BAYESIAN BELIEF NETWORK

In [ ]:

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In [ ]:

Dataset Information

DataSet name : **Adult dataset**

Description : This dataset contains the information about the income i.e <=50K or >50K. With the help of some attributes we can determine the target

In [ ]:

Aim:

The aim of this notebook is to perform BBN on the given Adult Income Dataset

In [ ]:

In [ ]:

Libs

In [1]:
```
import pandas as pd
import numpy as np
import networkx as nx # for drawing graphs
import matplotlib.pyplot as plt # for drawing graphs

from pybbn.graph.dag import Bbn
from pybbn.graph.node import BbnNode
from pybbn.graph.variable import Variable
from pybbn.graph.edge import Edge, EdgeType
from pybbn.pptc.inferencecontroller import InferenceController
from pybbn.graph.jointree import EvidenceBuilder
```

In [2]:
```
dataset=pd.read_csv("dataset/adult_new.csv")
```

In [3]:
```
dataset
```

Out[3]:

	Age	workclass	fnlwgt	education	educational-num	marital-status	occupation	relationship	race
0	39	State-gov	77516	Bachelors	13	Never-married	Adm-clerical	Not-in-family	White
1	50	Self-emp-not-inc	83311	Bachelors	13	Married-civ-spouse	Exec-managerial	Husband	White
2	38	Private	215646	HS-grad	9	Divorced	Handlers-cleaners	Not-in-family	White
3	53	Private	234721	11th	7	Married-civ-spouse	Handlers-cleaners	Husband	Black
4	28	Private	338409	Bachelors	13	Married-civ-spouse	Prof-specialty	Wife	Black
...	...	...	...	...	...	...	...	...	...
22275	71	?	287372	Doctorate	16	Married-civ-spouse	?	Husband	White
22276	39	Local-gov	111499	Assoc-acdm	12	Married-civ-spouse	Adm-clerical	Wife	White
22277	53	Private	321865	Masters	14	Married-civ-spouse	Exec-managerial	Husband	White
22278	40	Private	154374	HS-grad	9	Married-civ-spouse	Machine-op-inspct	Husband	White
22279	52	Self-emp-inc	287927	HS-grad	9	Married-civ-spouse	Exec-managerial	Wife	White

22280 rows × 15 columns

In [4]:
```
dataset.columns
```

Out[4]:
```
Index(['Age', 'workclass', 'fnlwgt', 'education', 'educational-num',
       'marital-status', 'occupation', 'relationship', 'race', 'gender',
       'capital-gain', 'capital-loss', 'hours-per-week', 'native-country',
       'income'],
      dtype='object')
```

In [5]:
```
dataset["hours-per-week"]=dataset["hours-per-week"].astype("object")
```

In [ ]:

PREPROCESSING

In [ ]:

In [6]:
```
dataset['hours-per-week'] = dataset['hours-per-week'].apply(lambda x: '<=40' if x
```

In [7]:
```
dataset
```

Out[7]:

	Age	workclass	fnlwgt	education	educational-num	marital-status	occupation	relationship	race
0	39	State-gov	77516	Bachelors	13	Never-married	Adm-clerical	Not-in-family	White
1	50	Self-emp-not-inc	83311	Bachelors	13	Married-civ-spouse	Exec-managerial	Husband	White
2	38	Private	215646	HS-grad	9	Divorced	Handlers-cleaners	Not-in-family	White
3	53	Private	234721	11th	7	Married-civ-spouse	Handlers-cleaners	Husband	Black
4	28	Private	338409	Bachelors	13	Married-civ-spouse	Prof-specialty	Wife	Black
...	...	...	...	...	...	...	...	...	...
22275	71	?	287372	Doctorate	16	Married-civ-spouse	?	Husband	White
22276	39	Local-gov	111499	Assoc-acdm	12	Married-civ-spouse	Adm-clerical	Wife	White
22277	53	Private	321865	Masters	14	Married-civ-spouse	Exec-managerial	Husband	White
22278	40	Private	154374	HS-grad	9	Married-civ-spouse	Machine-op-inspct	Husband	White
22279	52	Self-emp-inc	287927	HS-grad	9	Married-civ-spouse	Exec-managerial	Wife	White

22280 rows × 15 columns

In [ ]:

In [8]:
```
physical=['Farming-fishing',' Handlers-cleaners',' Machine-op-inspct','Armed-Forc
```

In [9]:
```
dataset['occupation'] = dataset['occupation'].apply(lambda x: 'physical' if x in
```

In [ ]:
```

```

In [10]:
```
dataset["Age"]=dataset["Age"].apply(lambda x:'<=40' if x<=40 else '>40')
```

In [11]:
```
dataset
```

Out[11]:

	Age	workclass	fnlwgt	education	educational-num	marital-status	occupation	relationship	race
0	<=40	State-gov	77516	Bachelors	13	Never-married	others	Not-in-family	White
1	>40	Self-emp-not-inc	83311	Bachelors	13	Married-civ-spouse	others	Husband	White
2	<=40	Private	215646	HS-grad	9	Divorced	physical	Not-in-family	White
3	>40	Private	234721	11th	7	Married-civ-spouse	physical	Husband	Black
4	<=40	Private	338409	Bachelors	13	Married-civ-spouse	others	Wife	Black
...	...	...	...	...	...	...	...	...	...
22275	>40	?	287372	Doctorate	16	Married-civ-spouse	others	Husband	White
22276	<=40	Local-gov	111499	Assoc-acdm	12	Married-civ-spouse	others	Wife	White
22277	>40	Private	321865	Masters	14	Married-civ-spouse	others	Husband	White
22278	<=40	Private	154374	HS-grad	9	Married-civ-spouse	physical	Husband	White
22279	>40	Self-emp-inc	287927	HS-grad	9	Married-civ-spouse	others	Wife	White

22280 rows × 15 columns

In [ ]:
```

```

Finding the Probablities of the each features

In [12]:
```
def probs(data, child, parent1=None, parent2=None):
    if parent1==None:
        # Calculate probabilities
        prob=pd.crosstab(data[child], 'Empty', margins=False, normalize='columns'
    elif parent1!=None:
            # Check if child node has 1 parent or 2 parents
            if parent2==None:
                # Caclucate probabilities
                prob=pd.crosstab(data[parent1],data[child], margins=False, norma
            else:
                # Caclucate probabilities
                prob=pd.crosstab([data[child],data[parent2]], data[parent1],margi
    else: print("Error in Probability Frequency Calculations")
    return prob
```

In [13]:
```
Age=BbnNode(Variable(0,'Age',['<=40','>40']),probs(dataset,child='Age'))
gender=BbnNode(Variable(1,'gender',['Male','Female']),probs(dataset,child='gender
occ=BbnNode(Variable(2,'occ',['physical','others']),probs(dataset,child='occupati
hours=BbnNode(Variable(3,'hours',['<=40','>40']),probs(dataset,child='hours-per-w
incom=BbnNode(Variable(4,'incom',['<=50','>50']),probs(dataset,child='gender',par


bbn = Bbn() \
    .add_node(Age) \
    .add_node(gender) \
    .add_node(occ) \
    .add_node(hours) \
    .add_node(incom) \
    .add_edge(Edge(Age, gender, EdgeType.DIRECTED)) \
    .add_edge(Edge(occ, hours, EdgeType.DIRECTED)) \
    .add_edge(Edge(gender, incom, EdgeType.DIRECTED)) \
    .add_edge(Edge(hours, incom, EdgeType.DIRECTED))

# Convert the BBN to a join tree
join_tree = InferenceController.apply(bbn)
```

In [ ]:

In [ ]:

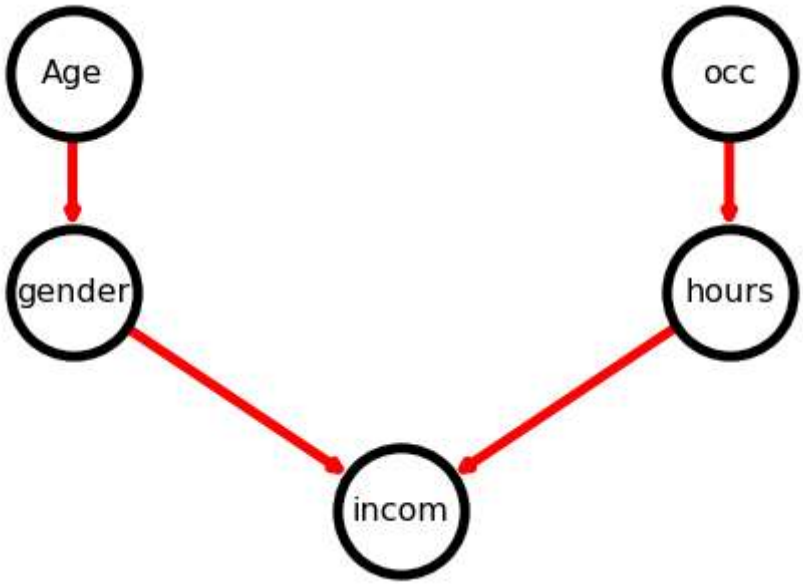
GRAPH

In [14]:
```
# Set node positions
pos = {0:(-1,2),1: (-1, 0.5), 2: (1, 2), 3: (1, 0.5), 4: (0, -1)}

# Set options for graph looks
options = {
    "font_size": 16,
    "node_size": 4000,
    "node_color": "white",
    "edgecolors": "black",
    "edge_color": "red",
    "linewidths": 5,
    "width": 5,}

# Generate graph
n, d = bbn.to_nx_graph()
nx.draw(n, with_labels=True, labels=d, pos=pos, **options)

# Update margins and print the graph
ax = plt.gca()
ax.margins(0.10)
plt.axis("off")
plt.show()
```



In [15]:
```
def print_probs():
    for node in join_tree.get_bbn_nodes():
        potential = join_tree.get_bbn_potential(node)
        print("Node: ", node)
        print("Values:")
        print(potential)
        print('----------------')

# Use the above function to print marginal probabilities
print_probs()
```

```
Node:  1|gender|Male,Female
Values:
1=Male|0.30489
1=Female|0.69511
----------------
Node:  0|Age|<=40,>40
Values:
0=<=40|0.55794
0=>40|0.44206
----------------
Node:  3|hours|<=40,>40
Values:
3=<=40|0.67774
3=>40|0.32226
----------------
Node:  2|occ|physical,others
Values:
2=physical|0.77724
2=others|0.22276
----------------
Node:  4|incom|<=50,>50
Values:
4=<=50|0.30489
4=>50|0.69511
----------------
```

In [16]:
```
def evidence(ev, nod, cat, val):
    ev = EvidenceBuilder().with_node(join_tree.get_bbn_node_by_name(nod)).with_ev
    join_tree.set_observation(ev)
```

In [ ]:
```
```

In [17]:
```
#p(occ|phy) and p(occ|oth)
p_age_yes=join_tree.get_bbn_potential(Age).entries[0].value;
p_age_no=join_tree.get_bbn_potential(Age).entries[1].value;
```

In [18]:
```
#p(gender|Age).p(Age)
evidence('ev1', 'Age', '<=40', 1.0)
p_gen_age_yes = join_tree.get_bbn_potential(hours).entries[1].value
join_tree.unobserve([occ])
#p(gender|~occ).p(Age)
evidence('ev1', 'Age', '>40', 1.0)
p_gen_age_no = join_tree.get_bbn_potential(hours).entries[1].value
join_tree.unobserve([occ])
```

Out[18]:
```
<pybbn.graph.jointree.JoinTree at 0x2211f069730>
```

In [ ]:
```

```

In [19]:
```
p_gender_male=p_gen_age_yes*p_age_yes + p_gen_age_no*p_age_no
print(p_gender_male)
```

```
0.3222621184919211
```

In [20]:
```
p_gender_female=1-p_gender_male
```

In [21]:
```
print(p_gender_female)
```

```
0.6777378815080789
```

In [22]:
```
# #p(gender|male) and p(gender|female)

# p_gender_male=join_tree.get_bbn_potential(gender).entries[0].value;
# p_gender_female=join_tree.get_bbn_potential(gender).entries[1].value;
```

In [ ]:
```

```

In [23]:
```
print(p_gen_age_yes)
```

```
0.32226211849192105
```

In [24]:
```
print(p_gen_age_no)
```

```
0.3222621184919211
```

In [25]:
```
print(join_tree.get_bbn_potential(gender))
```

```
1=Male|0.26155
1=Female|0.73845
```

In [26]:
```
#p(income|hours,male)
evidence('ev1', 'hours', '<=40', 1.0)
evidence('ev2', 'gender', 'Male', 1.0)
p_hours_yes_gender_male = join_tree.get_bbn_potential(incom).entries[1].value
join_tree.unobserve([hours, gender])

#p(income|hours,female)
evidence('ev1', 'hours', '<=40', 1.0)
evidence('ev2', 'gender', 'Female', 1.0)
p_hours_yes_gender_female = join_tree.get_bbn_potential(incom).entries[1].value
join_tree.unobserve([hours, gender])

#p(income|~hours,male)
evidence('ev1', 'hours', '>40', 1.0)
evidence('ev2', 'gender', 'Male', 1.0)
p_hours_no_gender_male = join_tree.get_bbn_potential(incom).entries[1].value
join_tree.unobserve([hours, gender])

#p(income|~hours,female)
evidence('ev1', 'hours', '>40', 1.0)
evidence('ev2', 'gender', 'Female', 1.0)
p_hours_no_gender_female = join_tree.get_bbn_potential(incom).entries[1].value
join_tree.unobserve([hours, gender])
```

Out[26]:
```
<pybbn.graph.jointree.JoinTree at 0x2211f069730>
```

In [27]:
```
#p(occ|phy) and p(occ|oth)
p_occ_phy=join_tree.get_bbn_potential(occ).entries[0].value;
p_occ_oth=join_tree.get_bbn_potential(occ).entries[1].value;
```

In [28]:
```
print(join_tree.get_bbn_potential(occ))
```

```
2=physical|0.77724
2=others|0.22276
```

In [ ]:

In [29]:
```
#p(hours|occ).p(occ)
evidence('ev1', 'occ', 'physical', 1.0)
p_hr_occ_phy = join_tree.get_bbn_potential(hours).entries[1].value
join_tree.unobserve([occ])



#p(hours|~occ).p(~occ)
evidence('ev1', 'occ', 'others', 1.0)
p_hr_occ_other = join_tree.get_bbn_potential(hours).entries[1].value
join_tree.unobserve([occ])
```

Out[29]:
```
<pybbn.graph.jointree.JoinTree at 0x2211f069730>
```

In [ ]:

In [30]:
```
p_hrs_yes=p_hr_occ_phy*p_occ_phy + p_hr_occ_other*p_occ_oth
p_hrs_yes
```

Out[30]: 0.322262118491921

In [31]:
```
p_hrs_no=1-p_hrs_yes
p_hrs_no
```

Out[31]: 0.677737881508079

In [ ]:

APPLYING ALL THE TERMS IN THE FORMULA

p_income_yes =
(p_hours_yes_gender_male*p_hrs_yes*p_gender_male)+
(p_hours_yes_gender_female*p_hrs_yes*p_gender_female)+
(p_hours_yes_gender_male*p_hrs_no*p_gender_male)+
(p_hours_yes_gender_female*p_hrs_no*p_gender_female)

In [ ]:

In [32]:
```
p_income_yes=(p_hours_yes_gender_male*p_hrs_yes*p_gender_male)+(p_hours_yes_gende
```

In [33]:
```
p_income_yes
```

Out[33]: 0.6777378815080789

In [34]:
```
p_income_no=1-p_income_yes
```

In [35]:
```
p_income_no
```

Out[35]: 0.3222621184919211

PROBABILITY OF INCOME <=50 IS

In [36]:
```
p_income_yes
```

Out[36]: 0.6777378815080789

In [ ]:

In [ ]:

Result

Thus, Bayesian Belief Network has been performed on the adult income dataset.

In [ ]: