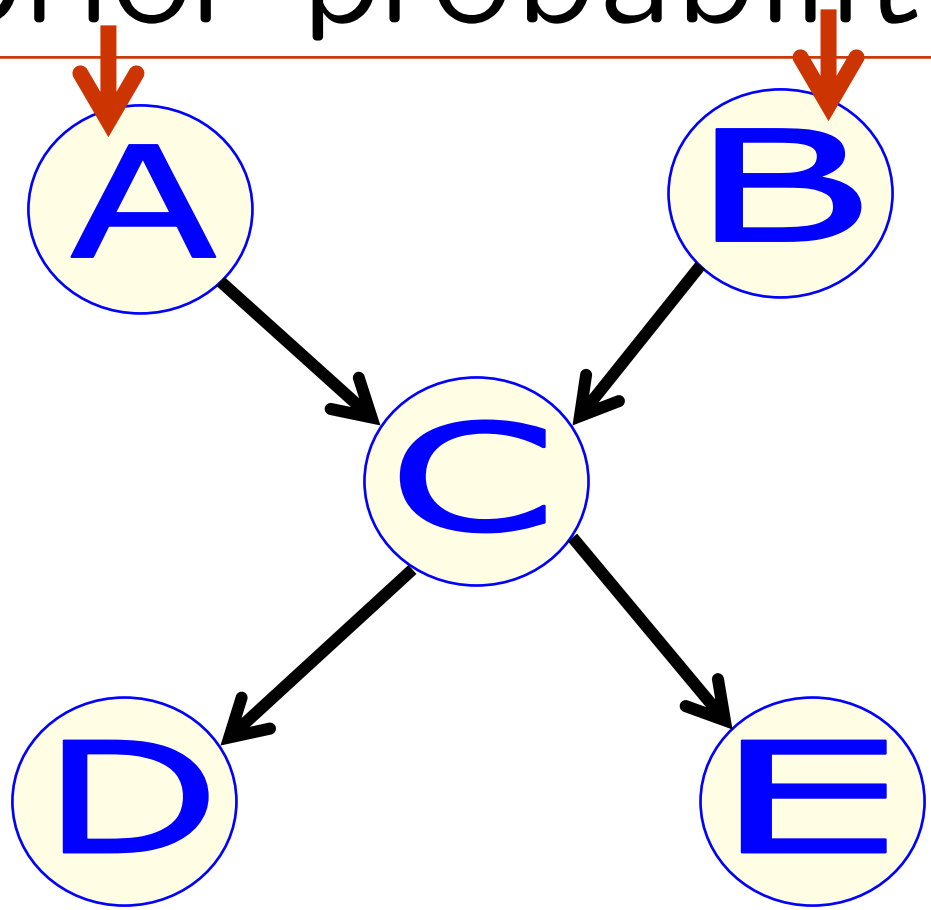
Bayesian Networks



- $\mathbf{P}[A, B, C, D, E] =$

$\mathbf{P}[A] \cdot \mathbf{P}[B] \cdot \mathbf{P}[C|A, B] \cdot \mathbf{P}[D|C] \cdot \mathbf{P}[E|C]$

prior probabilities

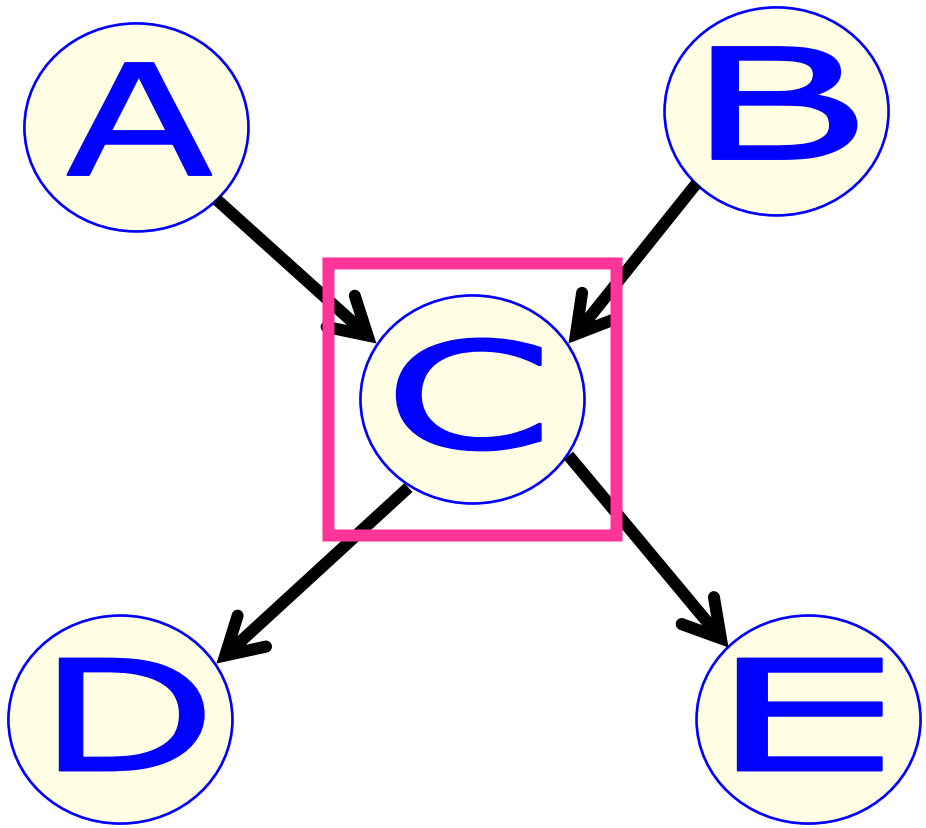


- $\mathbf{P}[A, B, C, D, E] =$

$\mathbf{P}[A] \cdot \mathbf{P}[B] \cdot \mathbf{P}[C|A, B] \cdot \mathbf{P}[D|C] \cdot \mathbf{P}[E|C]$

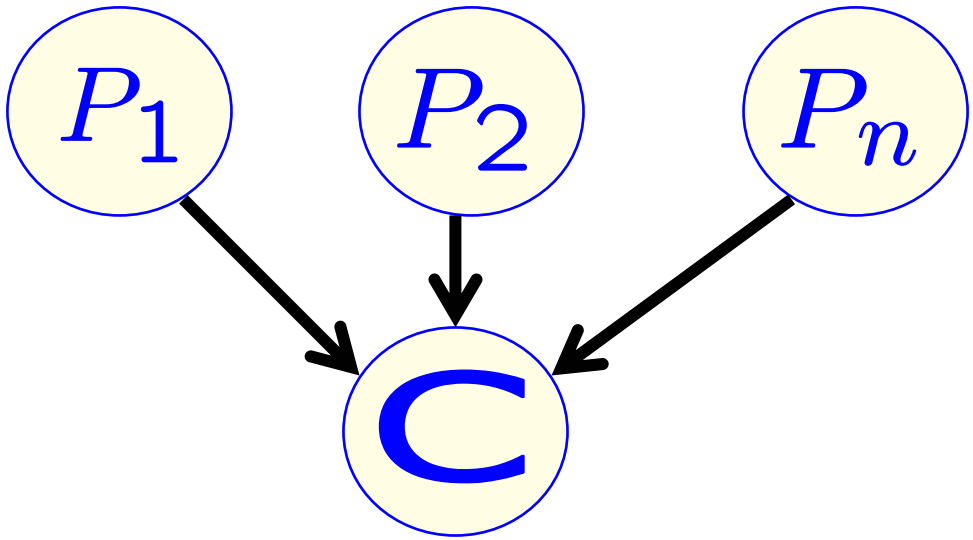
- if given prior and all conditionals, we can compute probabilities associated with any node

new evidence



- when the value of a node becomes known (0|1), computation is simplified

link matrices



- each node contains specification of dependencies upon its parents
- for binary nodes there are 2^n possibilities for $\mathbf{P}[C|P_1, P_2, ..., P_n]$ - too many
- in practice use closed form expressions (and independence) for conditional probabilities

- AND, OR, noisy OR
- logistic smoothing

belief propagation

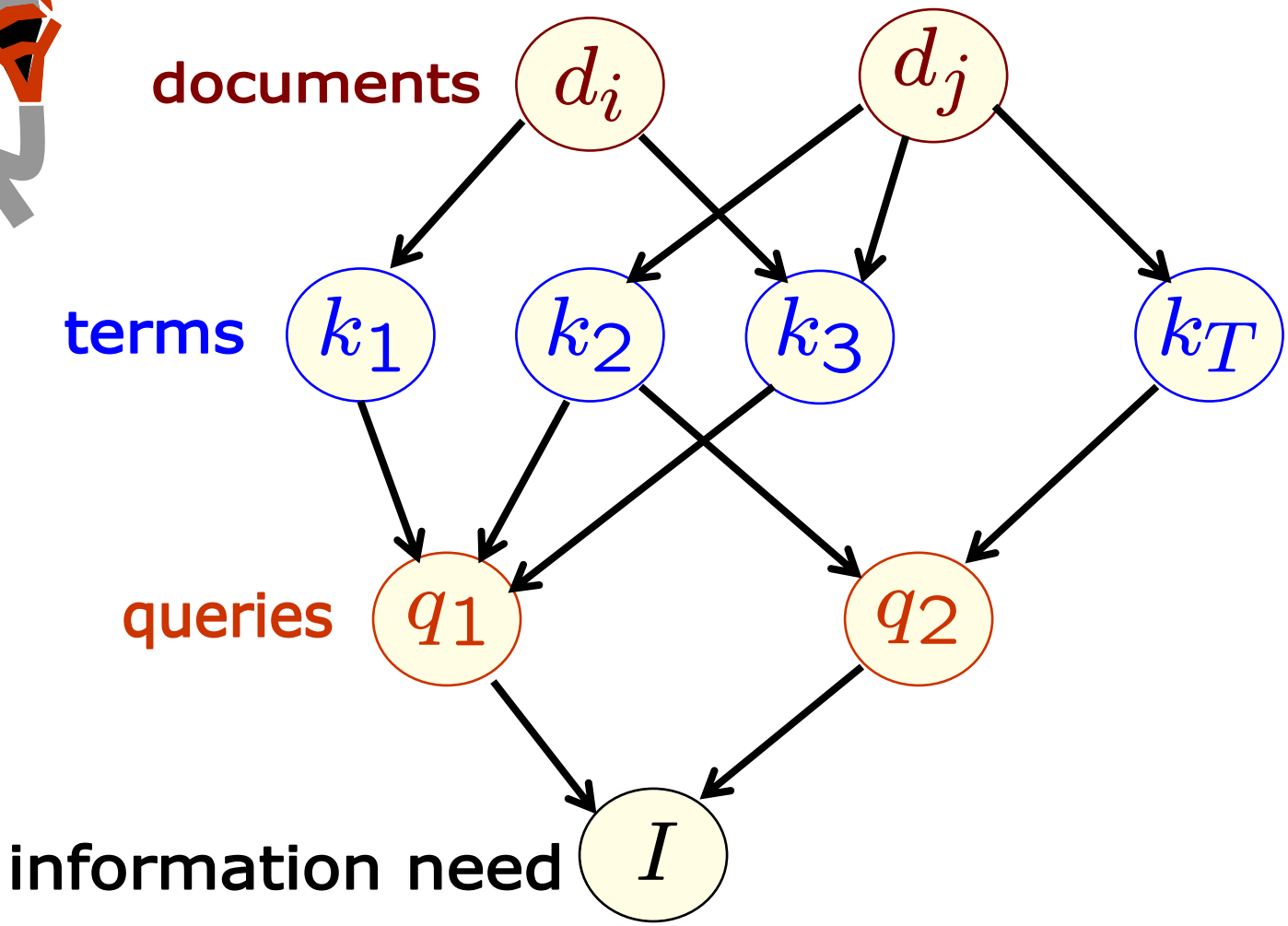
(in general case)

- marginalization

- P[U] too large
  - cluster trees
  - message passing
  - junction trees

- HUGIN propagatior

inference network



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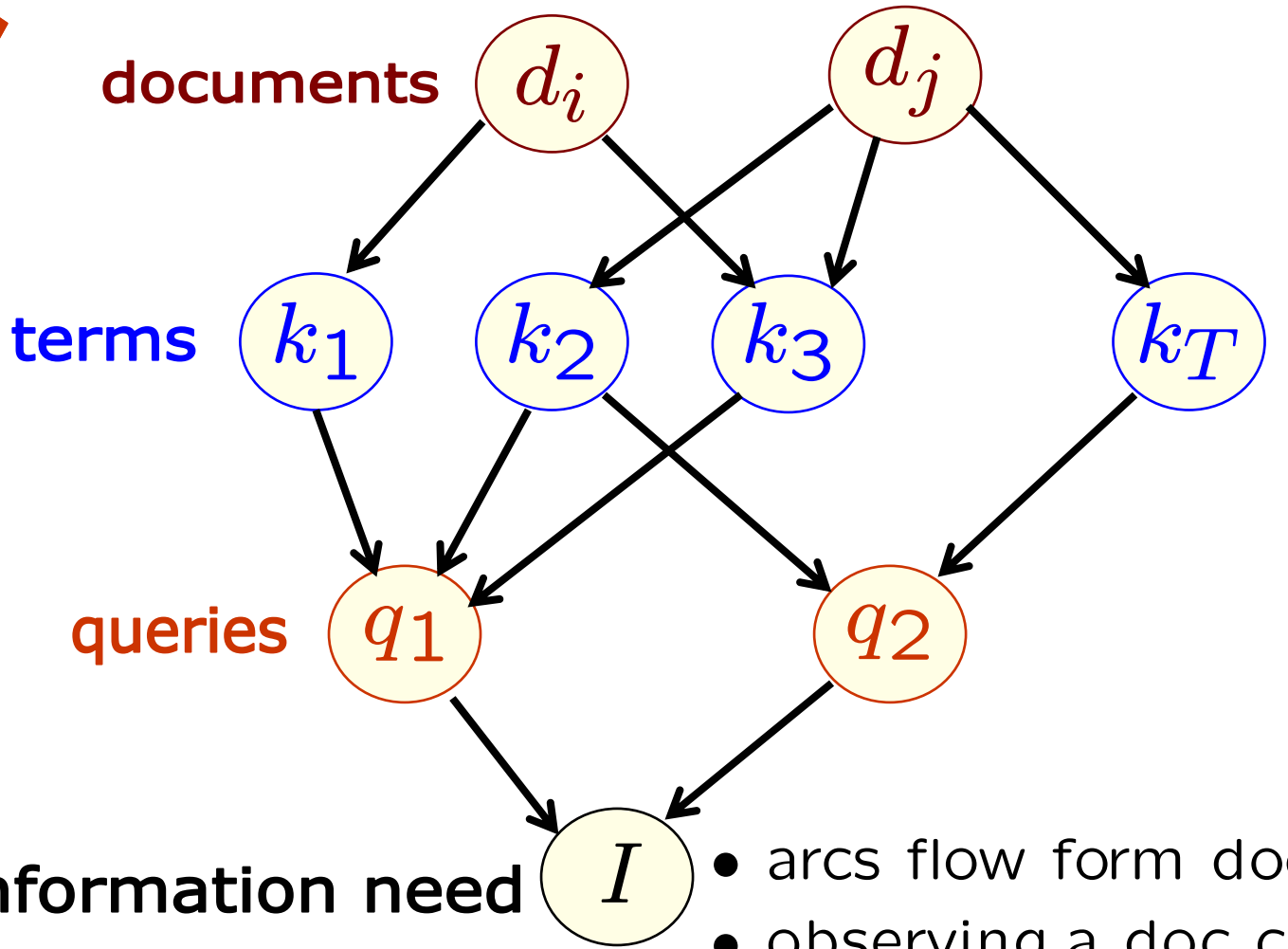
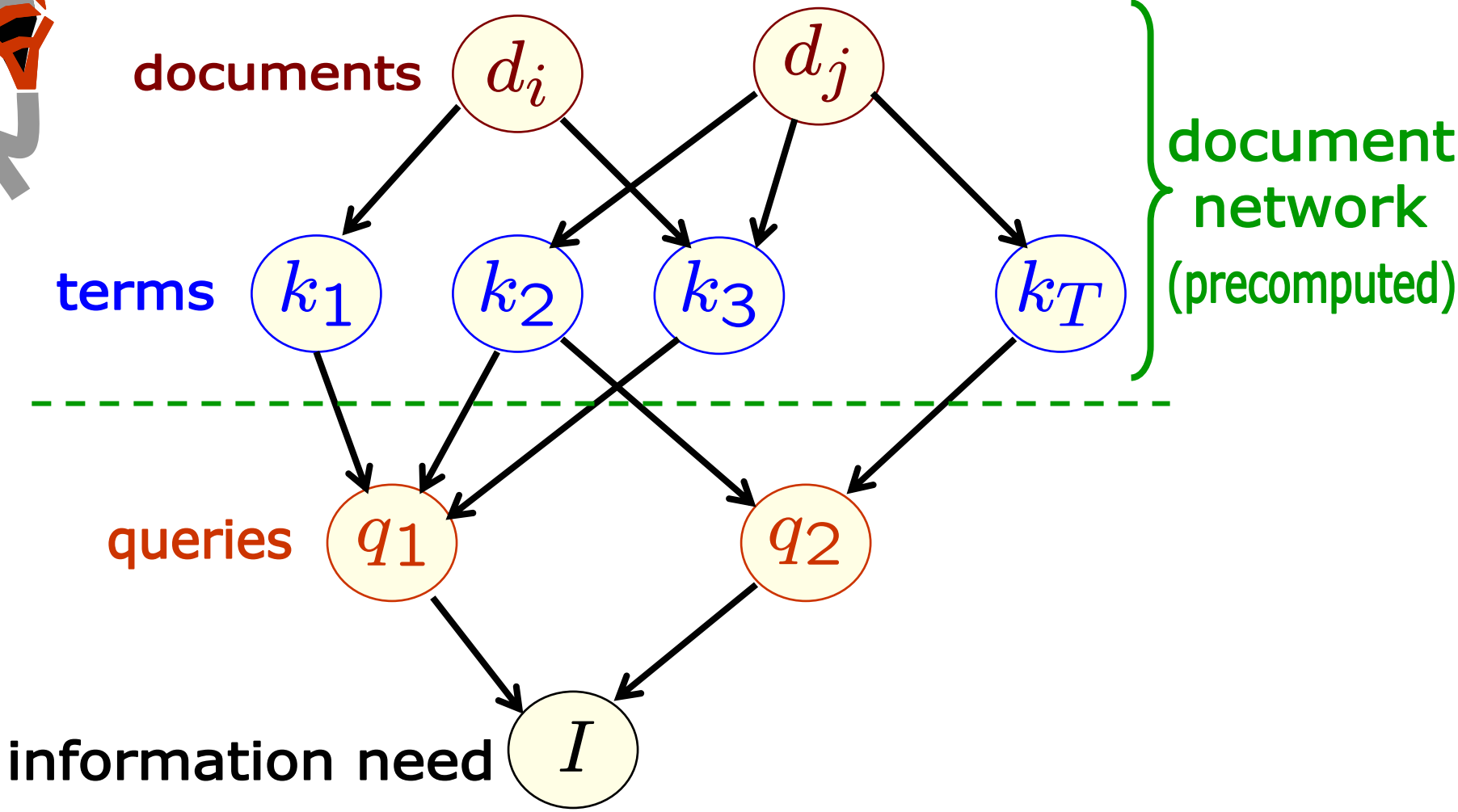


- arcs flow form docs to I
- observing a doc causes change in the belief that I is satisfied

inference network



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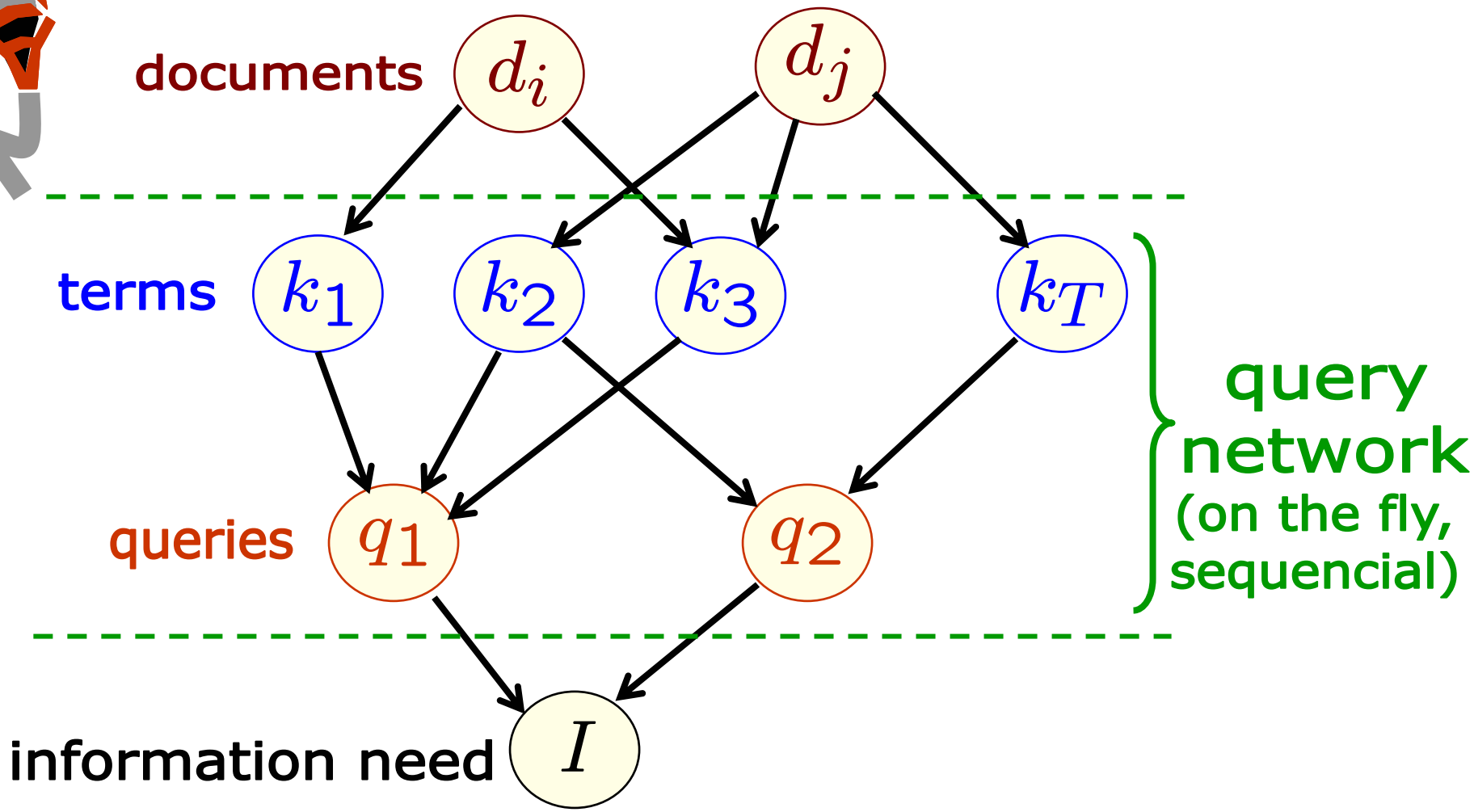
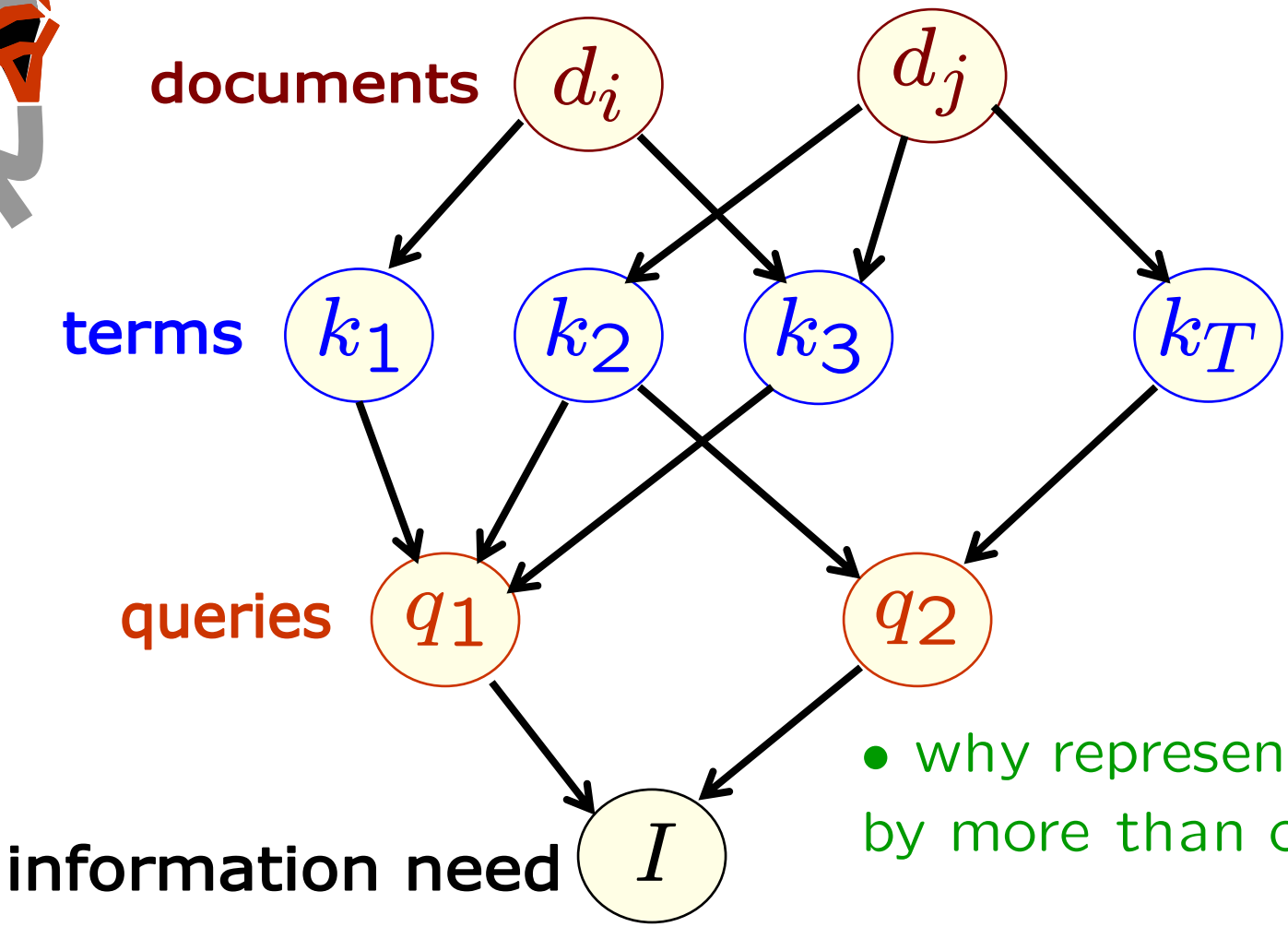
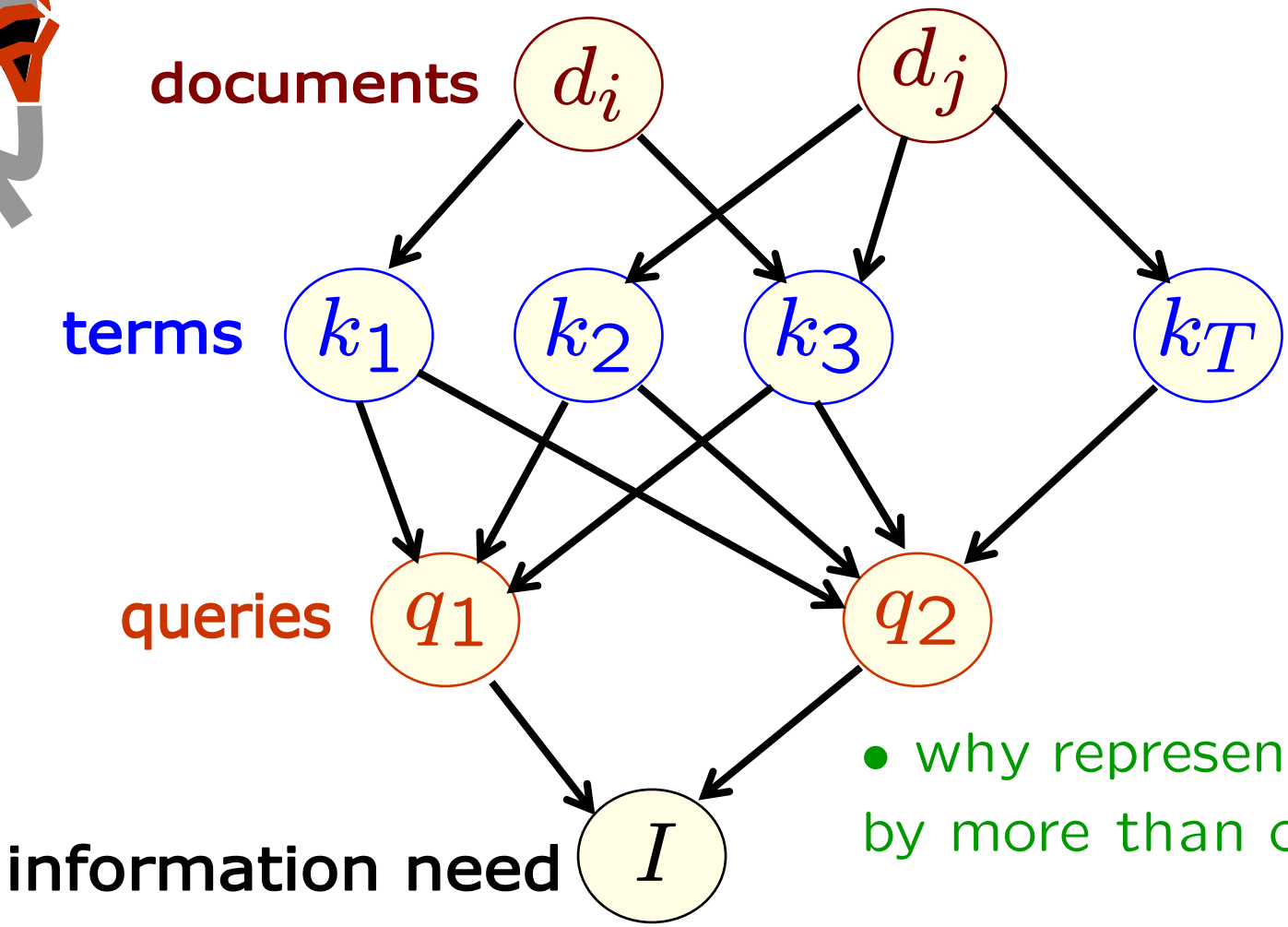


combine evidence



- why represent I by more than one query ?

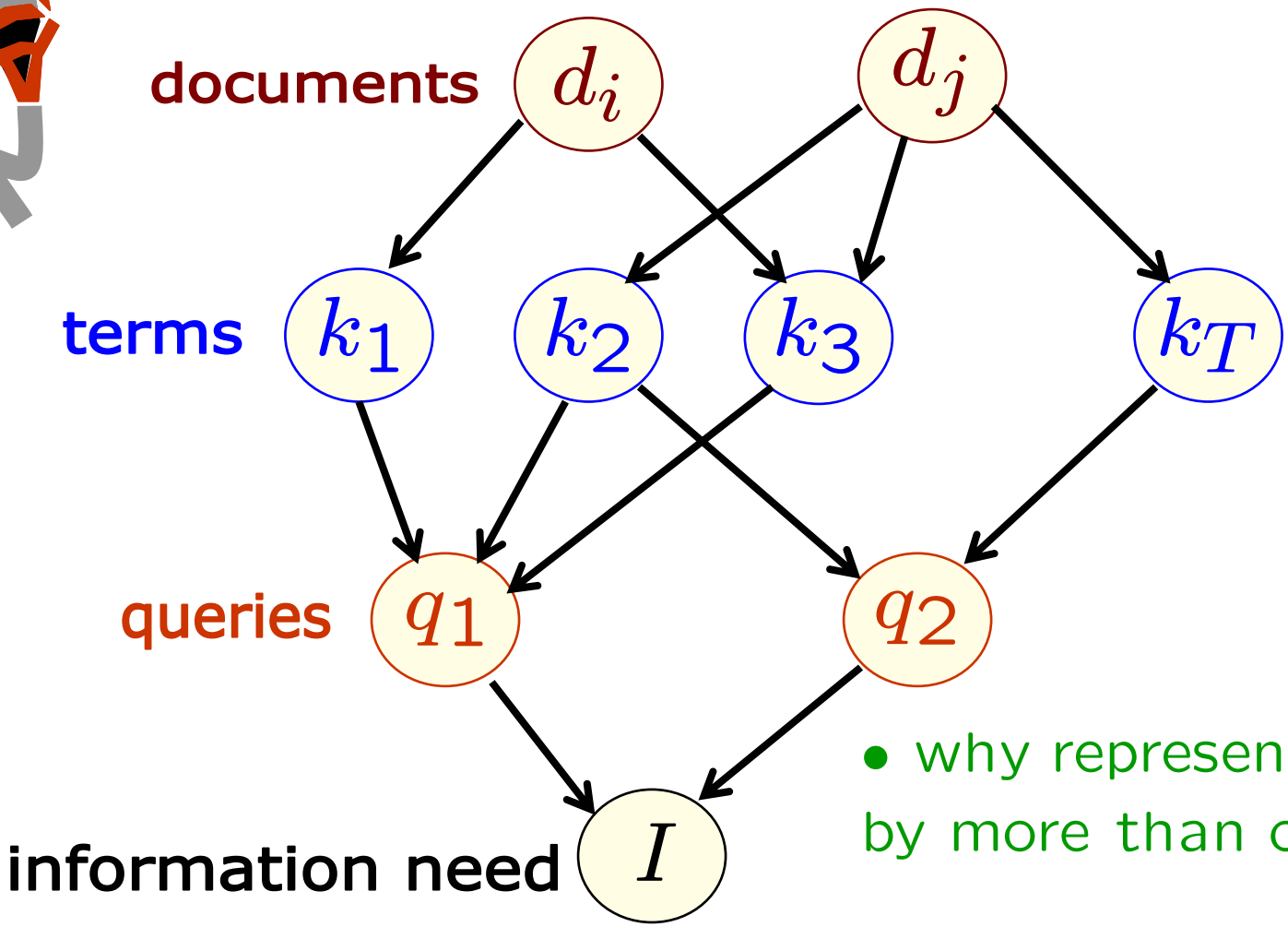
combine evidence



- why represent I by more than one query ?

- $q2$ is an expansion of $q1$

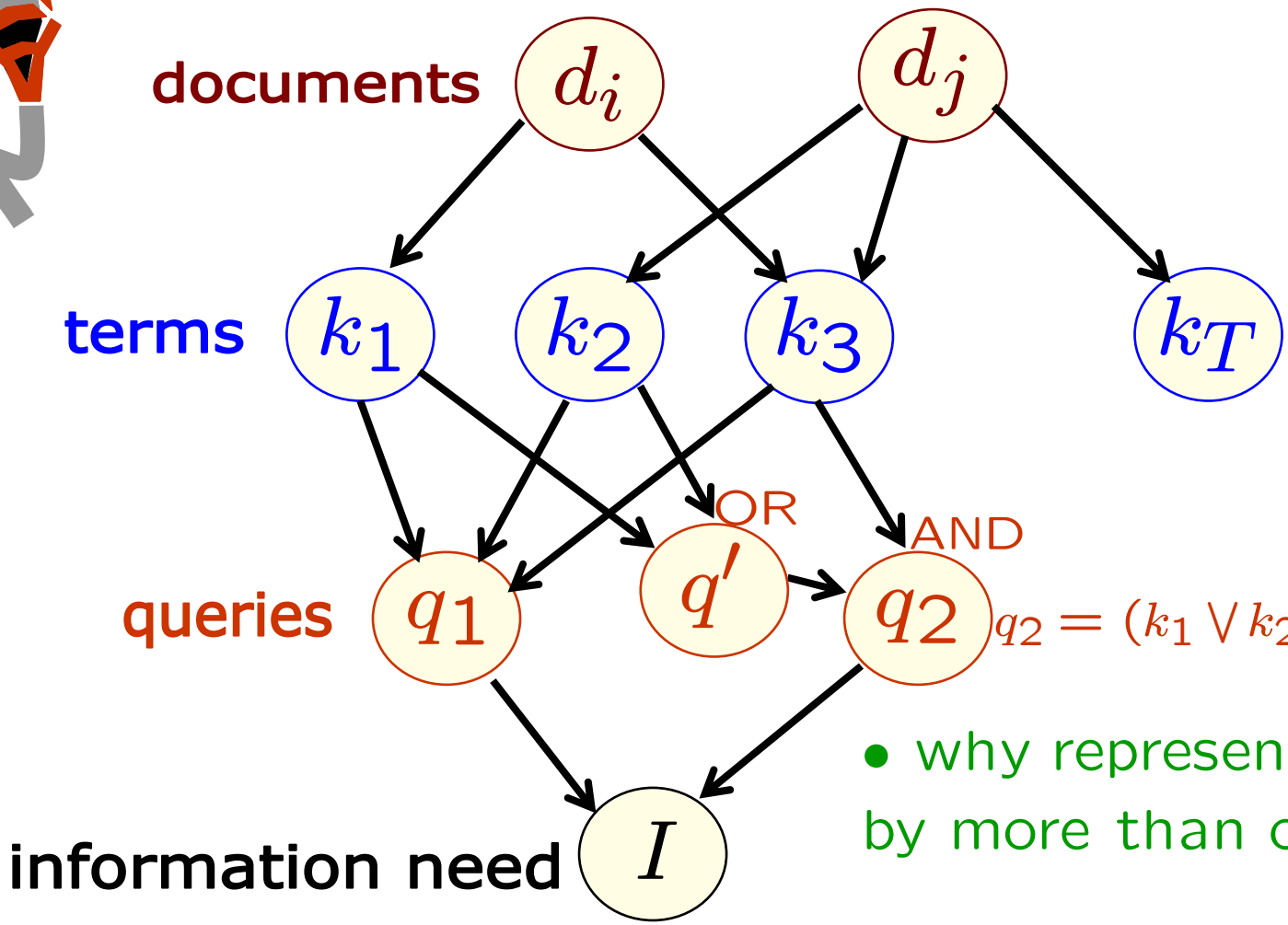
combine evidence



- why represent I by more than one query ?

- $q2$ is prior knowledge about user

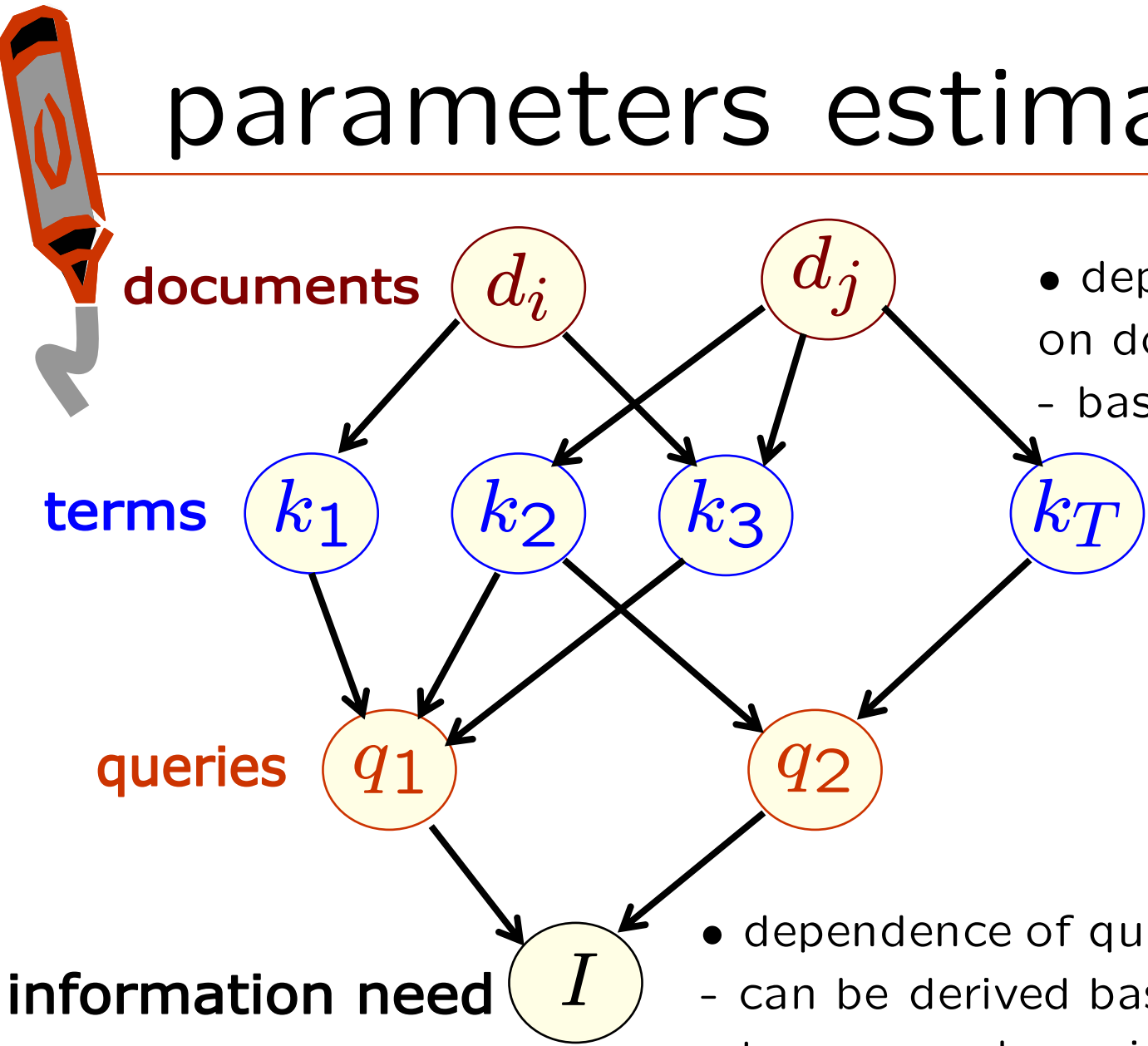
combine evidence



- why represent I by more than one query ?

- $q2$ is a boolean reformulation of $q1$

parameters estimation



- dependence of terms on docs $\mathbf{P}[k_t|d_i]$
  - based on TF-IDF

- dependence of query on terms $\mathbf{P}[q|k_t]$
  - can be derived based on query form
  - terms may be weighted

implementation

- simplify link matrices

- attach evidence only at roots

-evidence propagates in one pass

- restrict attention to small number of evidence assignments
  - real networks are sparse
  - tiny portion of network examined per query

boolean model

- uniform prior

- probabilities are 0|1

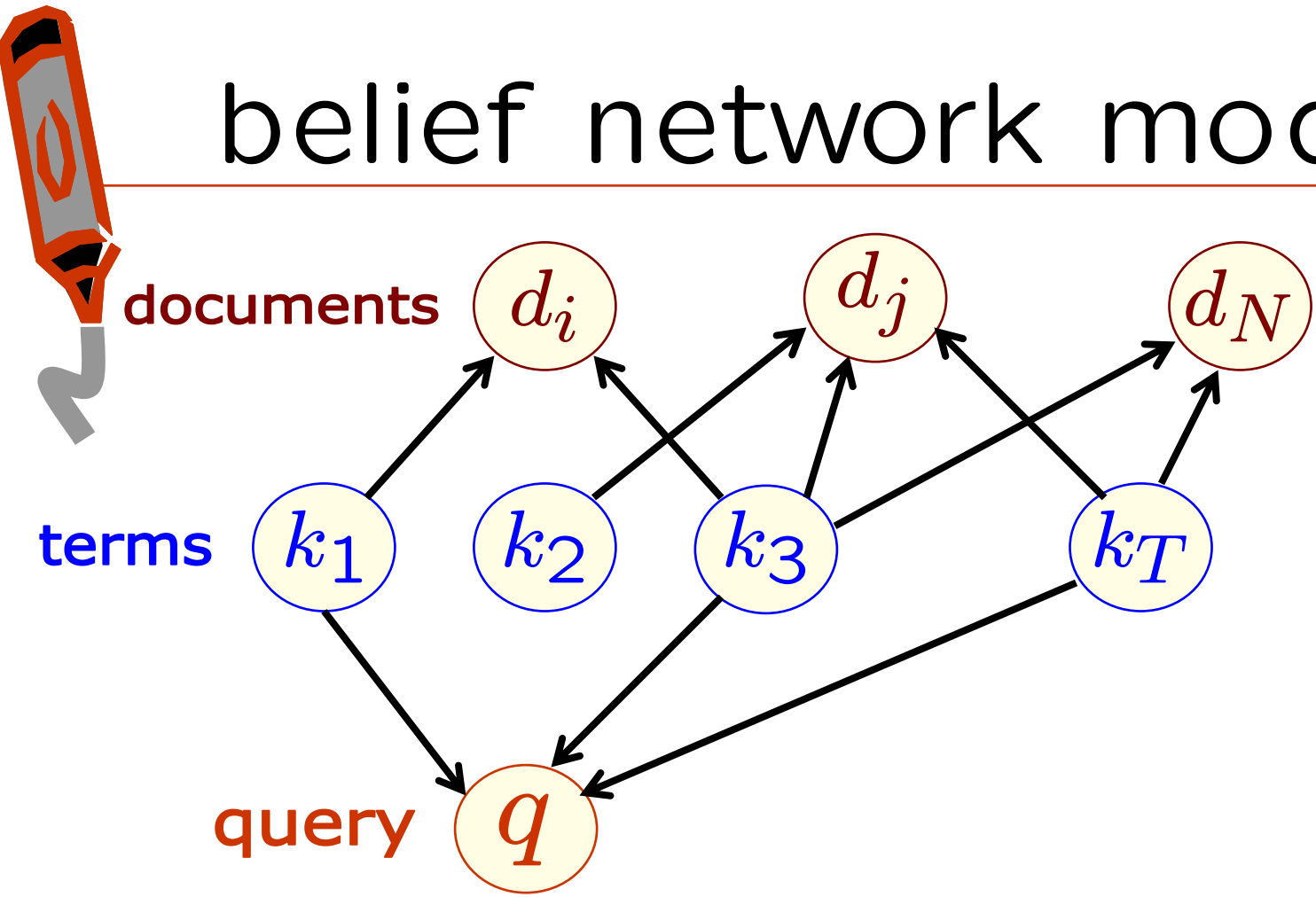
- terms *active* are only those contained by observed doc
- one of the conjunctive components of the query must match activated terms

TF-IDF -like model

- prior reflect the document length
- $\mathbf{P}[k_t|d_j]$ relates to TF
- $\mathbf{P}[q|k_t]$ relates to query IDF
- $\mathbf{P}[q \bigwedge d_j]$ is a large formula

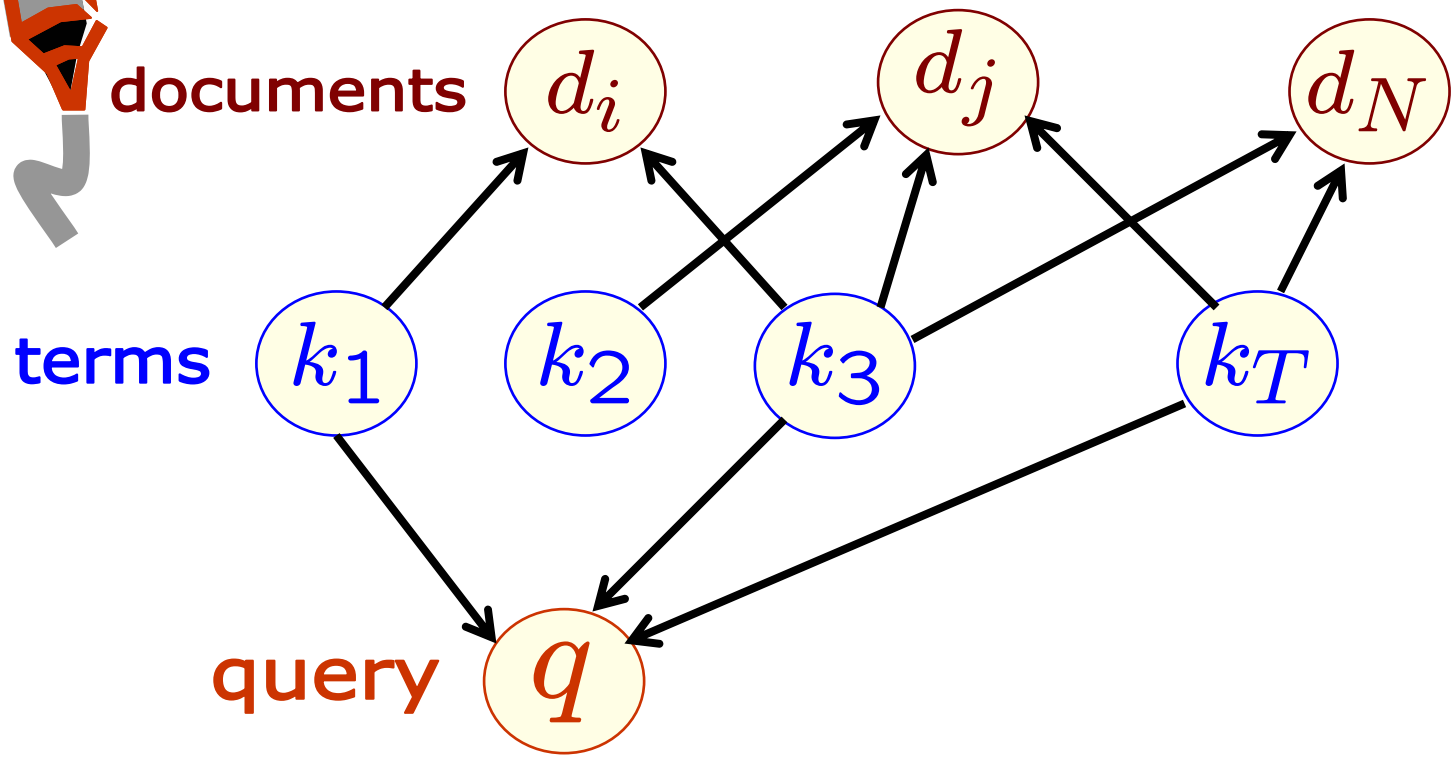
- contains a C_j which is not a constant across documents, therefore evaluation does not match perfecly TFIDF

belief network model



so...whats the difference ?

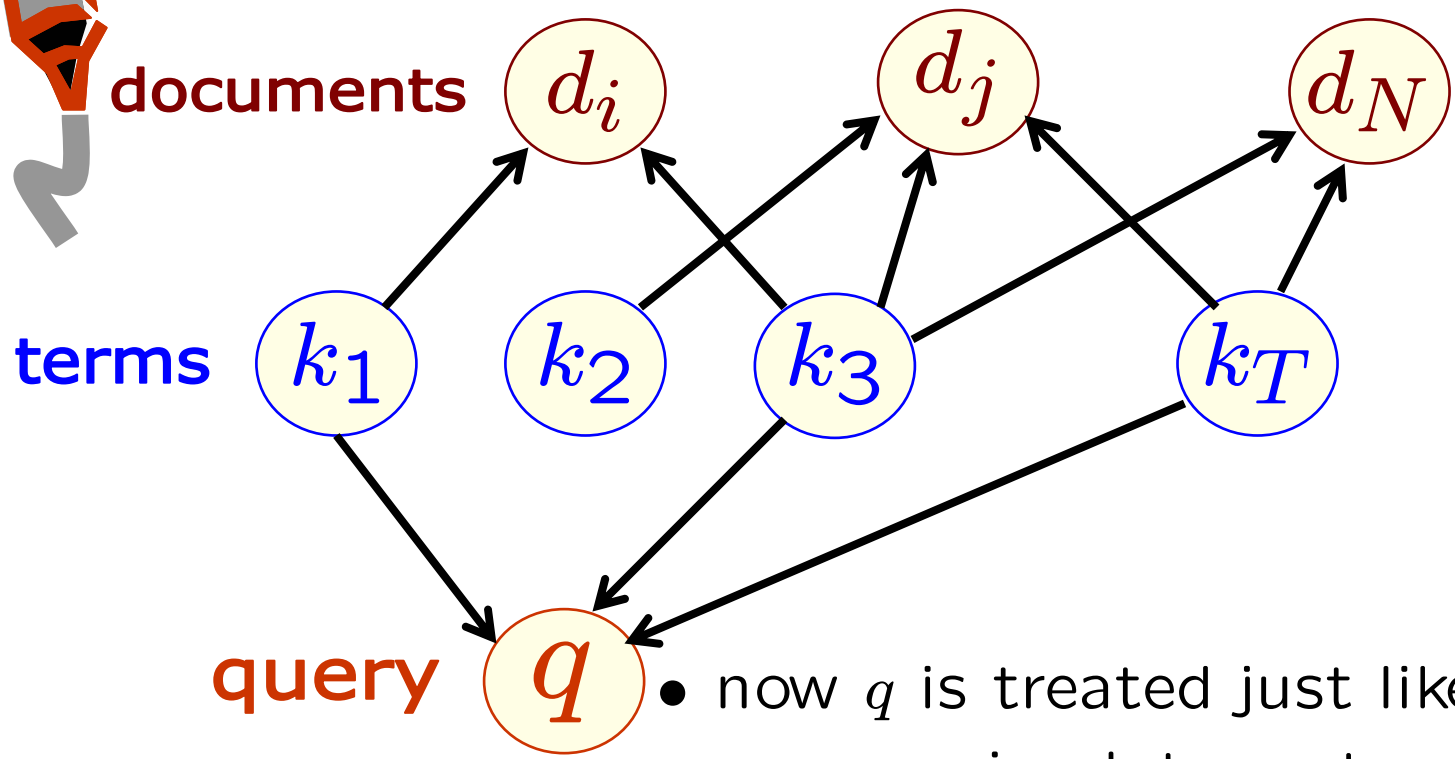
belief network model



so...whats the difference ?

the links between docs and terms are reversed!

vector space model



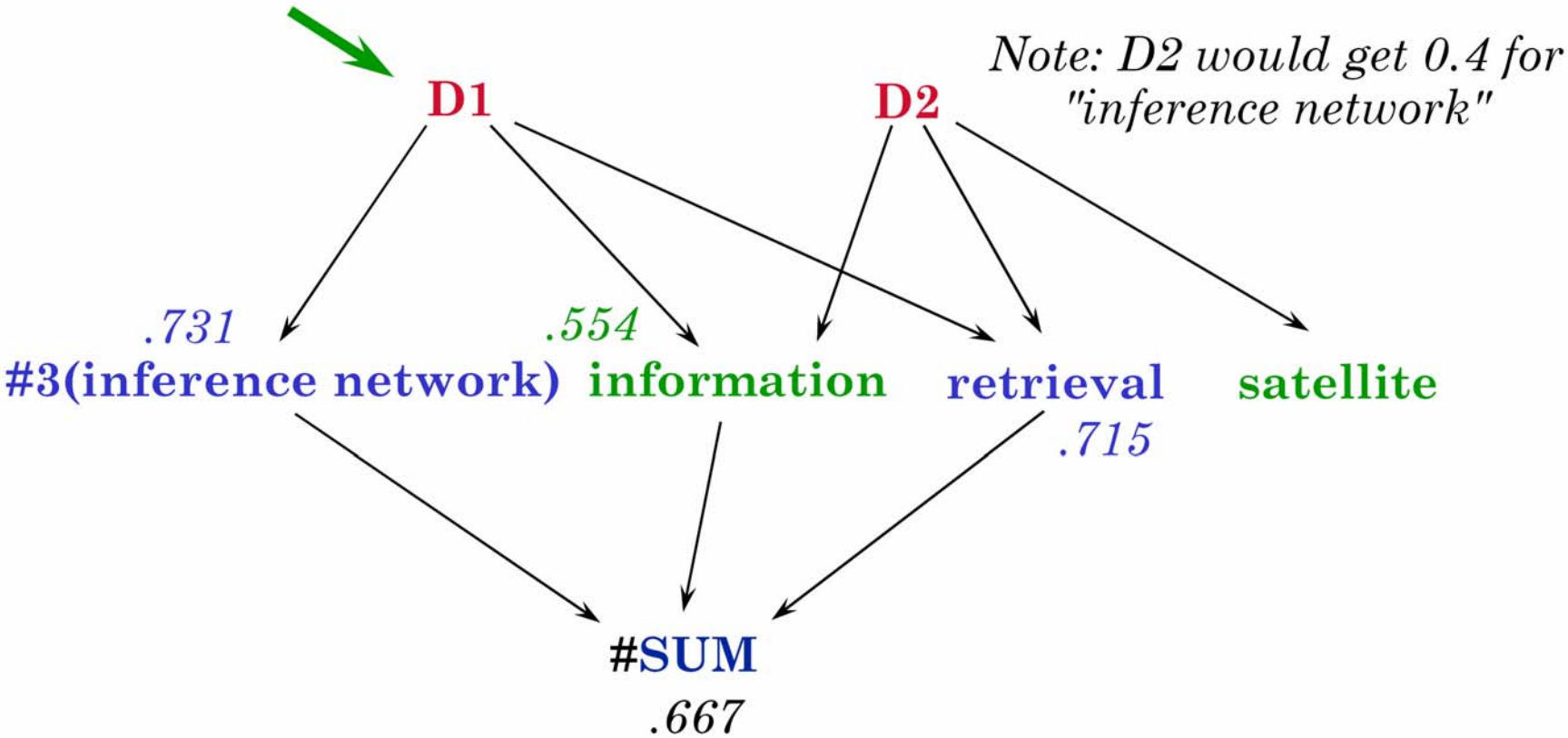
- now q is treated just like a document
- we can simulate vector space model

- $\mathbf{P}[d_j|q] = \sum_{\forall u} \mathbf{P}[d_j \wedge q|u] \cdot \mathbf{P}[u]$
- $\mathbf{P}[d_j|q] = \sum_{\forall \bar{k}} \mathbf{P}[d_j|\bar{k}] \cdot \mathbf{P}[q|\bar{k}] \cdot \mathbf{P}[\bar{k}]$

InQuery Engine

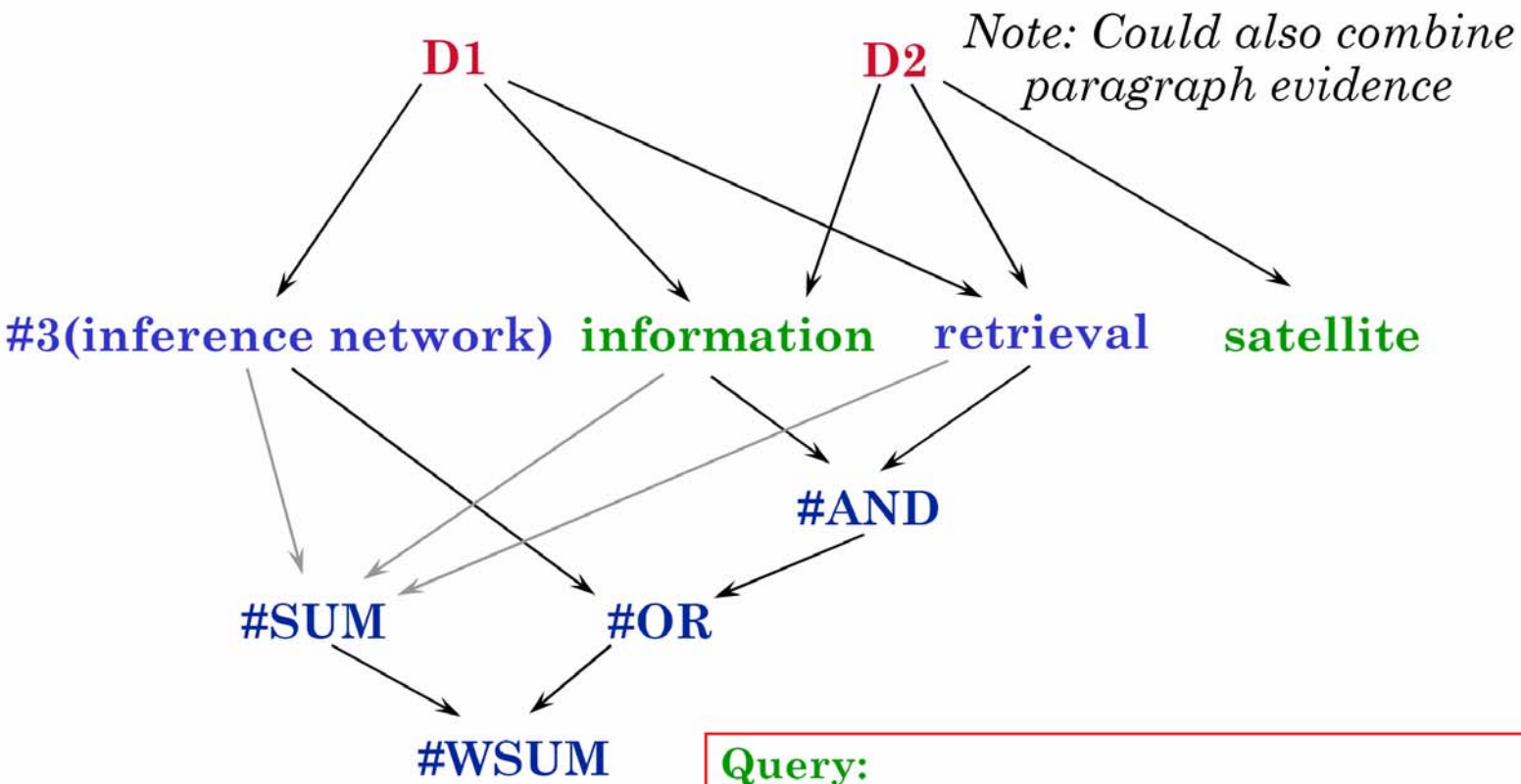
- developed by Turtle & Croft (1991)
  - used at UMASS Amherst
  - now moving to language modeling approaches
- inference network model
- rich set of operators
  - **belief**: sum,wsum,and,not,or,band,bandnot,max
  - **proximity**: phrase,odn,uwn,passagen,syn

InQuery Example



Query: #SUM(#PHRASE(inference network) information retrieval)

InQuery Example



Query:

```
#WSUM(1.0 #OR( #AND( information retrieval)
                #3(inference network)
          2.0 #SUM( #PHRASE(inference network)
                information retrieval)
```