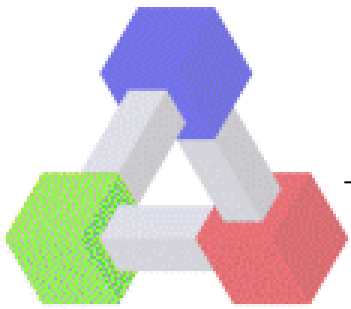


# Soft computing

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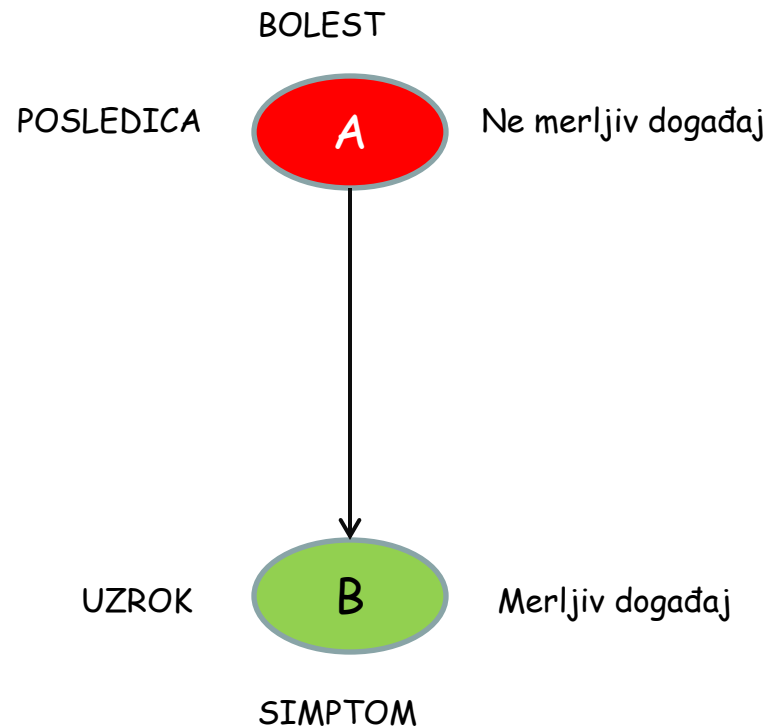
Bayes mreže

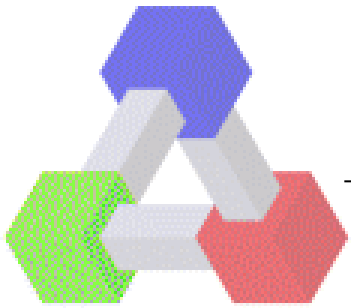


# Bayesovo pravilo

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Grafički primer dve slučajne promenljive A i B

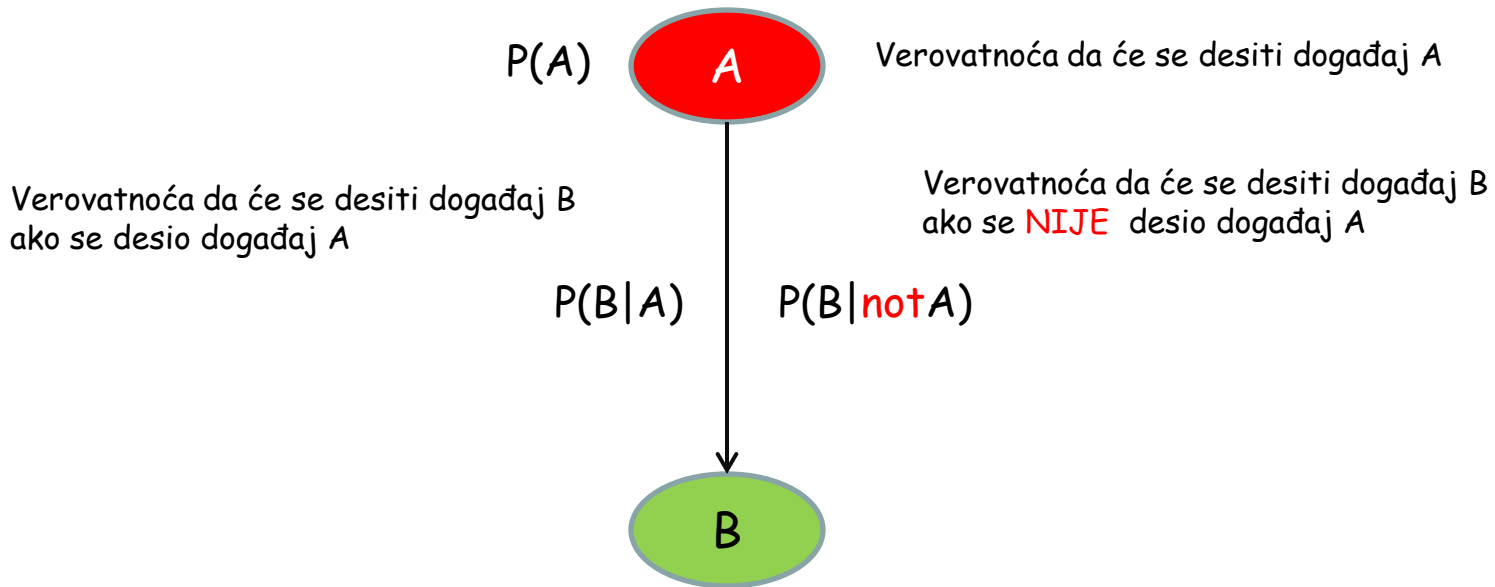




# Bayesovo pravilo

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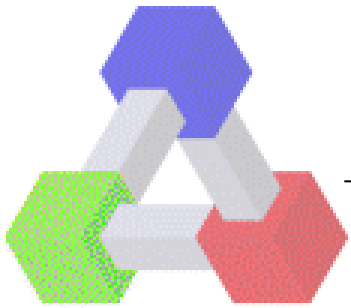
Primer dve slučajne promenljive A i B



Dijagnostičko rezonovanje:

$P(A|B)$

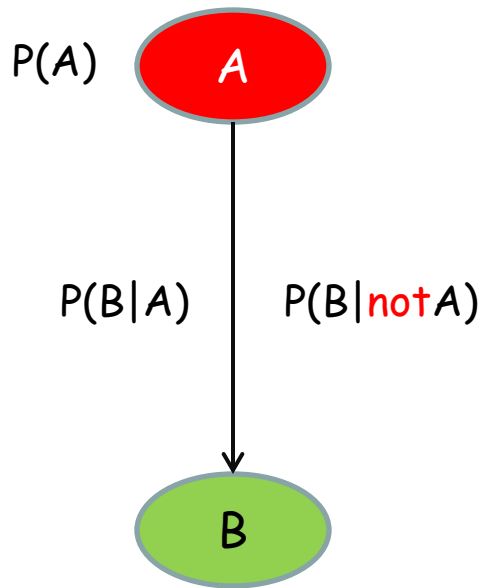
$P(A|\text{not}B)$



# Bayesovo pravilo

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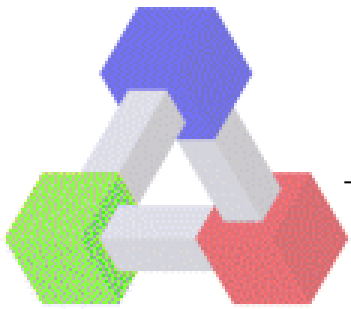
Dijagnostičko rezonovanje:



$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

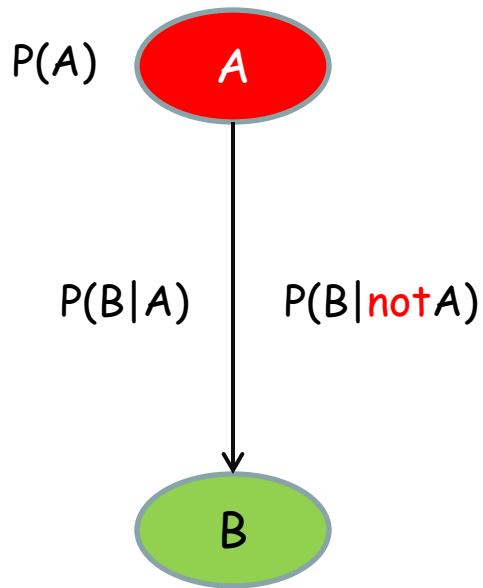
$$P(\bar{A}|B) = \frac{P(B|\bar{A})P(\bar{A})}{P(B)}$$

$$P(A|B) + P(\bar{A}|B) = 1$$



# Bayesovo pravilo

## Dijagnostičko rezonovanje:

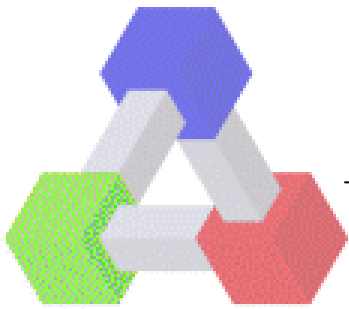


$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

$$P(\bar{A}|B) = \frac{P(B|\bar{A})P(\bar{A})}{P(B)}$$

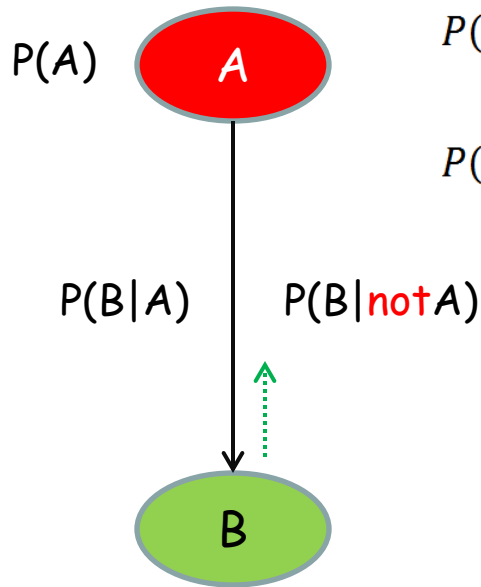
$$P(A|B) + P(\bar{A}|B) = 1$$

$$P(B) = P(B|A)P(A) + P(B|\bar{A})P(\bar{A})$$



# Bayesovo pravilo

## Dijagnostičko rezonovanje:



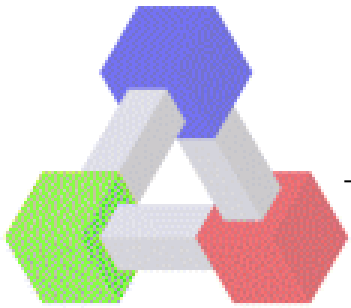
$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \quad P'(A|B) = P(B|A)P(A)$$

$$P(\bar{A}|B) = \frac{P(B|\bar{A})P(\bar{A})}{P(B)} \quad P'(\bar{A}|B) = P(B|\bar{A})P(\bar{A})$$

$$P(B) = P(B|A)P(A) + P(B|\bar{A})P(\bar{A})$$

$$P(B) = P'(A|B) + P'(\bar{A}|B)$$

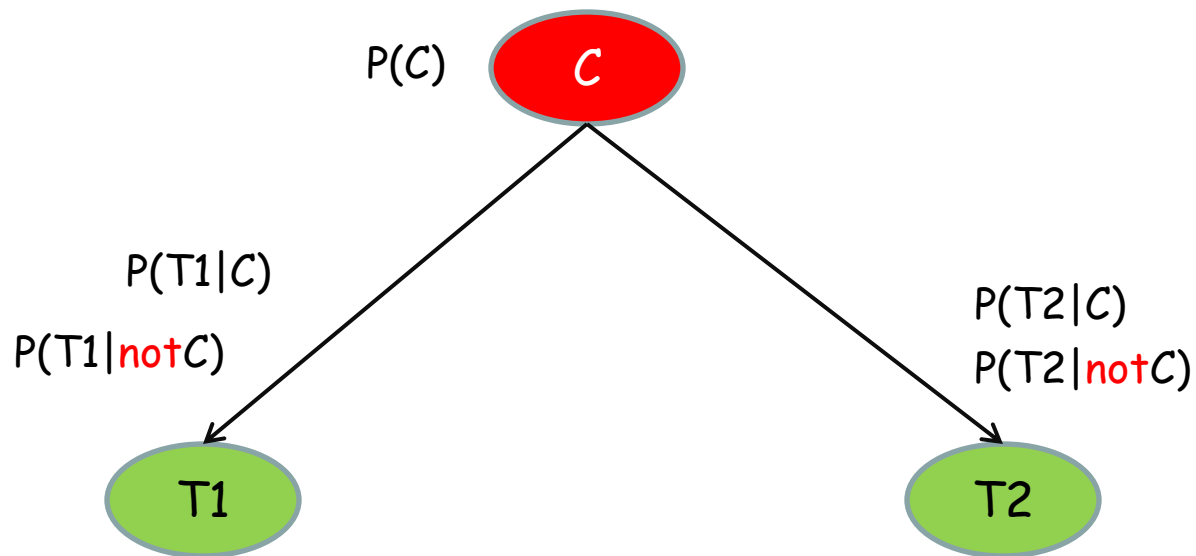
$$P(A|B) = \frac{P'(A|B)}{P(B)} \quad P(\bar{A}|B) = \frac{P'(\bar{A}|B)}{P(B)}$$

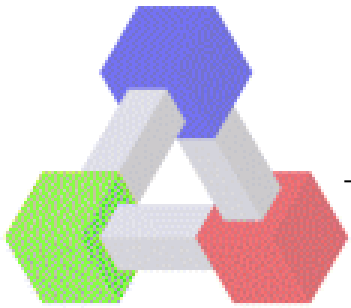


# Bayesove mreže

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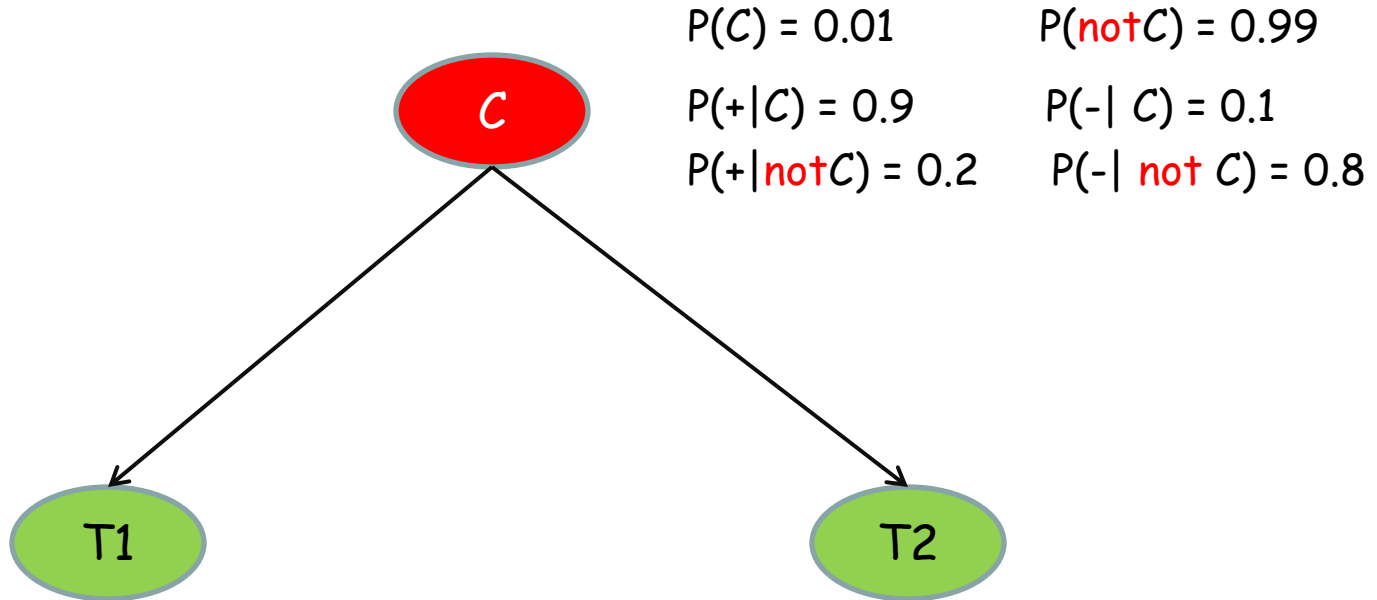
Primer bolesti  $C$  i dva testa  $T1$  i  $T2$





# Bayesove mreže

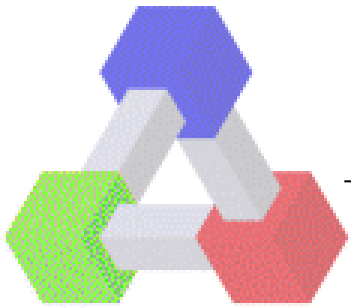
Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



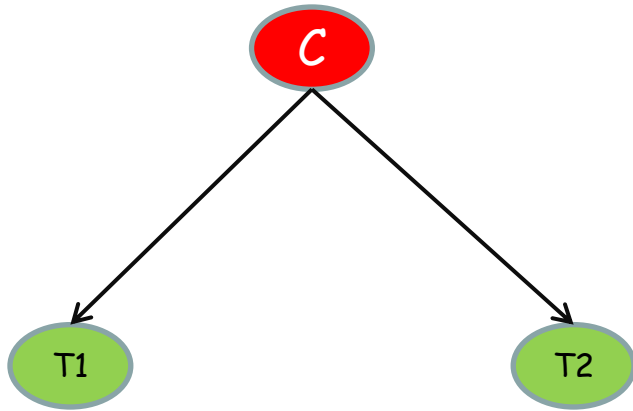
$$P(C|T1=+,T2=+) = P(C|++)=?$$



# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

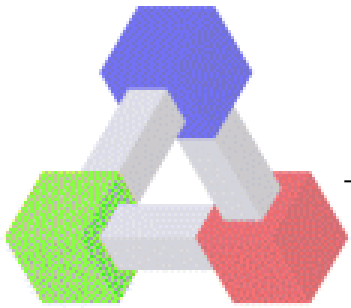
$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

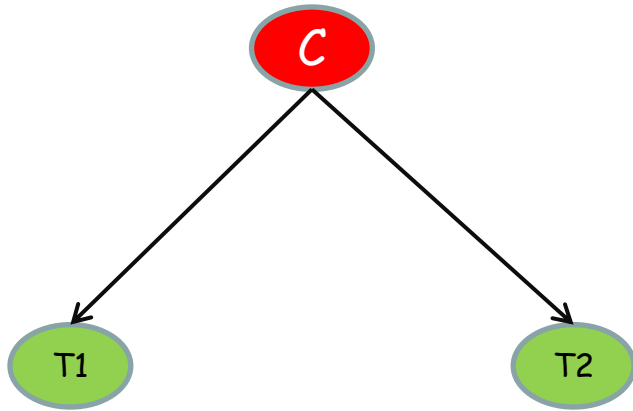
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2)$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

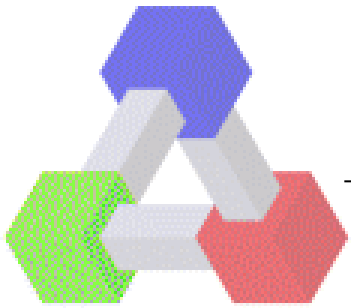
$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

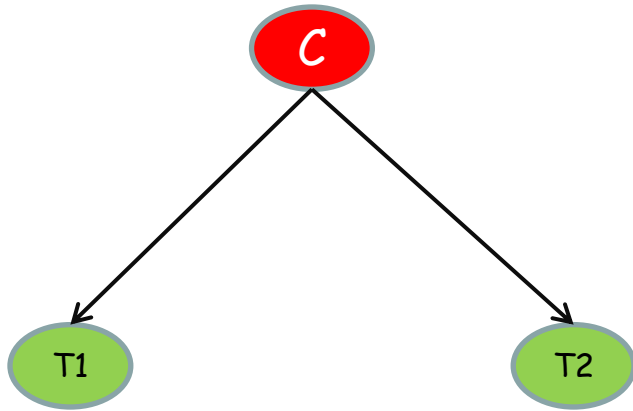
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) =$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

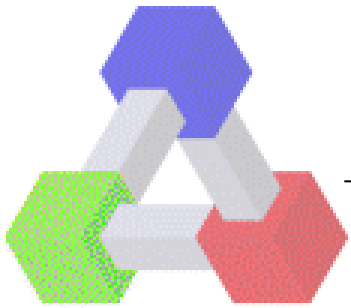
$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

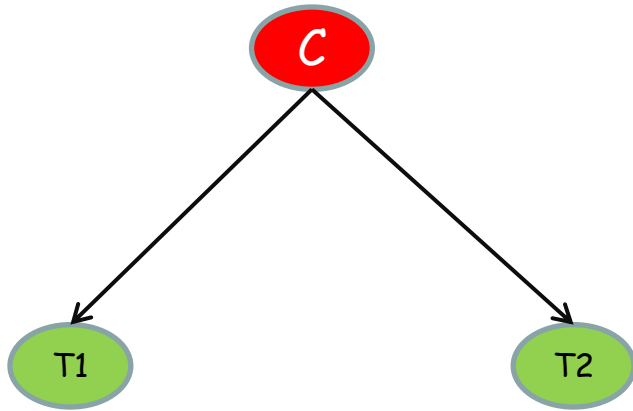
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = P(C)$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

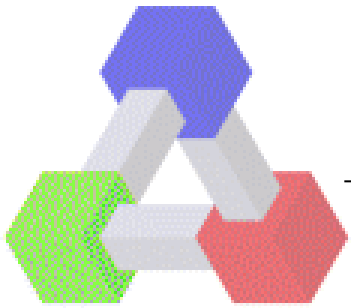
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

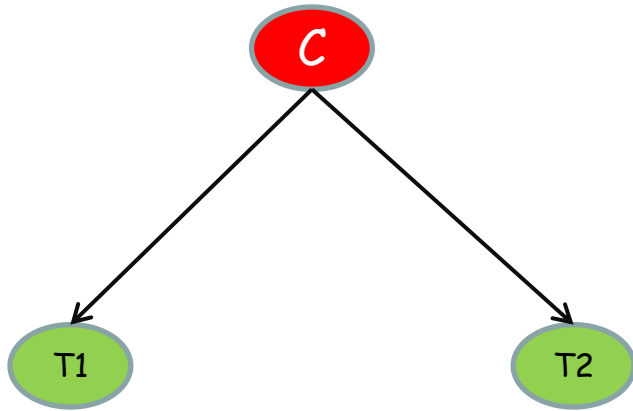
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(C)P(T_1|C)P(T_2|C) + P(\text{not}C)P(T_1|\text{not}C)P(T_2|\text{not}C)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(+|C) = 0.9$$

$$P(+|\text{not}C) = 0.2$$

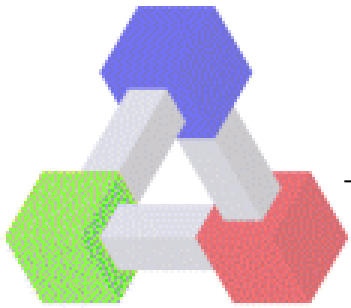
$$P(\text{not}C) = 0.99$$

$$P(-|C) = 0.1$$

$$P(-|\text{not}C) = 0.8$$

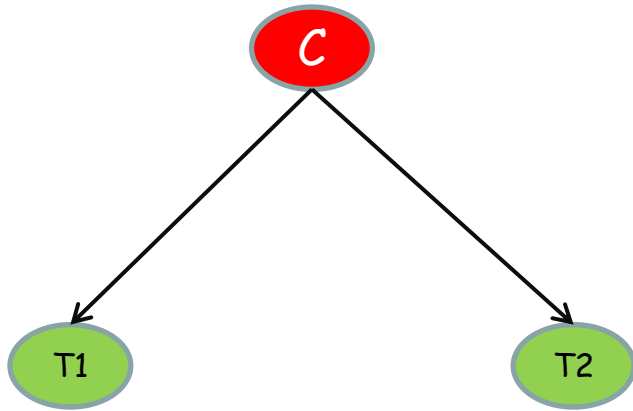
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(C)P(T_1|C)P(T_2|C) + P(\text{not}C)P(T_1|\text{not}C)P(T_2|\text{not}C)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

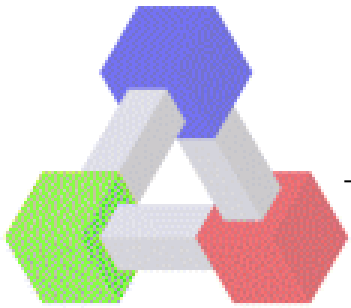
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

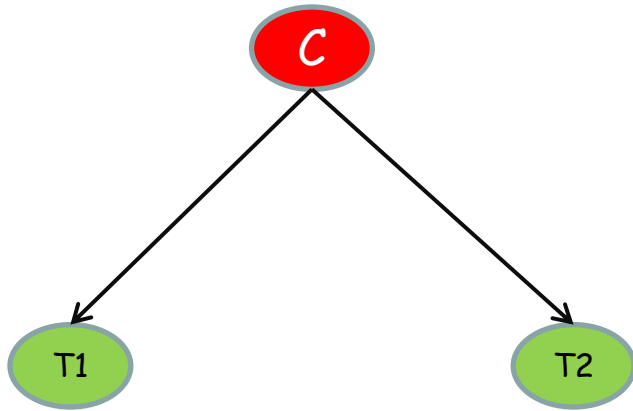
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

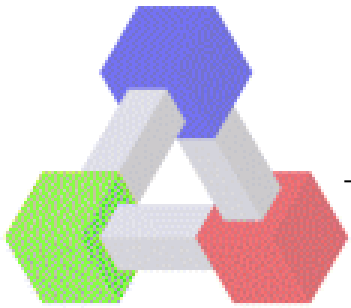
$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

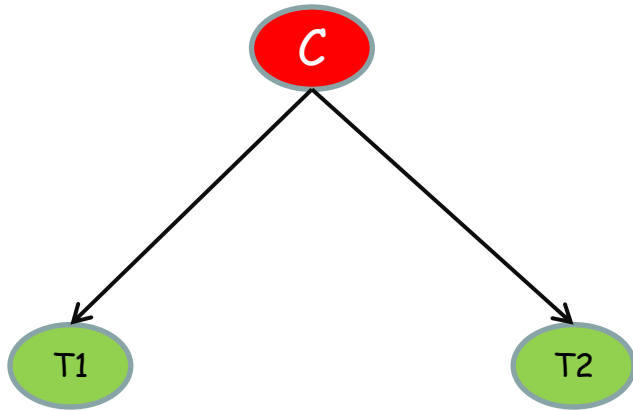
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} =$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

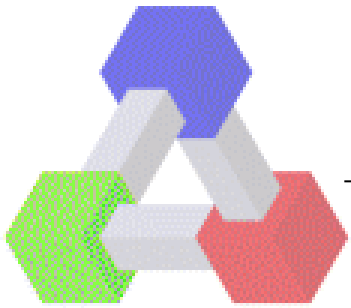
$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

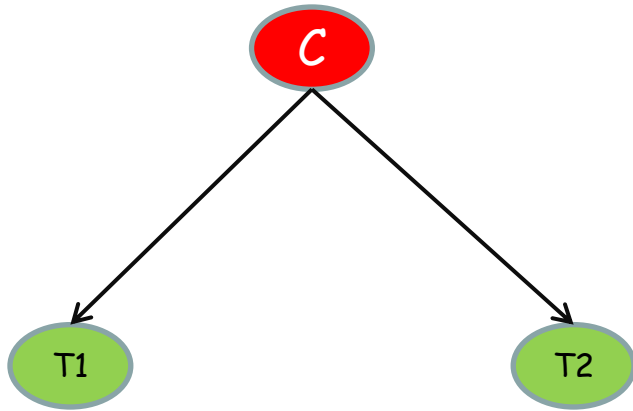
$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(T_1, T_2)}$$





# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

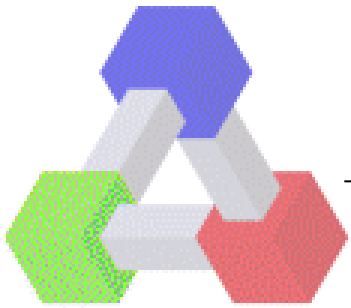
$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

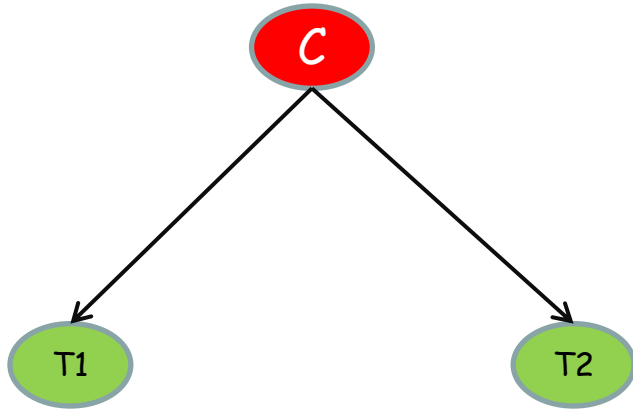
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(+|C) = 0.9$$

$$P(+|\text{not}C) = 0.2$$

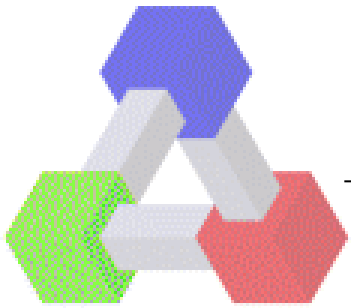
$$P(\text{not}C) = 0.99$$

$$P(-|C) = 0.1$$

$$P(-|\text{not}C) = 0.8$$

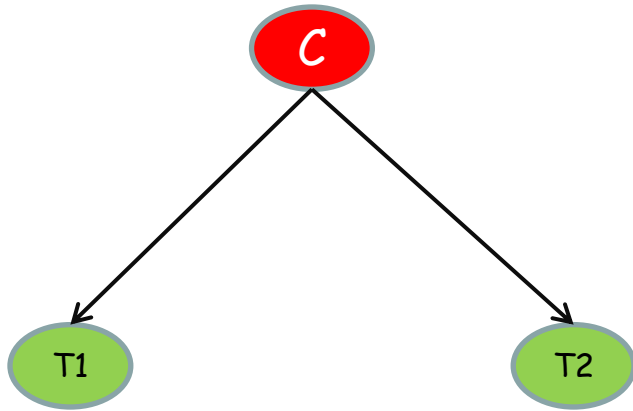
$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++)=$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

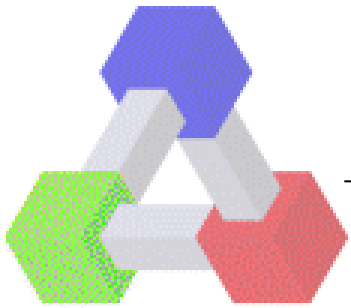
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

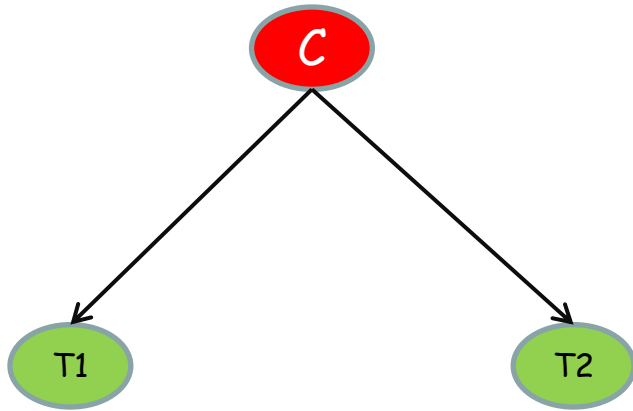
$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++ ) = \underline{\hspace{2cm}}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

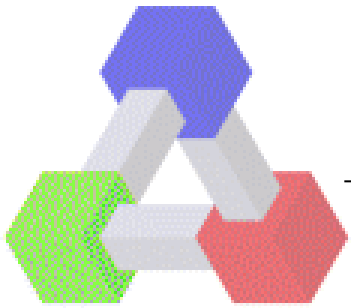
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

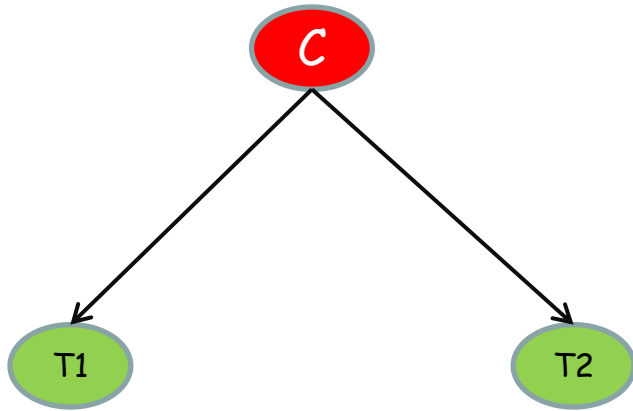
$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++ ) = \frac{P(++|C)P(C)}{P(++|C)P(C) + P(++|\text{not}C)P(\text{not}C)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

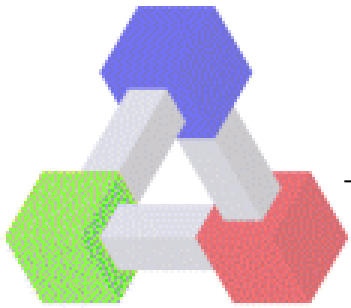
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

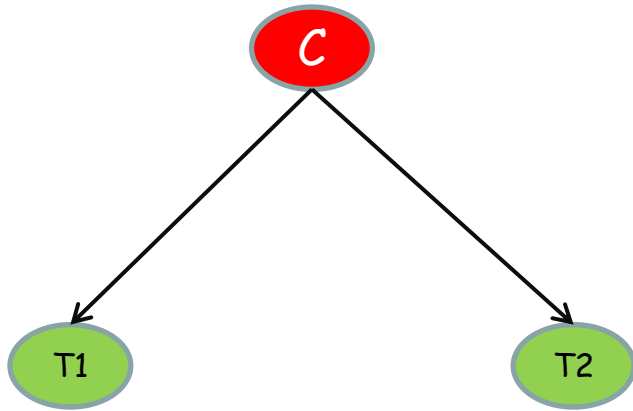
$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++ ) = \frac{P(++|C)P(C)}{P(++ )}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

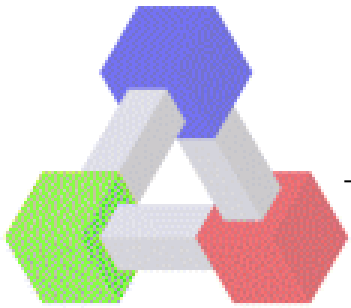
$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

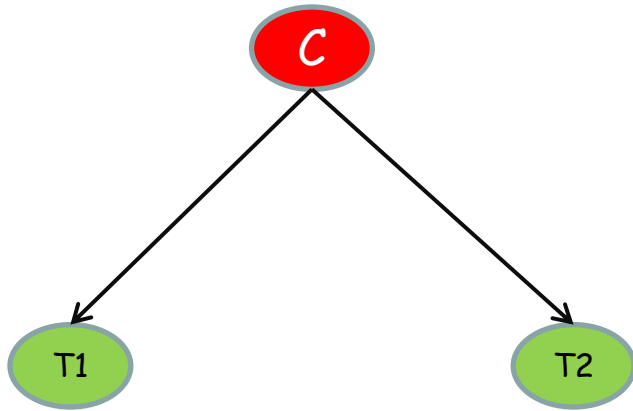
$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++) = \frac{P(++|C)P(C)}{P(++)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

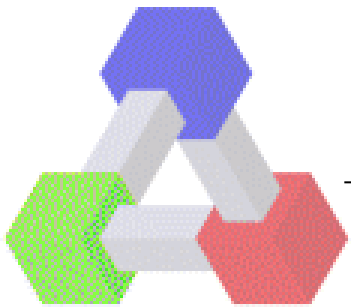
$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

$$P(C|T1=+, T2=+) = P(C|++)=?$$

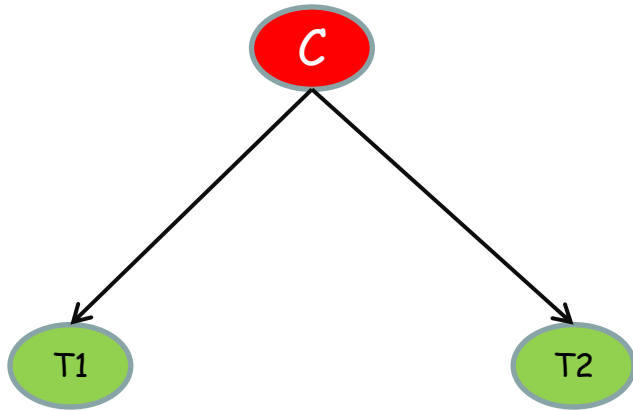
$$P(C|++) = \frac{P(++|C)P(C)}{P(++)}$$

$$P(\neg C|++) =$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

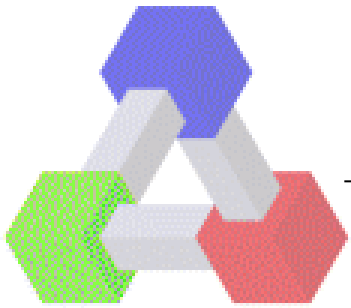
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++) = \frac{P(++|C)P(C)}{P(++)}$$

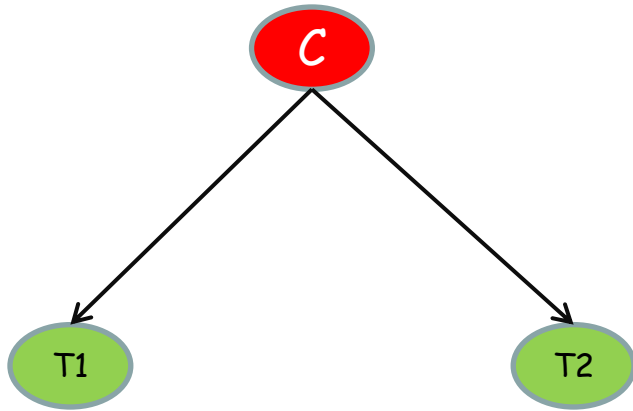
$$P(\neg C|++) = \frac{P(++|\neg C)P(\neg C)}{P(++)}$$





# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

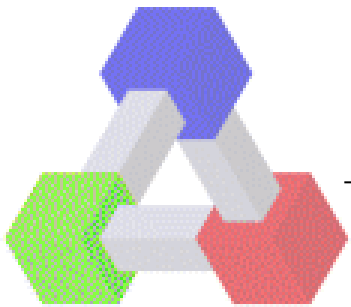
$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++)=?$$

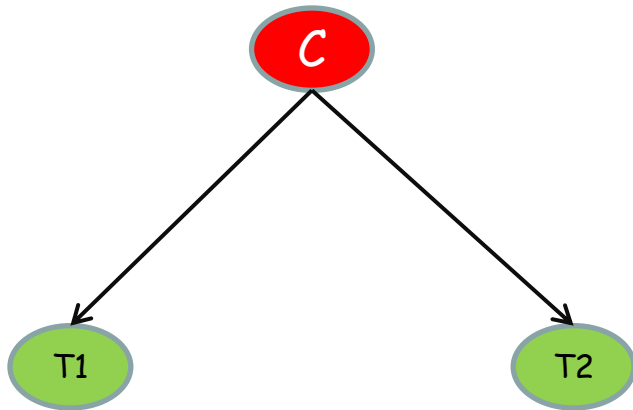
$$P(C|++) = \frac{P(++|C)P(C)}{P(++)}$$

$$P(\neg C|++) = \frac{P(++|\neg C)P(\neg C)}{P(++)}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

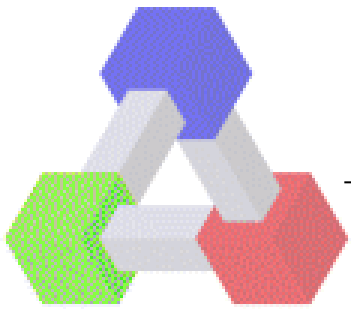
$$P(-|\text{not } C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++)=?$$

$$P(C|++) = \frac{P(++|C)P(C)}{P(++)}$$

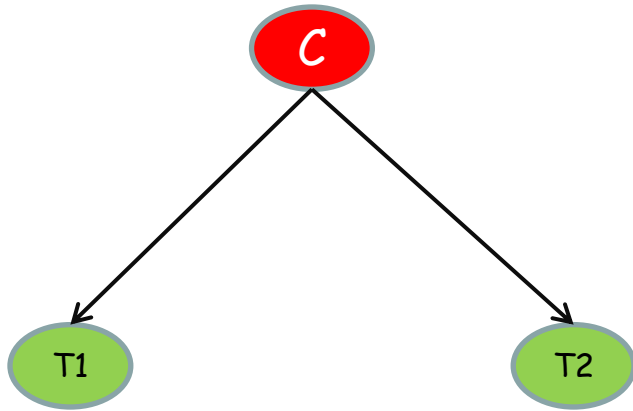
$$P(\neg C|++) = \frac{P(++|\neg C)P(\neg C)}{P(++)}$$

$$P(C|++) + P(\neg C|++) = 1$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

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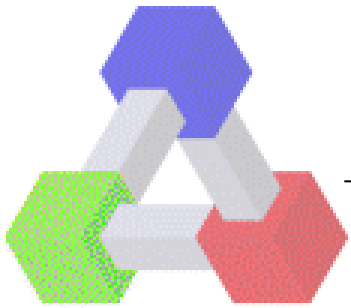
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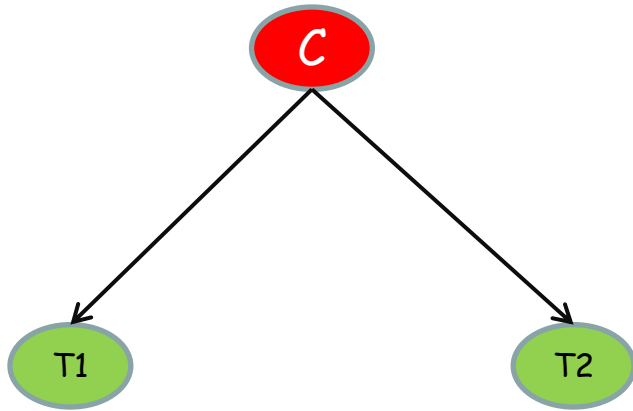
$$P(C|++) + P(\neg C|++) = 1$$

$$P(T_1, T_2) = P(++ ) = P(T_1, T_2|C)P(C) + P(T_1, T_2|\neg C)P(\neg C)$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

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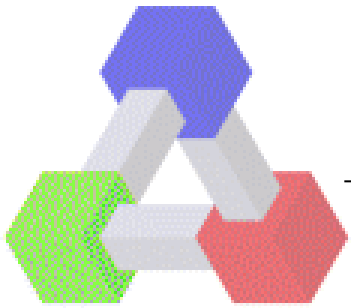
$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

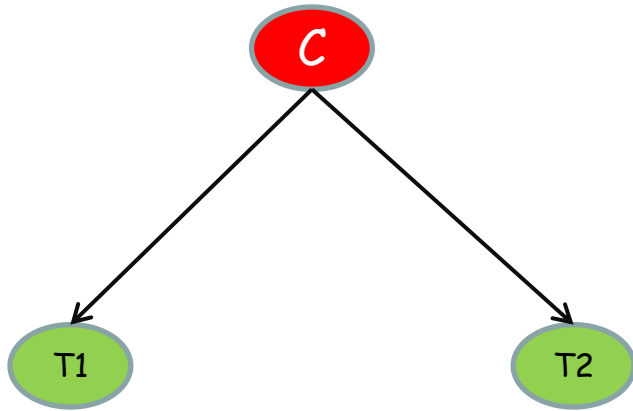
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# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



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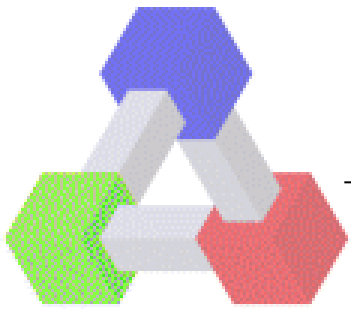
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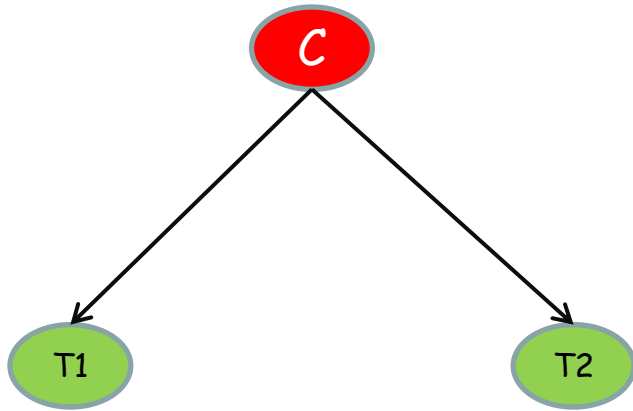
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# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



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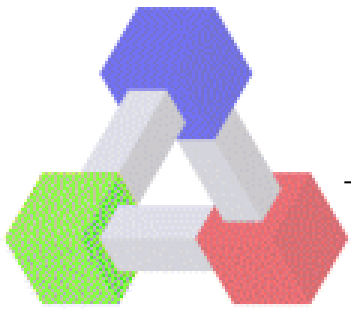
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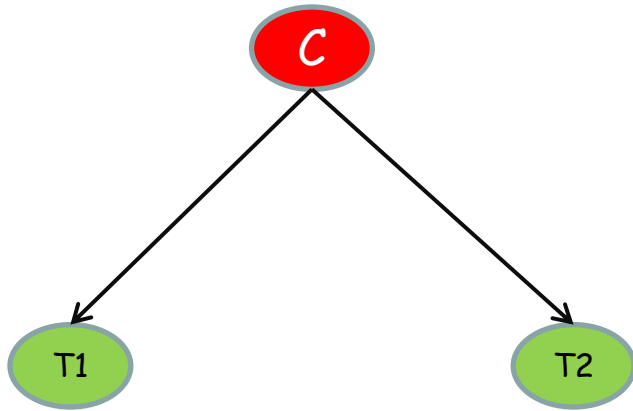
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# Bayesove mreže

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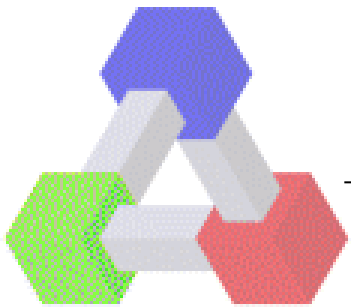
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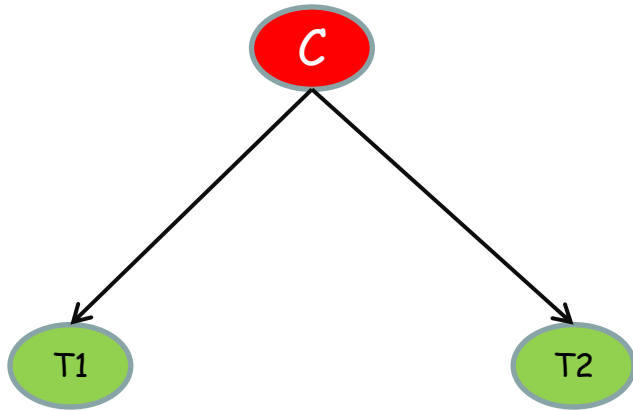
$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

$$P(T_1, T_2) = P(+ +) = P(T_1, T_2|C)$$



# Bayesove mreže

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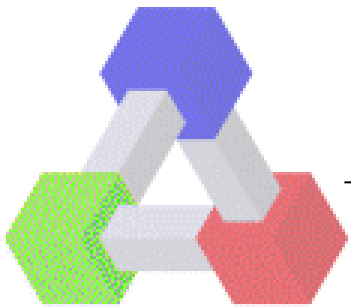
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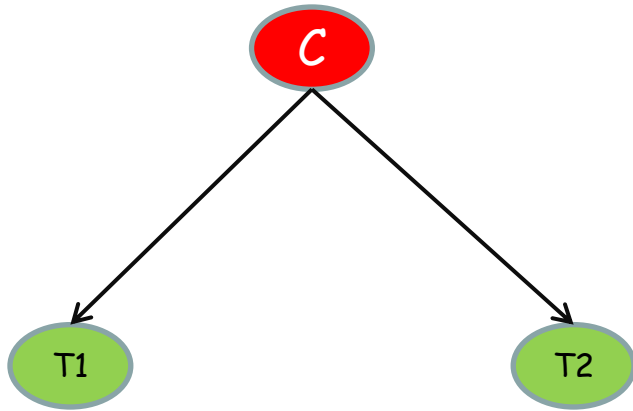
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# Bayesove mreže

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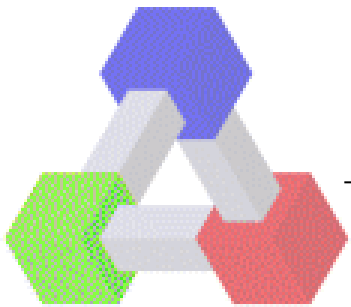
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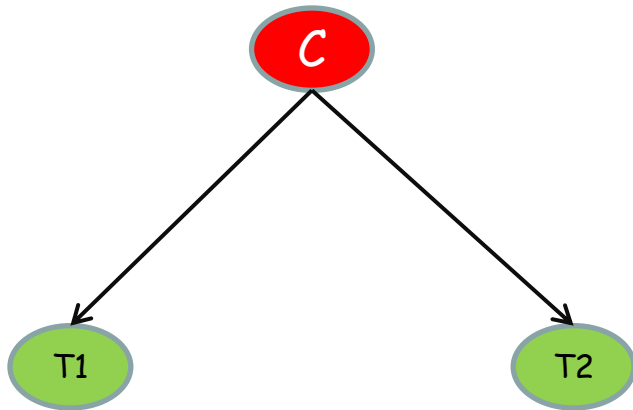
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# Bayesove mreže

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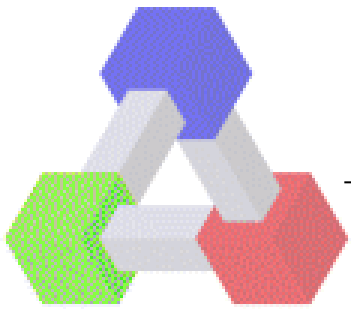
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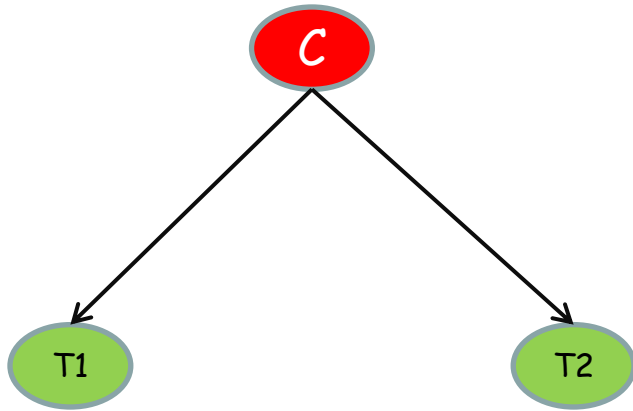
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# Bayesove mreže

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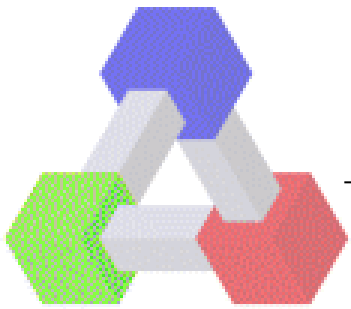
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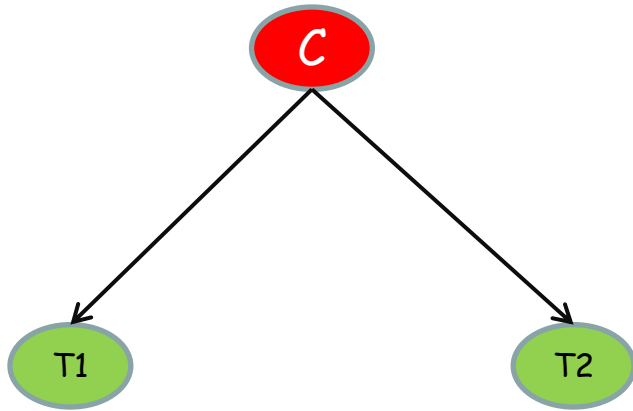
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# Bayesove mreže

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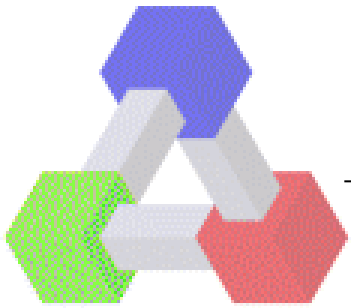
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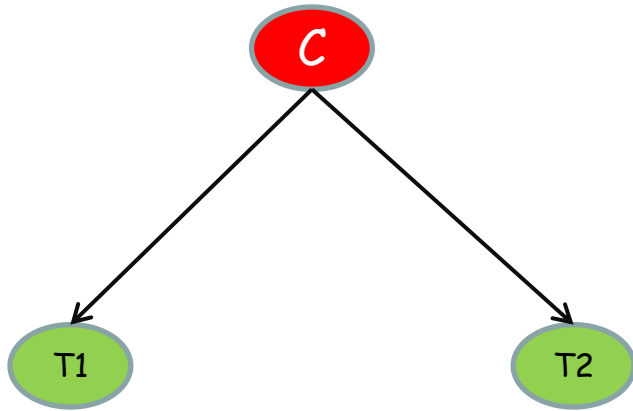
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# Bayesove mreže

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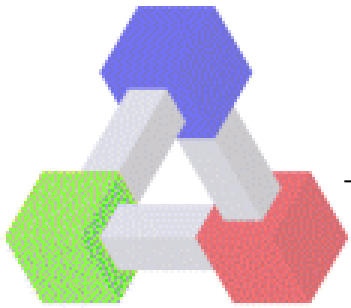
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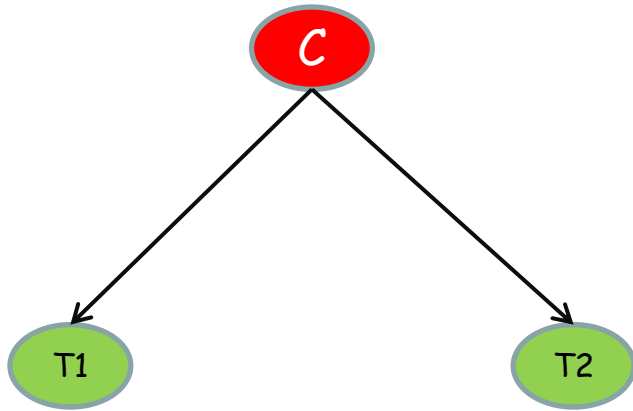
$$P(C|T_1, T_2) = \underline{\hspace{10em}}$$

$$P(T_1, T_2) = P(+ +) = P(T_1, T_2|C)P(C) + P(T_1, T_2|\neg C)P(\neg C)$$



# Bayesove mreže

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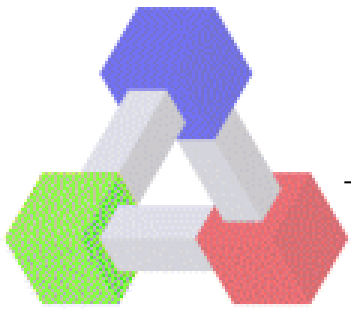
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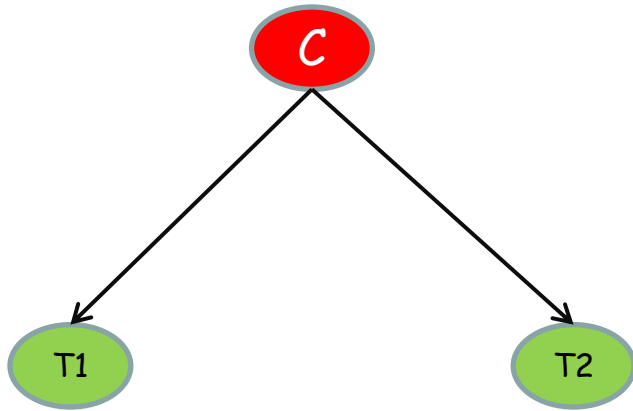
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# Bayesove mreže

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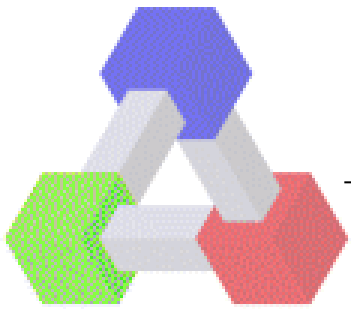
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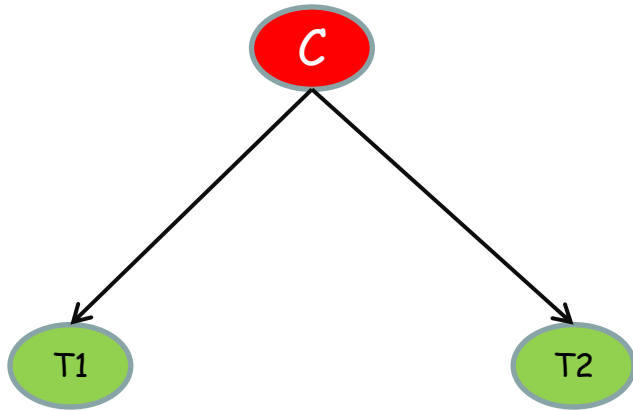
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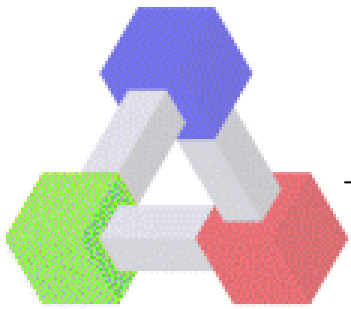
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$$P(C|T_1, T_2) = \frac{0.01 * 0.9}{\quad}$$

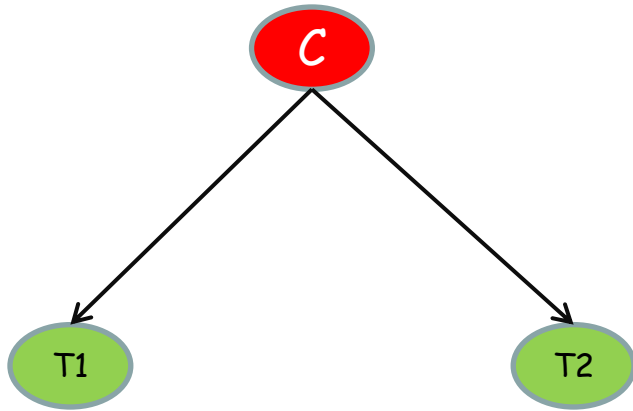
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# Bayesove mreže

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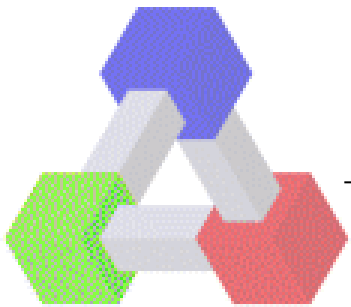
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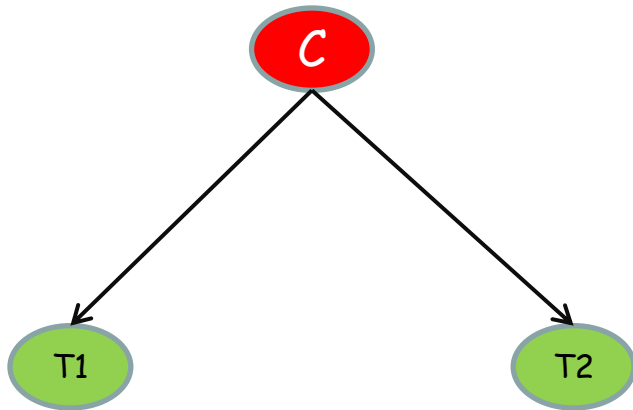
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{\quad}$$

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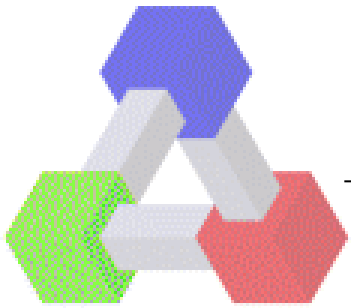
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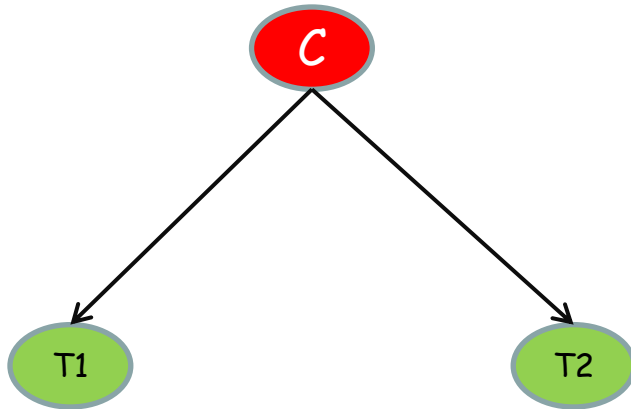
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9}$$

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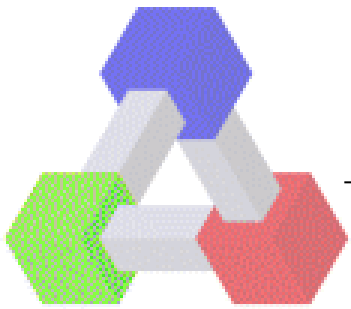
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$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

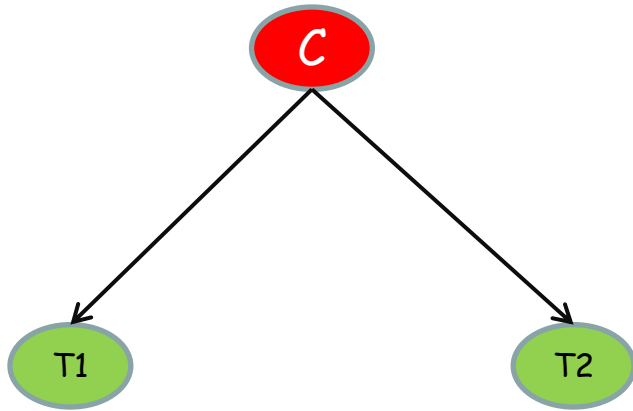
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

$$P(T_1, T_2) = P(+ +) = P(T_1, T_2|C)P(C) + P(T_1, T_2|\neg C)P(\neg C)$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

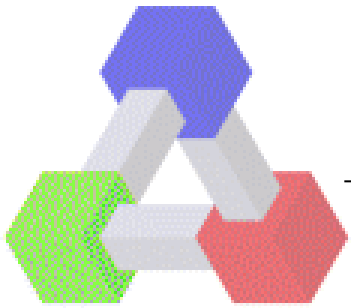
$$P(-|\text{not } C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

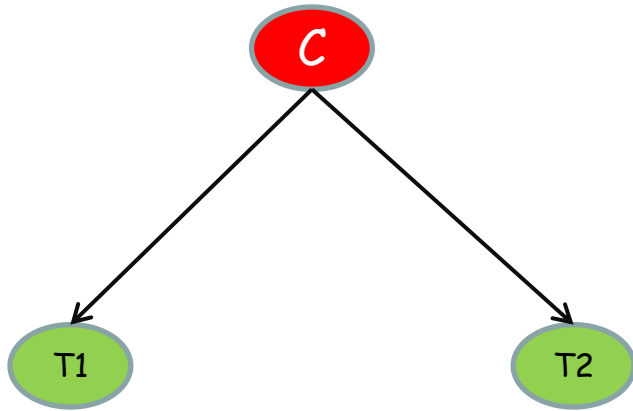
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

=



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

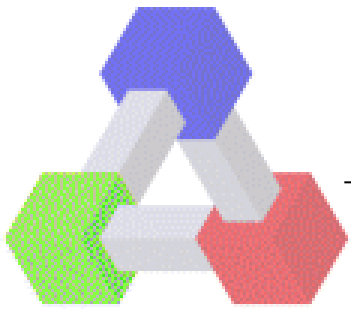
$$P(-|\text{not } C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

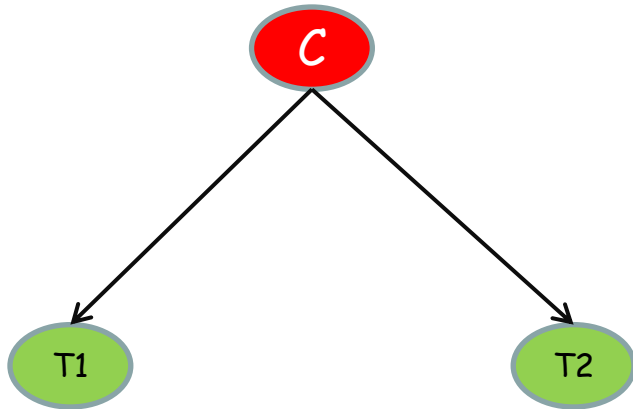
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

$$= 0.0081$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

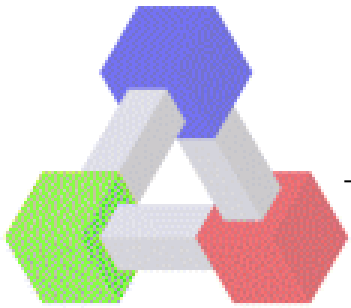
$$P(-|\text{not } C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

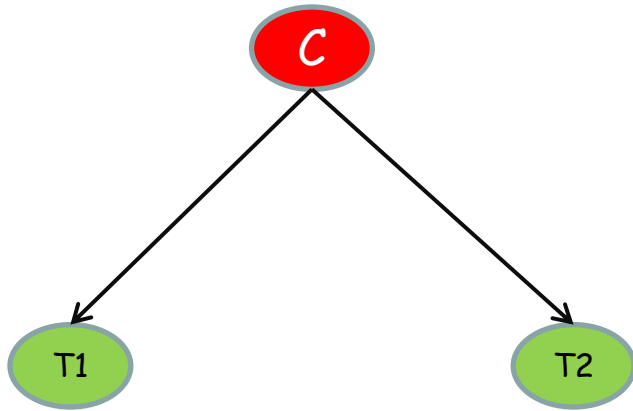
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

$$= \frac{0.0081}{\dots}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

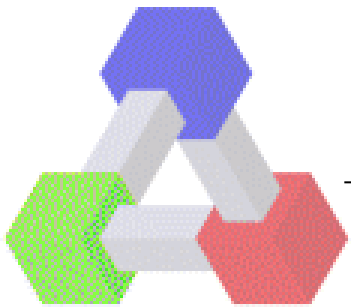
$$P(-|\text{not } C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

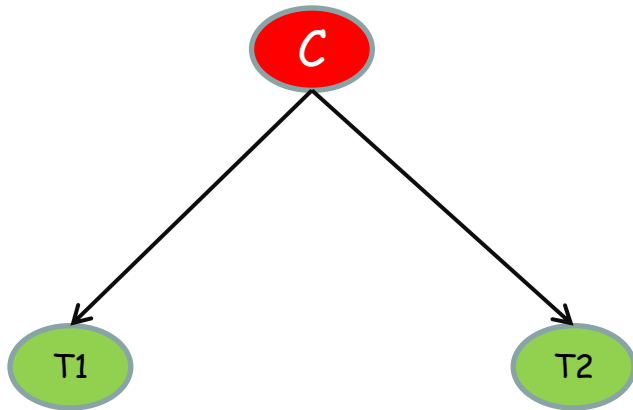
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

$$= \frac{0.0081}{0.0477} =$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

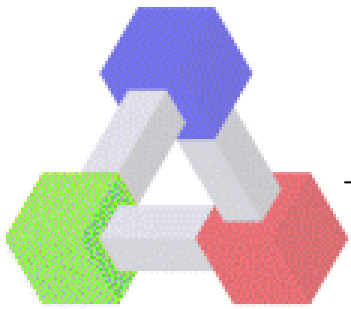
$$P(C|T_1=+, T_2=+) = P(C|++)=?$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

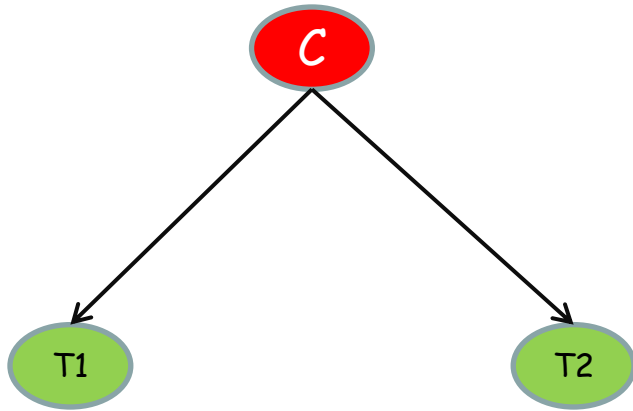
$$= \frac{0.0081}{0.0477} = 0.169811$$





# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

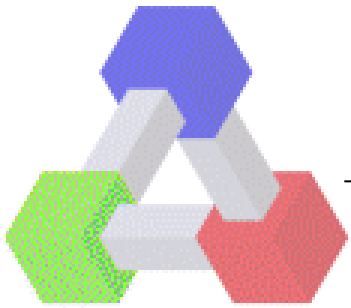
$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1, T_2) = \frac{P(C)P(T_1|C)P(T_2|C)}{P(T_1, T_2)} = \frac{P(C)P(+_1|C)P(+_2|C)}{P(+, +)}$$

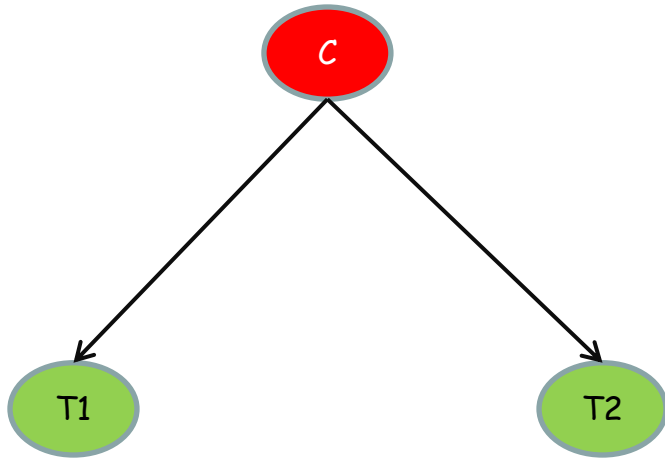
$$P(C|T_1, T_2) = \frac{0.01 * 0.9 * 0.9}{0.01 * 0.9 * 0.9 + 0.99 * 0.2 * 0.2}$$

$$= \frac{0.0081}{0.0477} = 0.169811$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

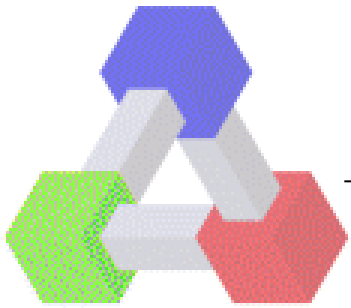
$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

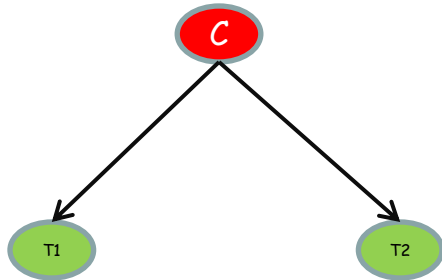
$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

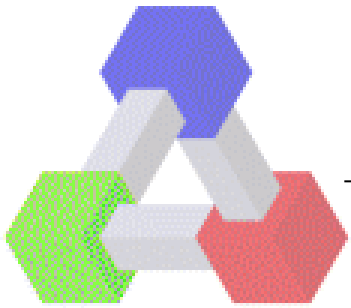
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

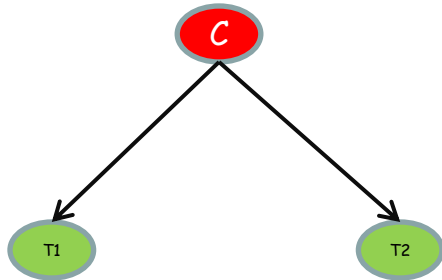
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$P(C|+ -) =$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

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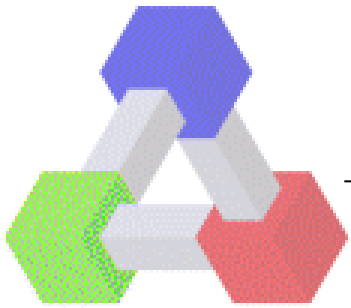
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

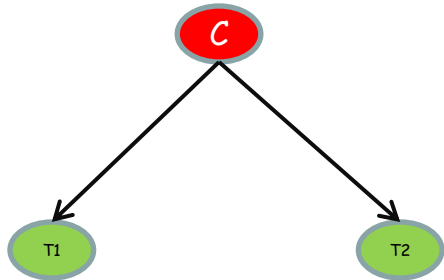
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = P(+ - |C)$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

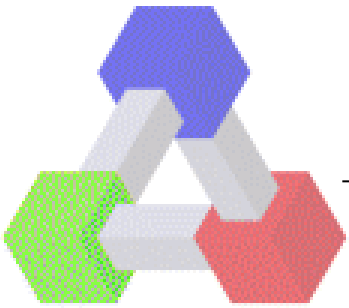
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

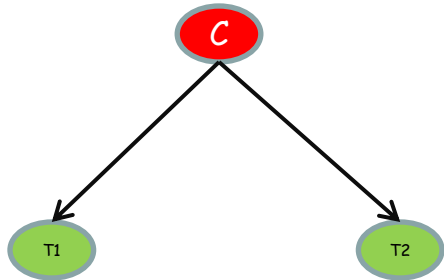
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = P(+ - |C)P(C)$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

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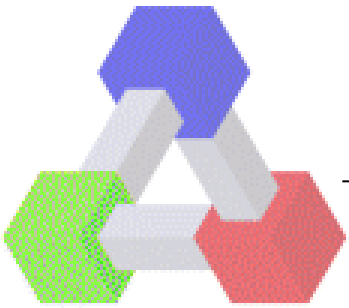
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

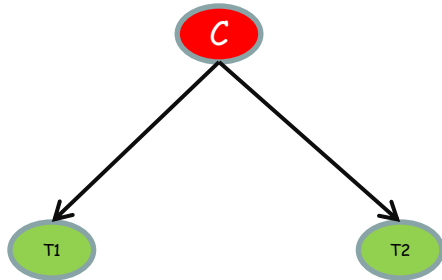
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+ -) = \frac{P(+ - |C)P(C)}{P(+ -)}$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

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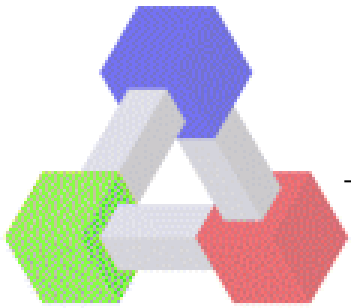
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

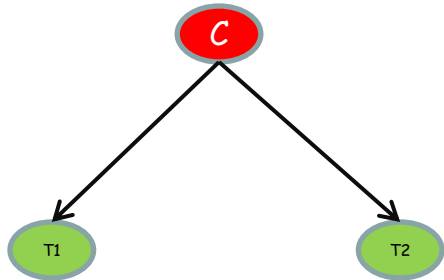
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+ -) = \frac{P(+ - |C)P(C)}{P(+ -)}$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

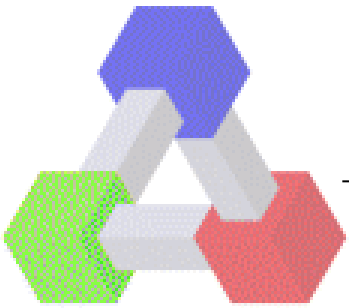
$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

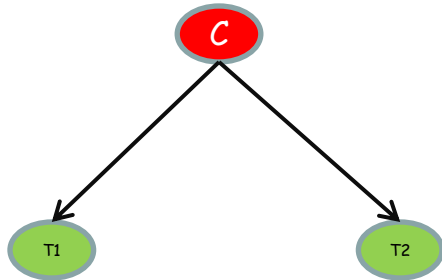
$$P(C|+ -) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$



# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

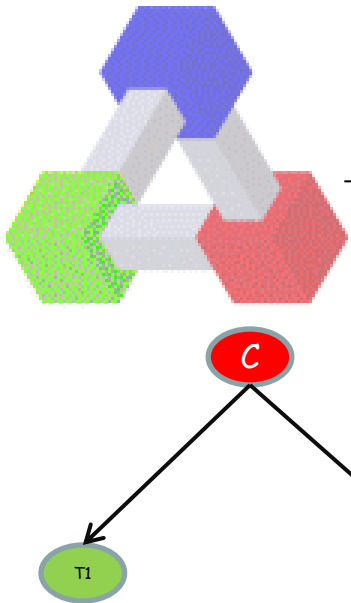
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+ -) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+ -) =$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

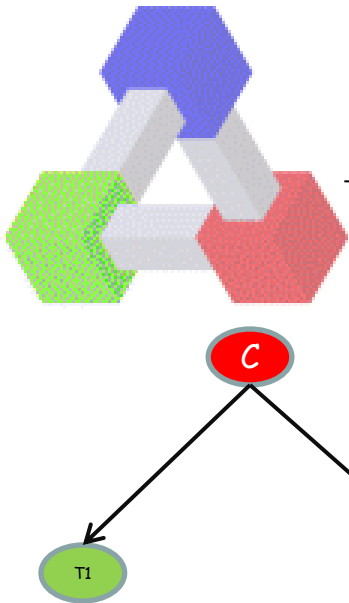
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)}$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

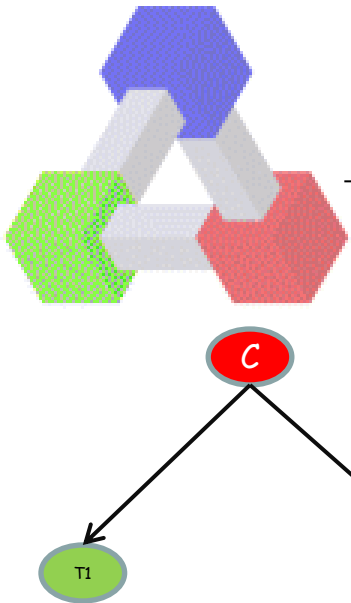
$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

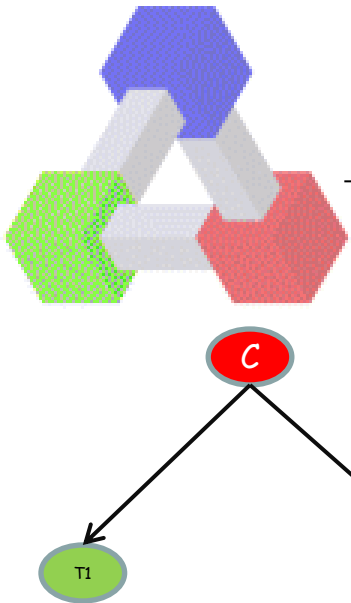
$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C)$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

$$P(C|T1=+, T2=+) = P(C|++) = \mathbf{0.169811}$$

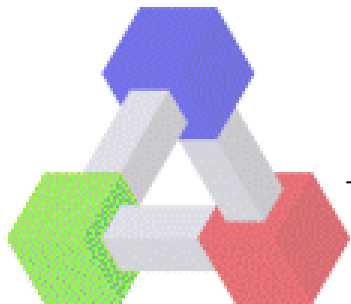
$$P(C|T1=+, T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - | C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

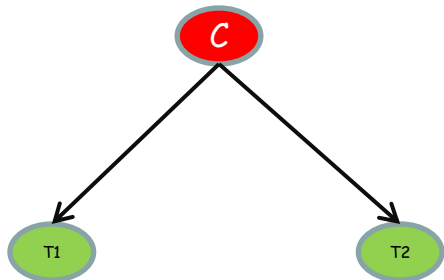
$$P(\neg C|+-) = \frac{P(+ - | \neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - | C)P(C) = P(+|C)P(-|C)P(C)$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

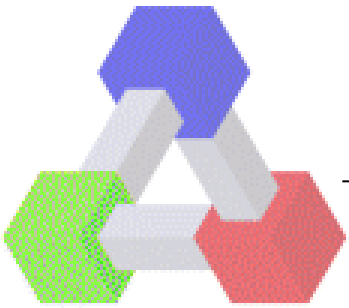
$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

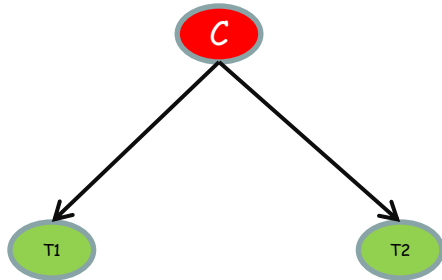
$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

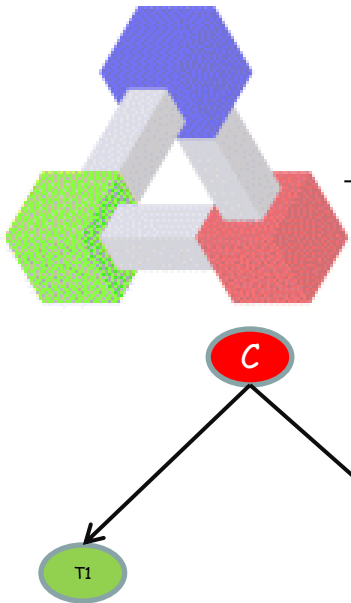
$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|\neg C)P(\neg C)$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not } C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not } C) = 0.2$$

$$P(-|\text{not } C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

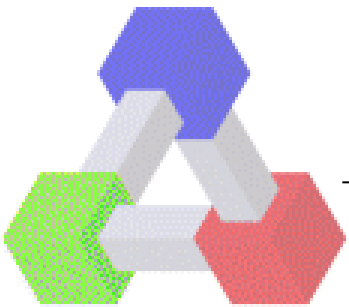
$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

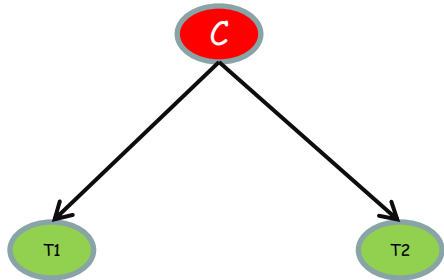
$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$



# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

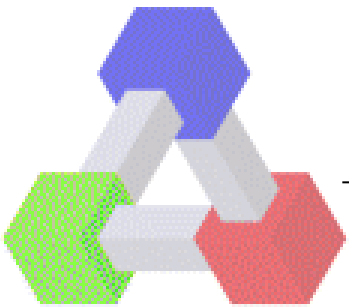
$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|\neg C)P(\neg C)$$

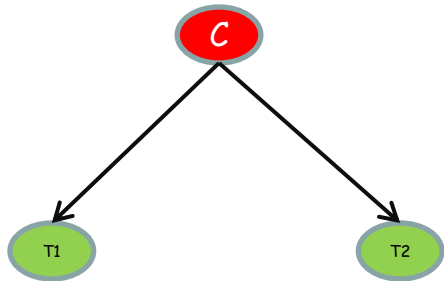
$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

$$P(+ -) =$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

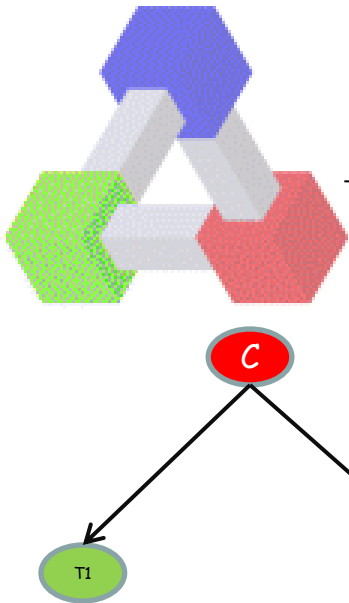
$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

$$P(+ -) = 0.9 * 0.1 * 0.001$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|\neg C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

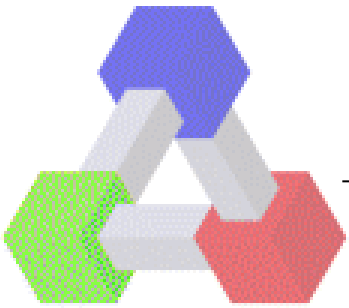
$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|\neg C)P(\neg C)$$

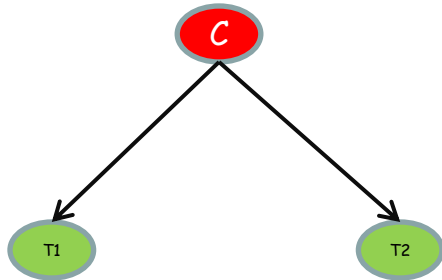
$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

$$P(+ -) = 0.9 * 0.1 * 0.001 + 0.2 * 0.8 * 0.99$$

# Bayesove mreže



Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

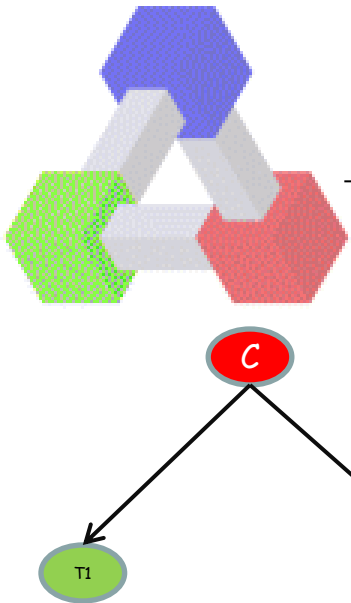
$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

$$P(+ -) = 0.9 * 0.1 * 0.001 + 0.2 * 0.8 * 0.99 = 0.1593$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

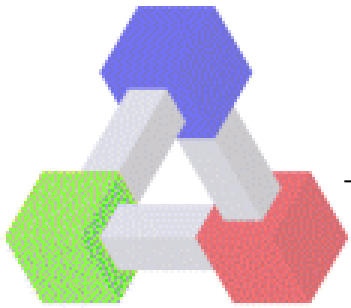
$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

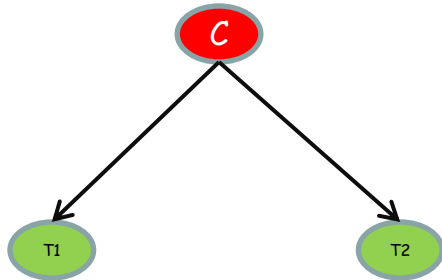
$$P(+ -) = 0.9 * 0.1 * 0.001 + 0.2 * 0.8 * 0.99 = 0.1593$$

$$P(C|+-) = \frac{0.9 * 0.1 * 0.001}{0.1593}$$



# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = ?$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

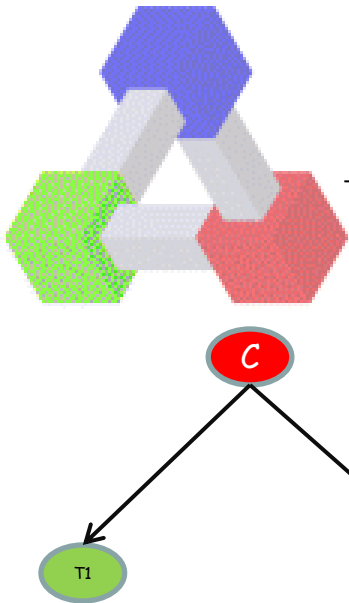
$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

$$P(+ -) = 0.9 * 0.1 * 0.001 + 0.2 * 0.8 * 0.99 = 0.1593$$

$$P(C|+-) = \frac{0.9 * 0.1 * 0.001}{0.1593} = 0.00565$$

# Bayesove mreže

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(C|+-) = \frac{P(+ - |C)P(C)}{P(+ -)} = \frac{P(+|C)P(-|C)P(C)}{P(+ -)}$$

$$P(\neg C|+-) = \frac{P(+ - |\neg C)P(\neg C)}{P(+ -)} = \frac{P(+|\neg C)P(-|C)P(\neg C)}{P(+ -)}$$

$$P'(C|+-) = P(+ - |C)P(C) = P(+|C)P(-|C)P(C)$$

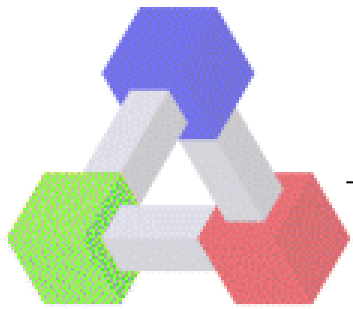
$$P'(C|+-) = 0.9 * 0.1 * 0.001$$

$$P'(\neg C|+-) = P(+ - |\neg C)P(\neg C) = P(+|\neg C)P(-|C)P(\neg C)$$

$$P'(\neg C|+-) = 0.2 * 0.8 * 0.99$$

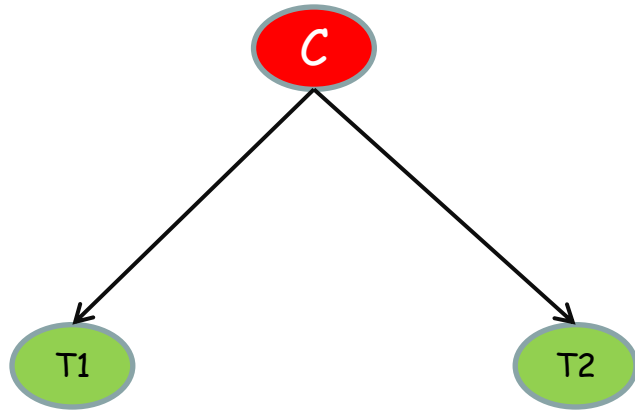
$$P(+ -) = 0.9 * 0.1 * 0.001 + 0.2 * 0.8 * 0.99 = 0.1593$$

$$P(C|+-) = \frac{0.9 * 0.1 * 0.001}{0.1593} = 0.00565$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

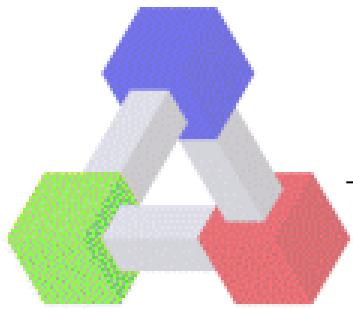
$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T2=+|T1=+) = ?$$

**USLOVNO NEZAVISNI**

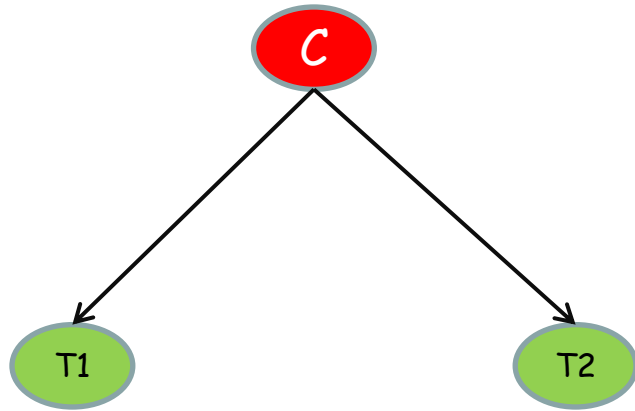
$$P(T2|C,T1) = P(T2|C)$$





# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(T2=+|T1=+) = ?$$

$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

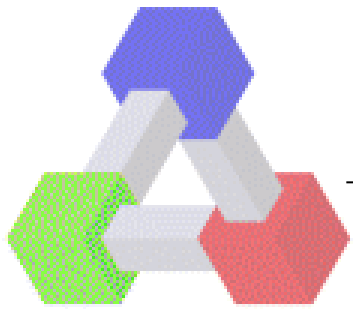
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

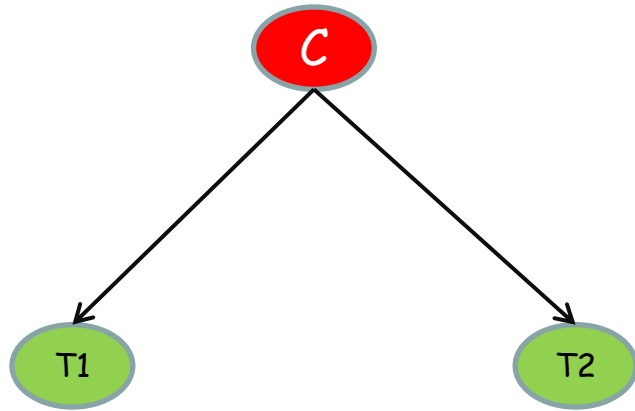
**USLOVNO NEZAVISNI**

$$P(T2|C,T1) = P(T2|C)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

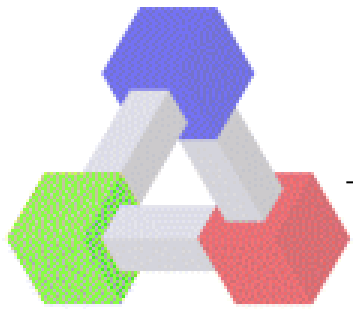
$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

$$P(T2|C,T1) = P(T2|C)$$

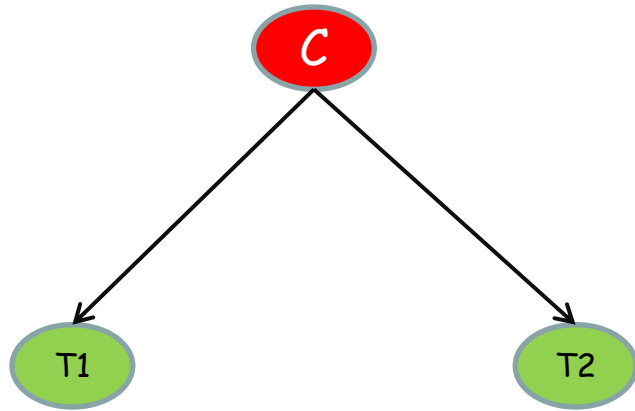
$$P(T2=+|T1=+) = ?$$

$$P(T2|T1) =$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(T_2=+|T_1=+) = ?$$

$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

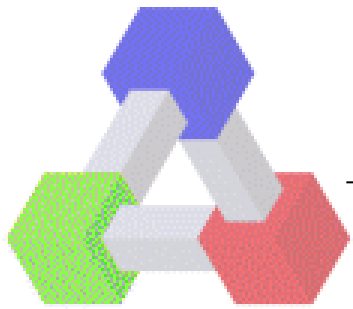
$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

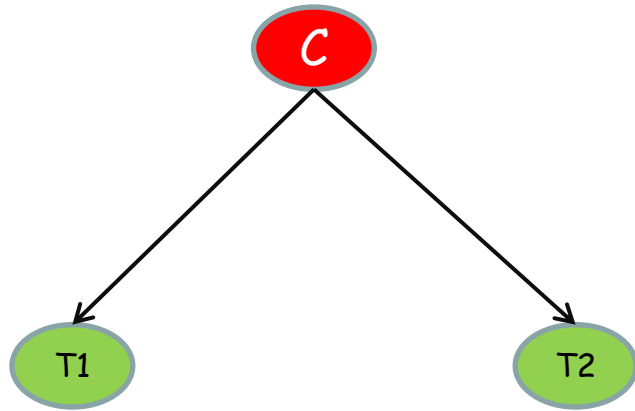
$$P(T_2|C,T_1) = P(T_2|C)$$

$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(T_2=+|T_1=+) = ?$$

$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

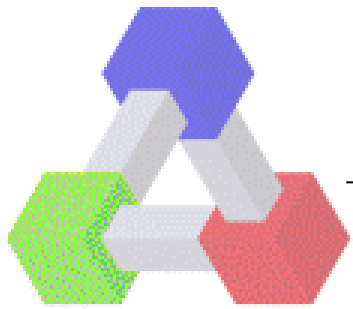
$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

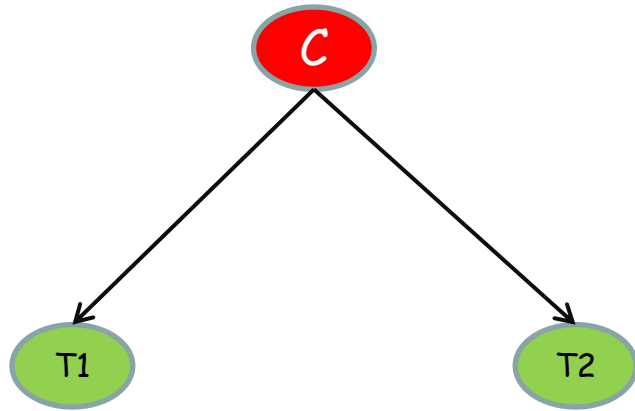
$$P(T_2|C,T_1) = P(T_2|C)$$

$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

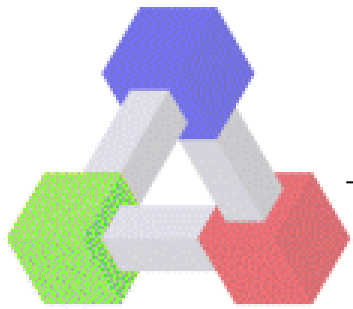
**USLOVNO NEZAVISNI**

$$P(T_2|C, T_1) = P(T_2|C)$$

$$P(T_2=+|T_1=+) = ?$$

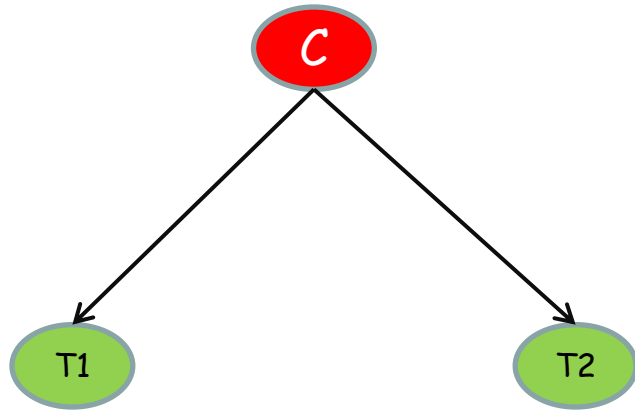
$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$

$$P(T_2|T_1) = P(T_2|C)P(C|T_1)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

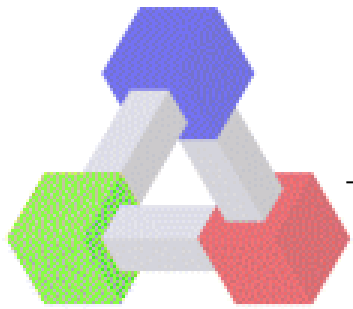
**USLOVNO NEZAVISNI**

$$P(T2|C,T1) = P(T2|C)$$

$$P(T2=+|T1=+) = ?$$

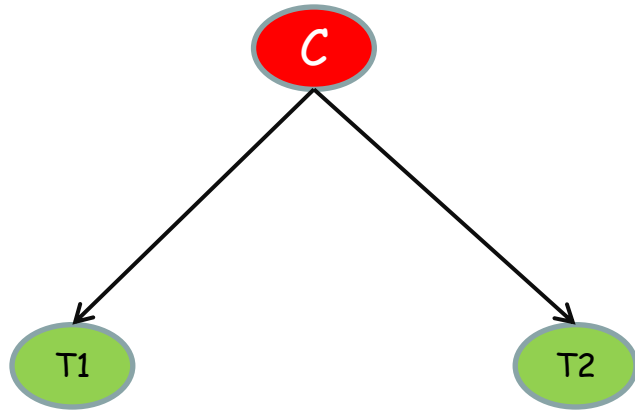
$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$

$$P(T_2|T_1) = P(T_2|C)P(C|T_1) + P(T_2|\neg C)P(\neg C|T_1)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

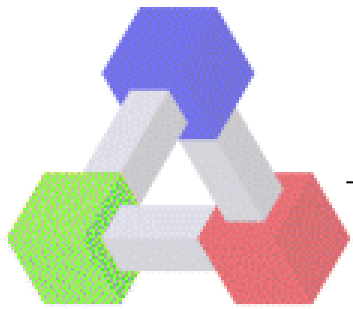
$$P(T_2|C, T_1) = P(T_2|C)$$

$$P(T_2=+|T_1=+) = ?$$

$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$

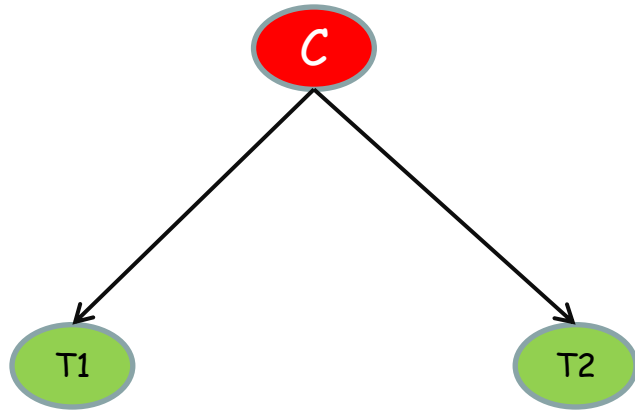
$$P(T_2|T_1) = P(T_2|C)P(C|T_1) + P(T_2|\neg C)P(\neg C|T_1)$$

$$P(T_2|T_1) = 0.9 * 0.0452$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(T2=+|T1=+) = ?$$

$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

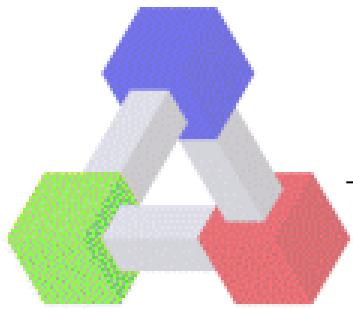
$$P(T2|C,T1) = P(T2|C)$$

$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$

$$P(T_2|T_1) = P(T_2|C)P(C|T_1) + P(T_2|\neg C)P(\neg C|T_1)$$

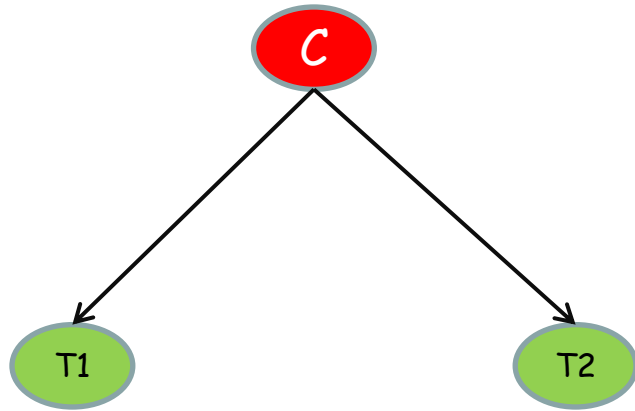
$$P(T_2|T_1) = 0.9 * 0.0452 + 0.2 * 0.995475$$





# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(T2=+|T1=+) = \mathbf{0.239775}$$

$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

**USLOVNO NEZAVISNI**

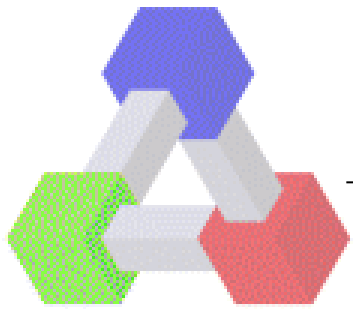
$$P(T2|C,T1) = P(T2|C)$$

$$P(T_2|T_1) = P(T_2|T_1, C)P(C|T_1) + P(T_2|T_1, \neg C)P(\neg C|T_1)$$

$$P(T_2|T_1) = P(T_2|C)P(C|T_1) + P(T_2|\neg C)P(\neg C|T_1)$$

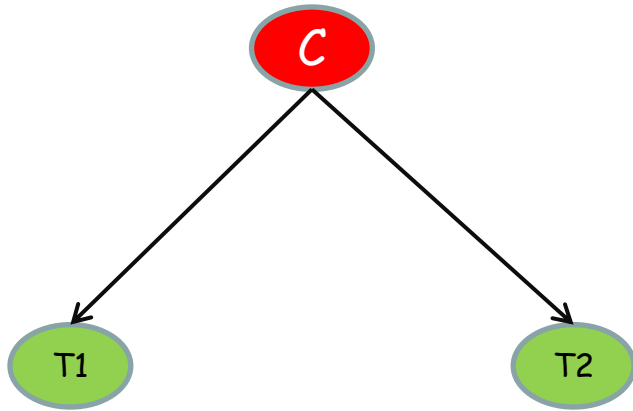
$$P(T_2|T_1) = 0.9 * 0.0452 + 0.2 * 0.995475$$

$$P(T_2|T_1) = 0.239775$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

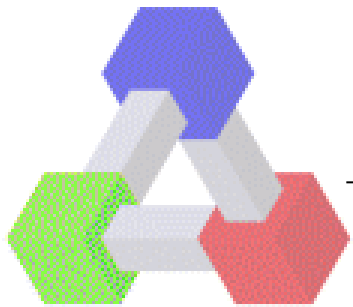
$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

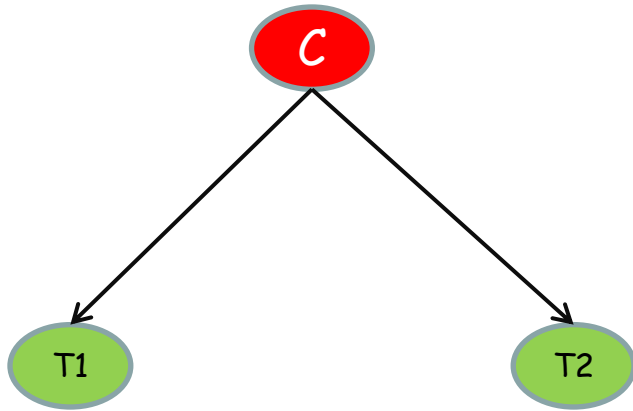
$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) =$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

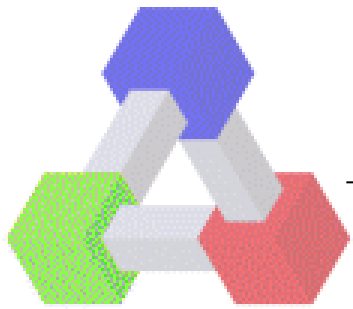
$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

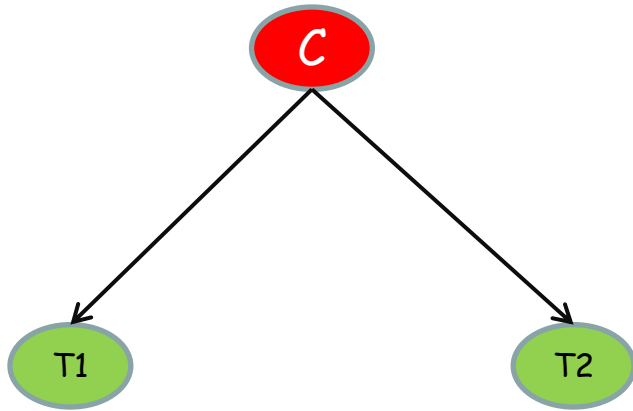
$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)}$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

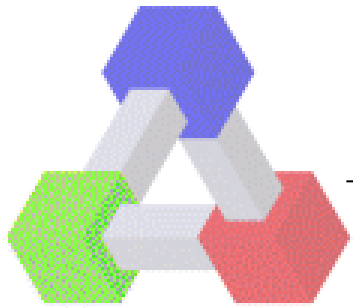
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

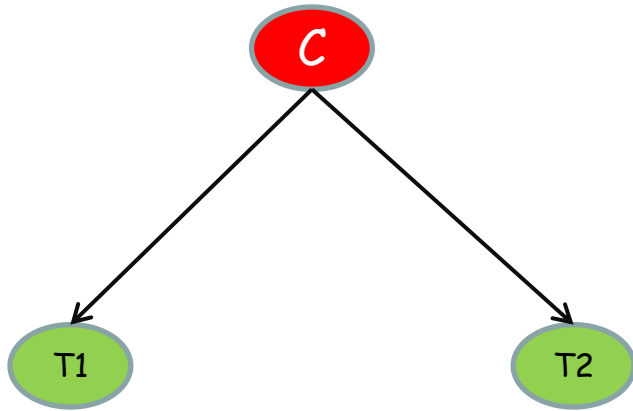
$$P(T2=+|T1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)}$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

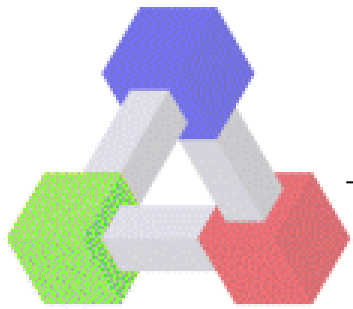
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

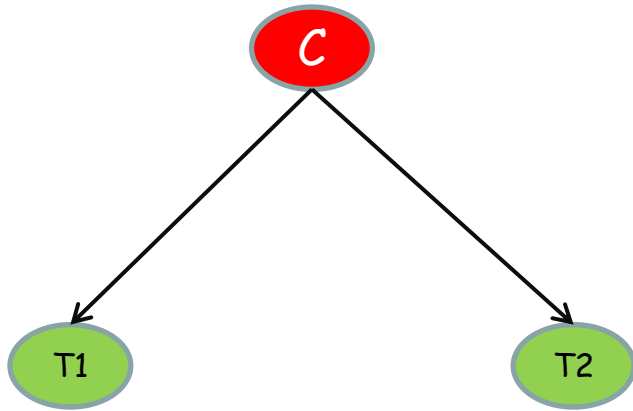
$$P(T2=+|T1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) =$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T1$  i  $T2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

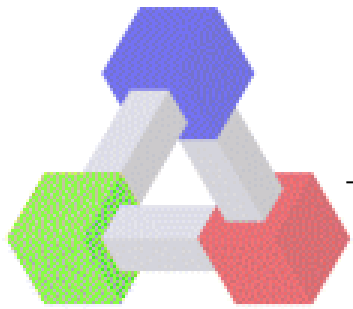
$$P(-|\text{not}C) = 0.8$$

$$P(C|T1=+,T2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T1=+,T2=-) = P(C|+-) = \mathbf{0.00565}$$

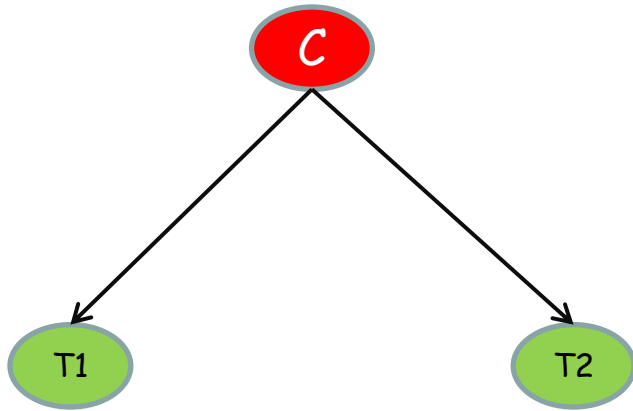
$$P(T2=+|T1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

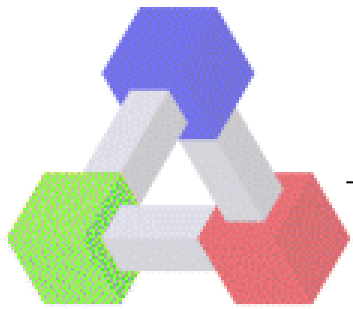
$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

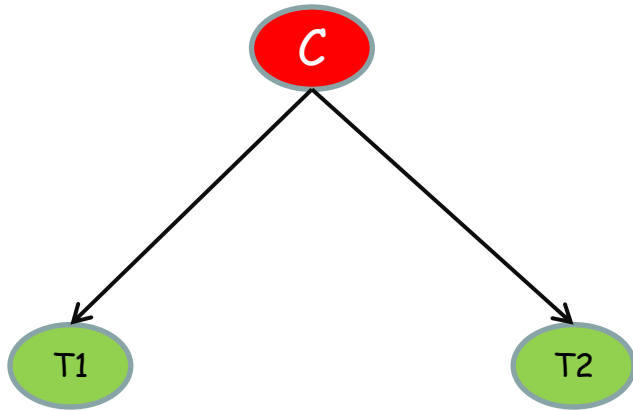
$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

$$P(T_1) = P(T_1|C)P(C)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

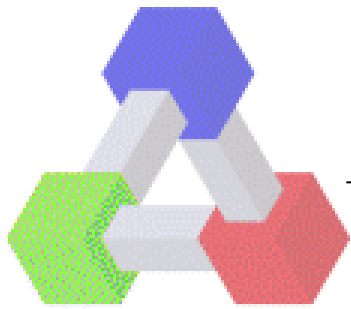
$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

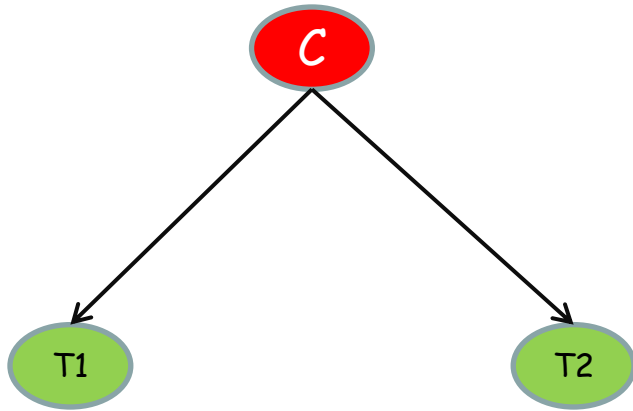
$$P(T_1) = P(T_1|C)P(C) +$$





# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

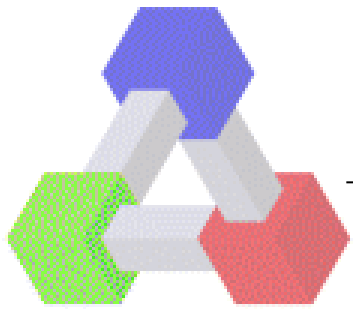
$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

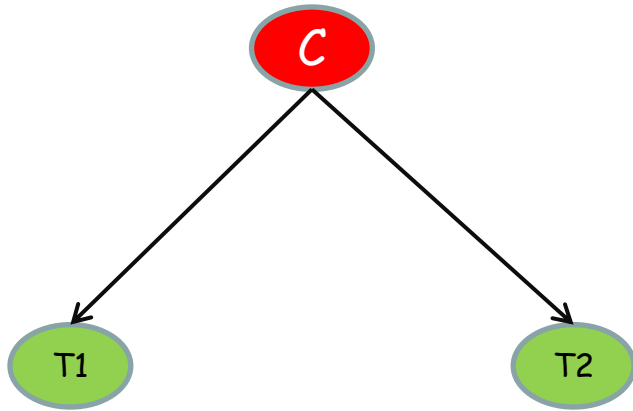
$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

$$P(T_1) = P(T_1|C)P(C) + P(T_1|\neg C)P(\neg C)$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+, T_2=+) = P(C|++) = \mathbf{0.169811}$$

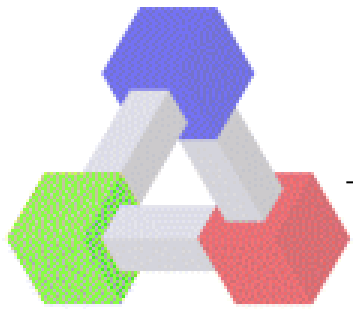
$$P(C|T_1=+, T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

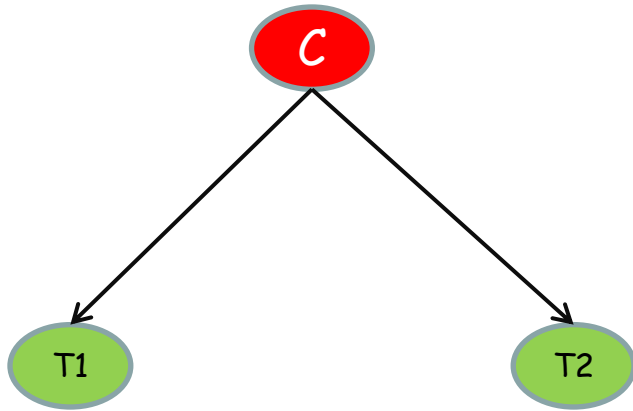
$$P(T_1) = P(T_1|C)P(C) + P(T_1|\neg C)P(\neg C)$$

$$P(T_1) = 0.9 * 0.01 +$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

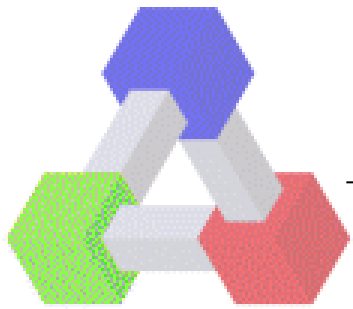
$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

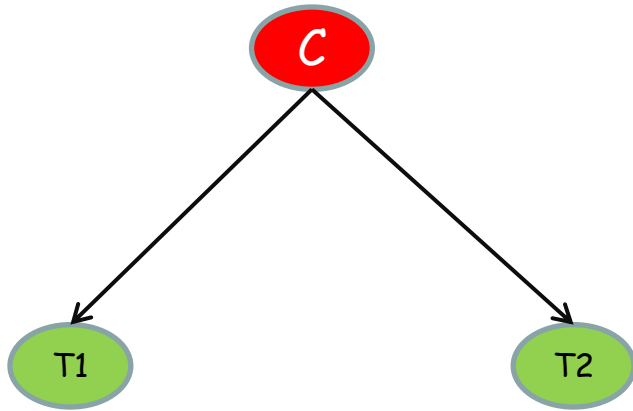
$$P(T_1) = P(T_1|C)P(C) + P(T_1|\neg C)P(\neg C)$$

$$P(T_1) = 0.9 * 0.01 + 0.2 * 0.99$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

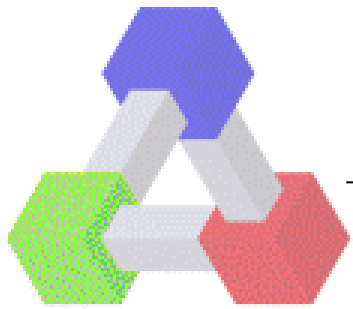
$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

$$P(T_1) = P(T_1|C)P(C) + P(T_1|\neg C)P(\neg C)$$

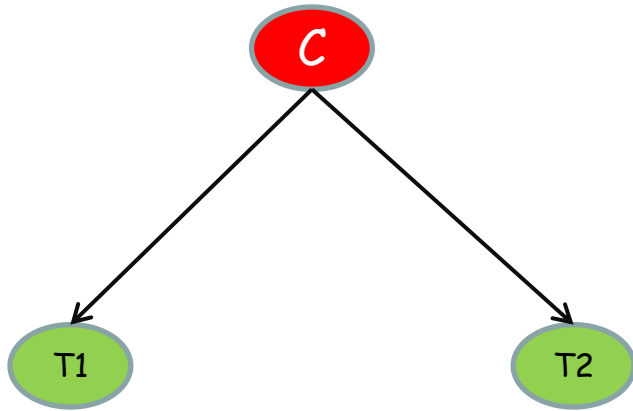
$$P(T_1) = 0.9 * 0.01 + 0.2 * 0.99$$

$$P(C|T_1) = 0.0452$$



# Bayesove mreže - uslovna nezavisnost

Primer bolesti  $C$  i dva testa  $T_1$  i  $T_2$



$$P(C) = 0.01$$

$$P(\text{not}C) = 0.99$$

$$P(+|C) = 0.9$$

$$P(-|C) = 0.1$$

$$P(+|\text{not}C) = 0.2$$

$$P(-|\text{not}C) = 0.8$$

$$P(C|T_1=+,T_2=+) = P(C|++) = \mathbf{0.169811}$$

$$P(C|T_1=+,T_2=-) = P(C|+-) = \mathbf{0.00565}$$

$$P(T_2=+|T_1=+) = \mathbf{0.239775}$$

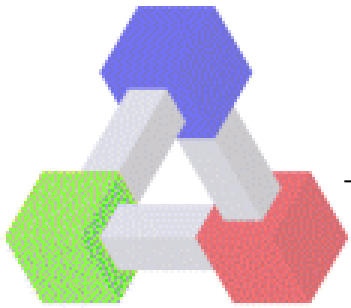
$$P(C|T_1) = \frac{P(T_1|C)P(C)}{P(T_1)} \quad P(\neg C|T_1) = \frac{P(T_1|\neg C)P(\neg C)}{P(T_1)}$$

$$P(T_1) = P(T_1|C)P(C) + P(T_1|\neg C)P(\neg C)$$

$$P(T_1) = 0.9 * 0.01 + 0.2 * 0.99$$

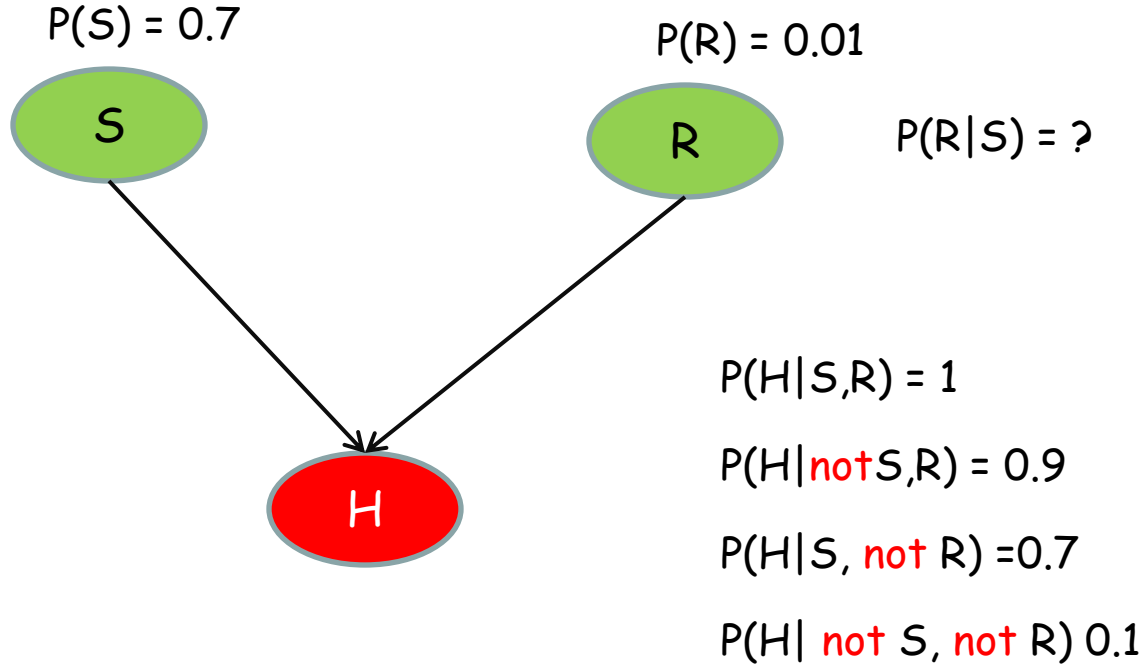
$$P(C|T_1) = 0.0452$$

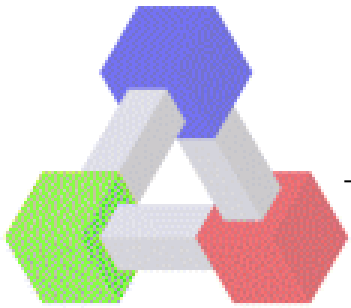
$$P(\neg C|T_1) = 0.995475$$



# Bayesove mreže

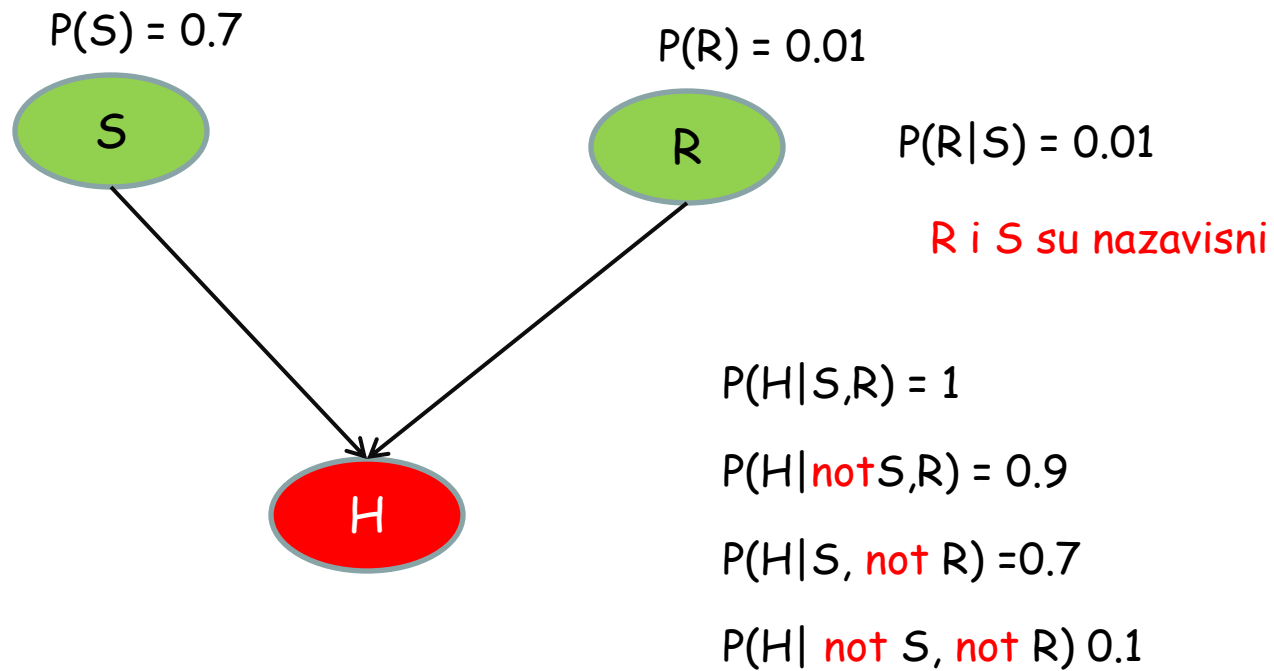
## Interpretacija

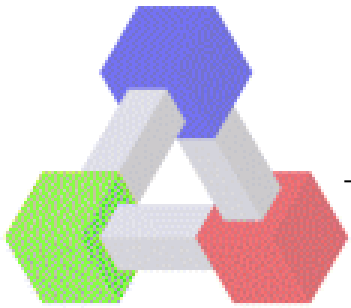




# Bayesove mreže

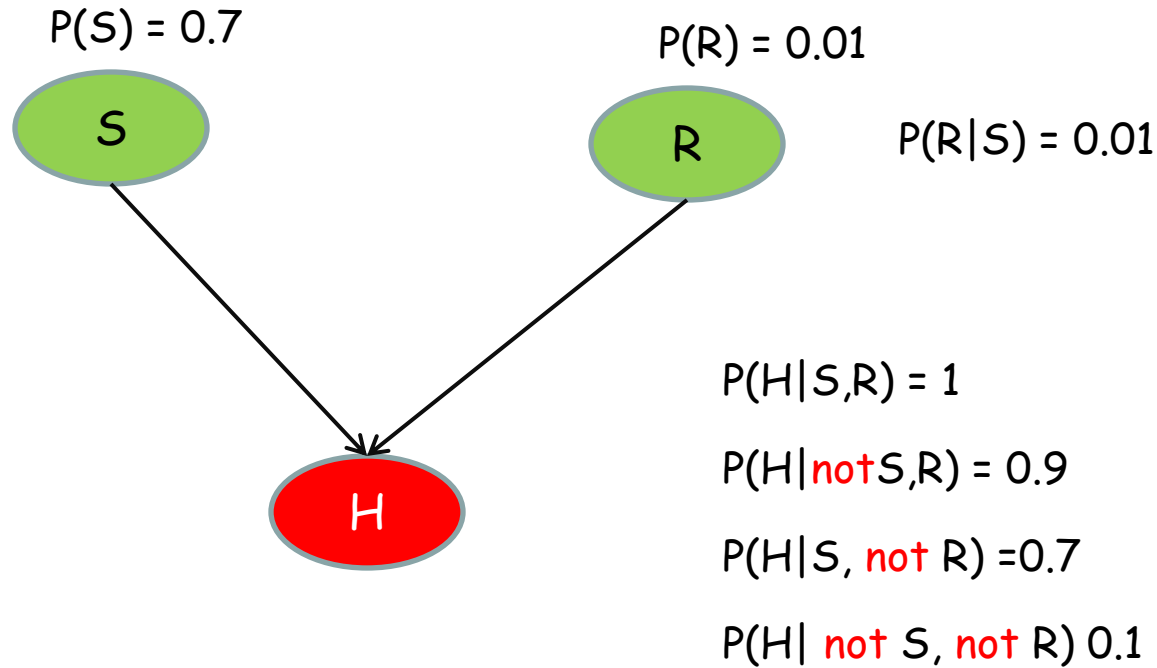
## Interpretacija





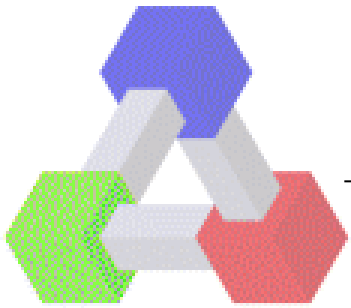
# Bayesove mreže

## Interpretacija



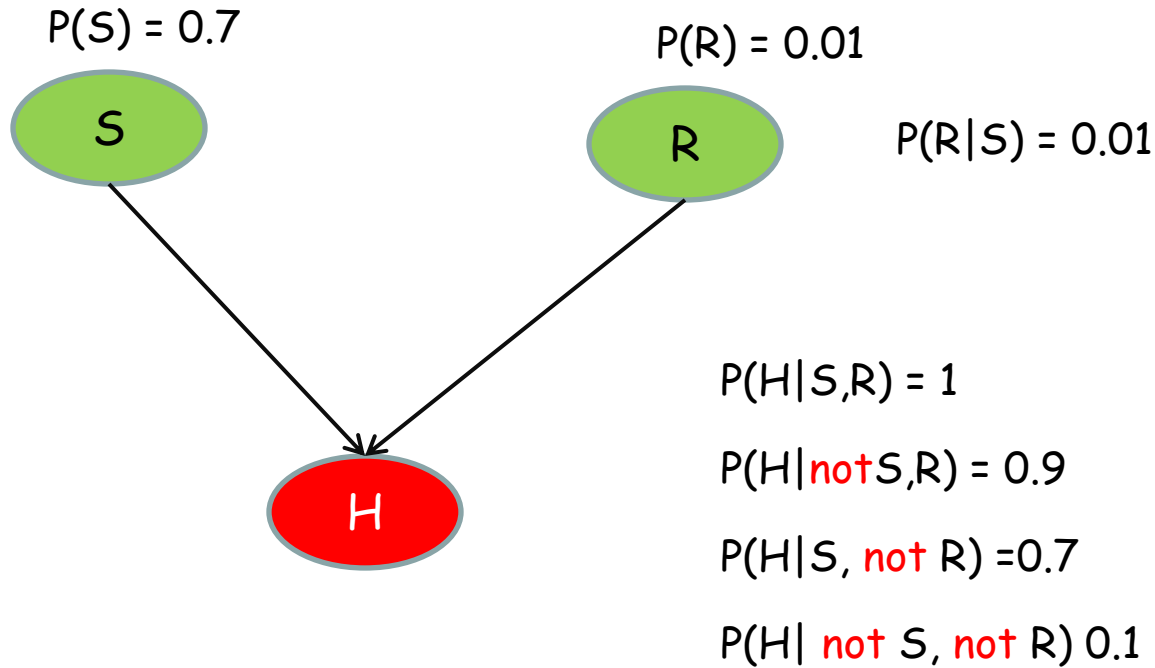
$P(R|H,S) = ?$





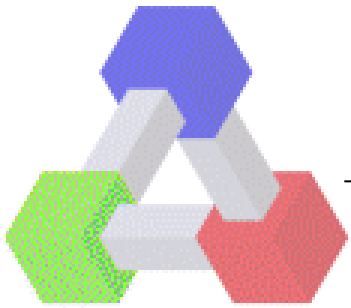
# Bayesove mreže

## Interpretacija



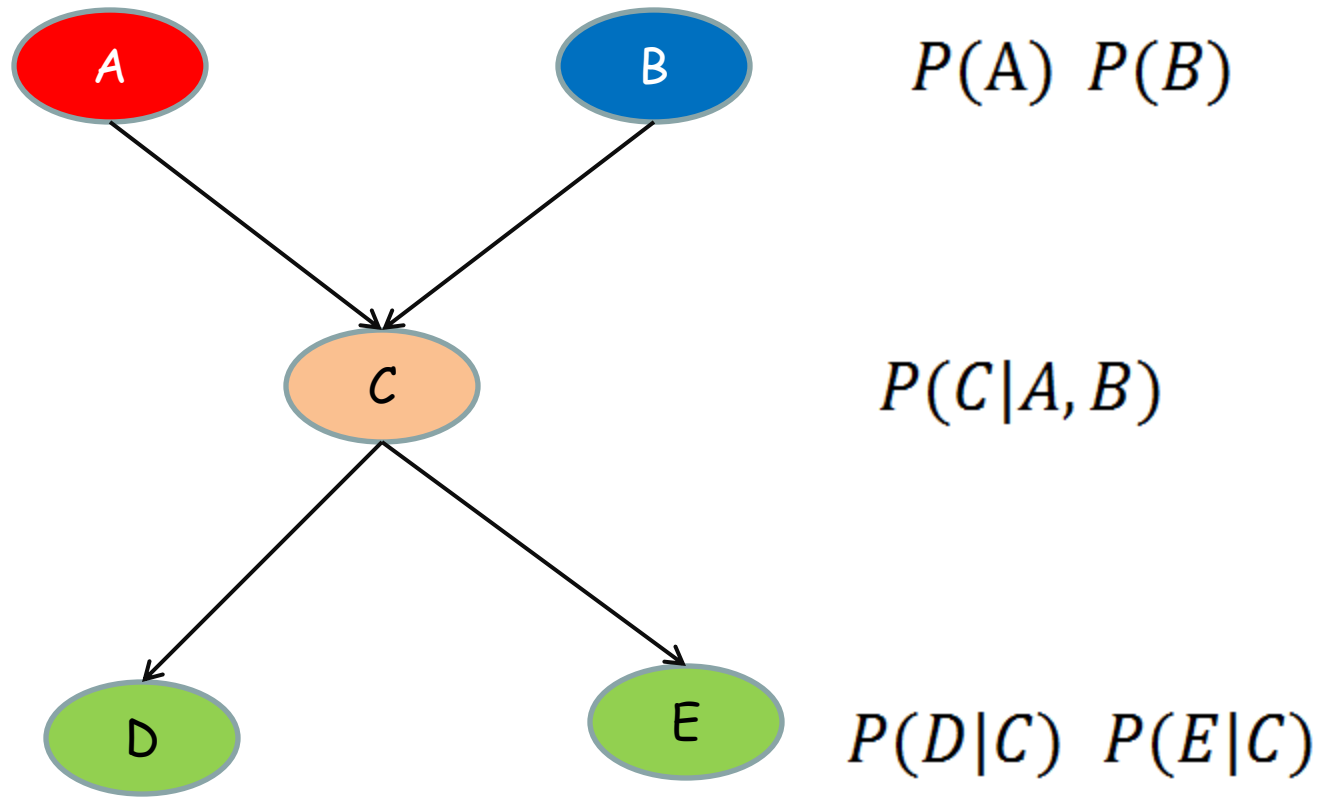
$$P(R|H) = ?$$

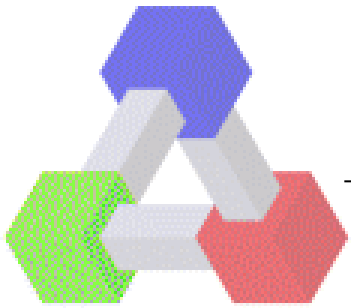
$$P(R|H, \text{not } S) = ?$$



# Bayesove mreže

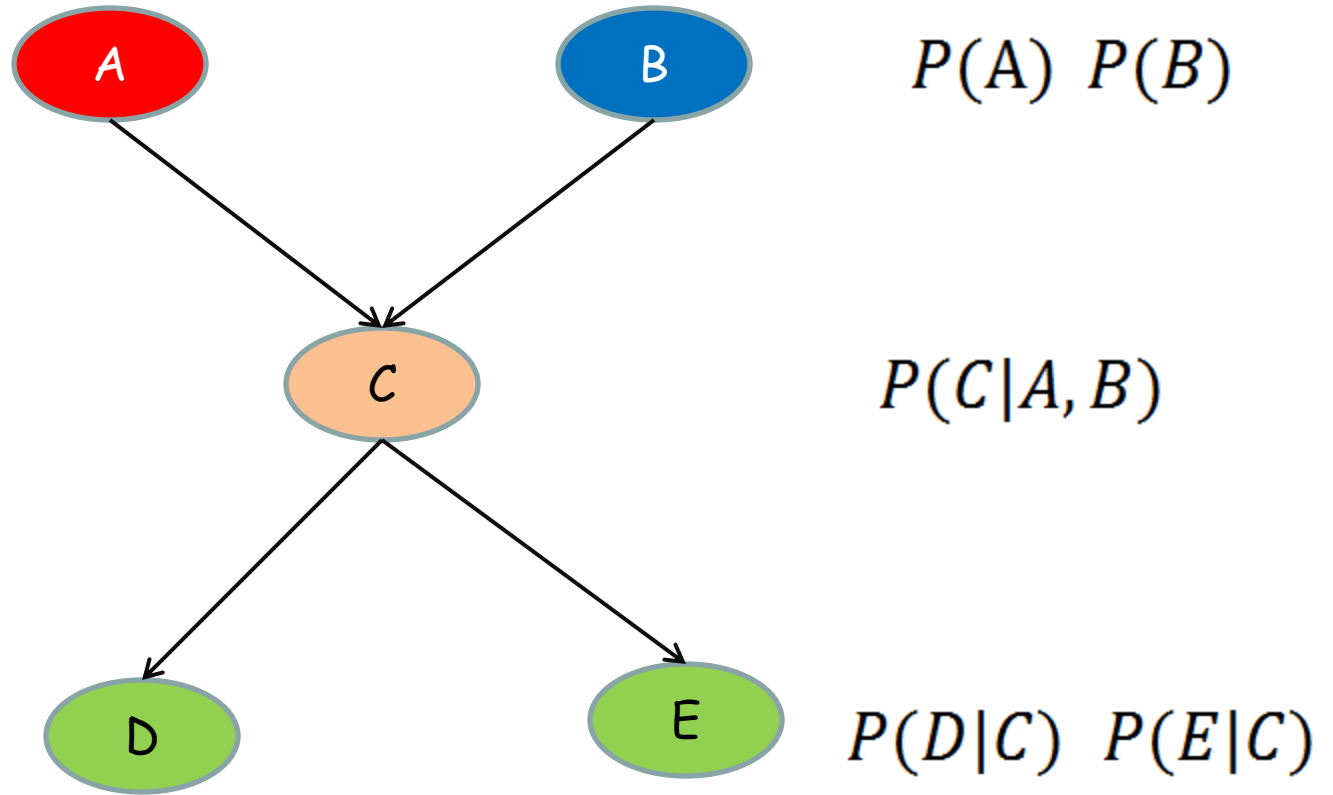
Generalni slučaj





# Bayesove mreže

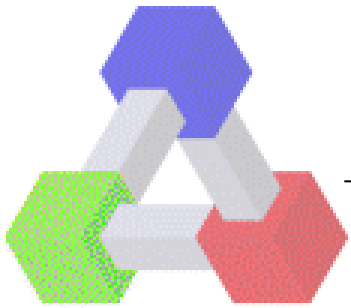
Generalni slučaj



$$2^5 - 1 = 31$$

$$P(A, B, C, D, E) = P(A) P(B) P(C|A, B) P(D|C) P(E|C)$$

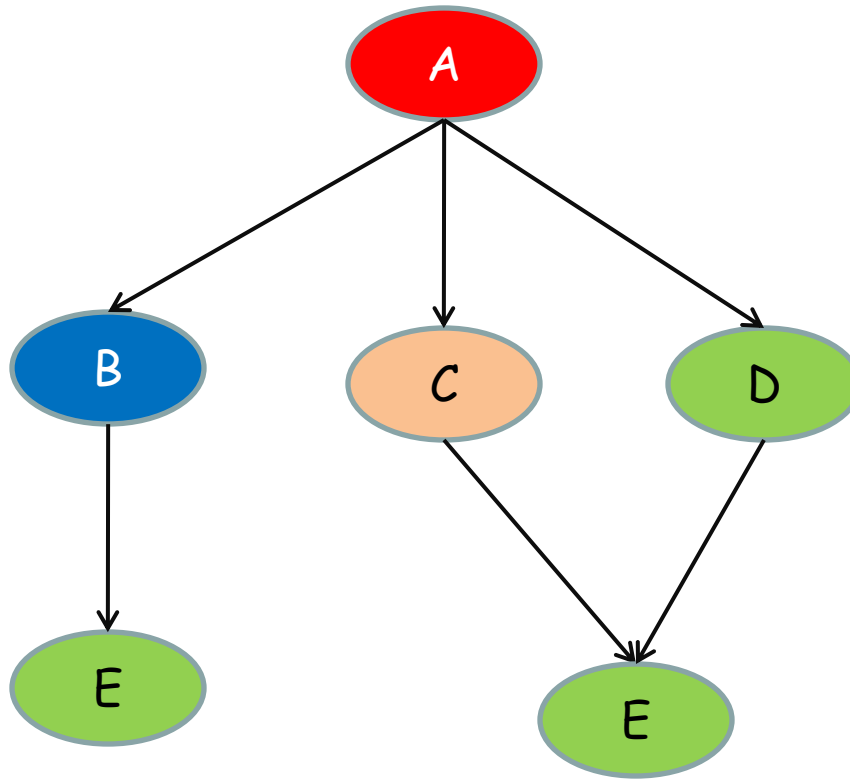
1      1            4            2            2

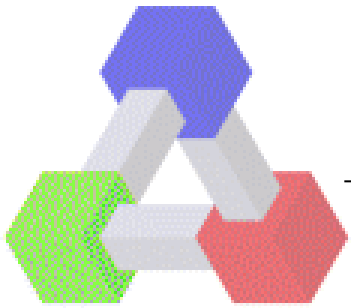


# Bayesove mreže

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Generalni slučaj

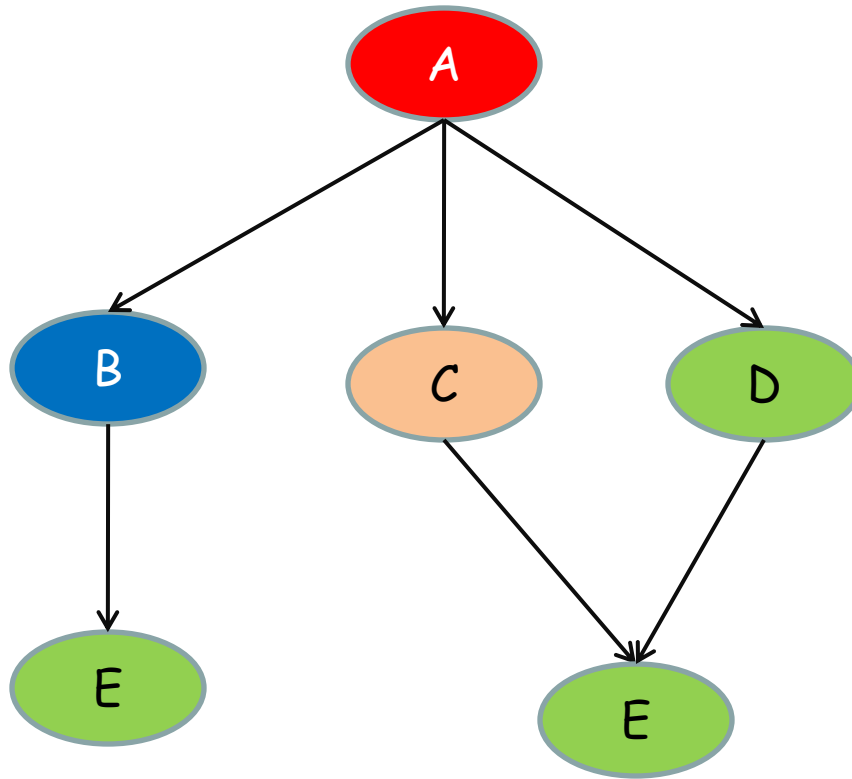


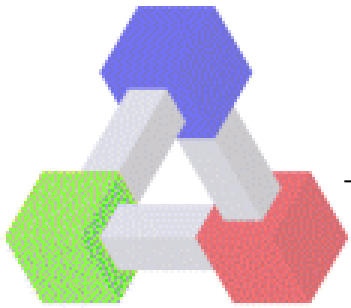


# Bayesove mreže

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Generalni slučaj





# Bayesove mreže

Generalni slučaj

