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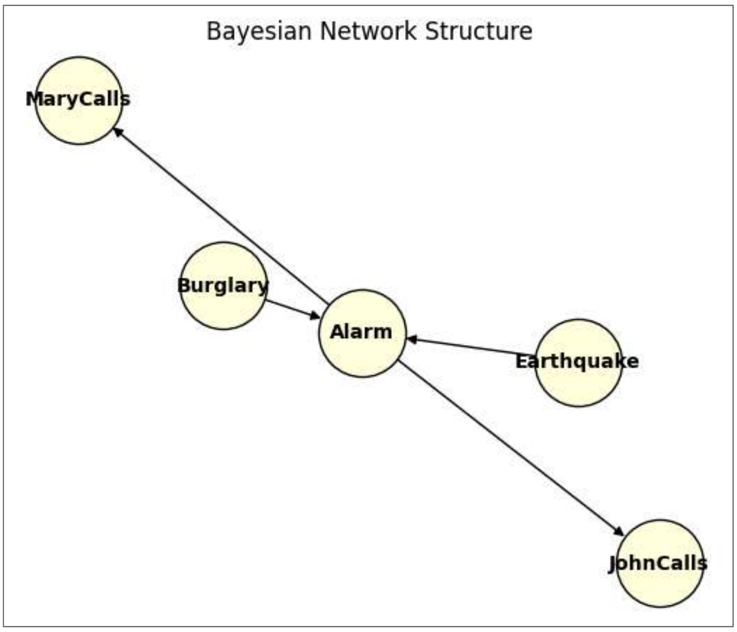
In [ ]:

```
# Import necessary modules
from pgmpy.models import DiscreteBayesianNetwork
from pgmpy.factors.discrete import TabularCPD
from pgmpy.inference import VariableElimination
import networkx as nx
import matplotlib.pyplot as plt

# Define the Bayesian Network structure
model = DiscreteBayesianNetwork([
    ('Burglary', 'Alarm'),
    ('Earthquake', 'Alarm'),
    ('Alarm', 'JohnCalls'),
    ('Alarm', 'MaryCalls')
])

# Define CPDs
cpd_burglary = TabularCPD(variable='Burglary', variable_card=2,
                           values=[[0.001], [0.999]],
                           state_names={'Burglary': ['True', 'False']})

cpd_earthquake = TabularCPD(variable='Earthquake', variable_card=2,
                             values=[[0.002], [0.998]],
                             state_names={'Earthquake': ['True', 'False']})

cpd_alarm = TabularCPD(variable='Alarm', variable_card=2,
                        values=[[0.95, 0.94, 0.29, 0.001],
                                [0.05, 0.06, 0.71, 0.999]],
                        evidence=['Burglary', 'Earthquake'],
                        evidence_card=[2, 2],
                        state_names={
                            'Alarm': ['True', 'False'],
                            'Burglary': ['True', 'False'],
                            'Earthquake': ['True', 'False']
                        })

cpd_johncalls = TabularCPD(variable='JohnCalls', variable_card=2,
                           values=[[0.90, 0.05],
                                   [0.10, 0.95]],
                           evidence=['Alarm'],
                           evidence_card=[2],
                           state_names={'JohnCalls': ['True', 'False'],
                                        'Alarm': ['True', 'False']})

cpd_marycalls = TabularCPD(variable='MaryCalls', variable_card=2,
                           values=[[0.70, 0.01],
                                   [0.30, 0.99]],
                           evidence=['Alarm'],
                           evidence_card=[2],
                           state_names={'MaryCalls': ['True', 'False'],
                                        'Alarm': ['True', 'False']})

# Add CPDs to the model
model.add_cpds(cpd_burglary, cpd_earthquake, cpd_alarm, cpd_johncalls, cpd_marycalls)

# Validate the model
assert model.check_model(), "Model is incorrect or incomplete"

# iii. Display Network Structure
```

```python
print("\nNetwork Structure (Edges):")
print(model.edges())

# Visualize the Bayesian Network (improved layout)
plt.figure(figsize=(5, 4))
G = nx.DiGraph()
G.add_edges_from(model.edges())
pos = nx.spring_layout(G, seed=42)  # Better layout
nx.draw(G, pos, with_labels=True, node_color='lightyellow',
        node_size=2000, font_size=10, font_weight='bold', edgecolors='black')
plt.title("Bayesian Network Structure")
plt.show()

# iv. Display Conditional Probability Tables
print("\nConditional Probability Tables (CPDs):")
for cpd in model.get_cpds():
    print("\n", cpd)

# Inference setup
infer = VariableElimination(model)

# Queries
q1 = infer.query(['Burglary'], evidence={'JohnCalls': 'True'})
print("\nP(Burglary | JohnCalls=True):")
print(q1)

q2 = infer.query(['Burglary'], evidence={'JohnCalls': 'False', 'MaryCalls': 'True'})
print("\nP(Burglary | JohnCalls=False, MaryCalls=True):")
print(q2)

q3 = infer.query(['Earthquake'], evidence={'JohnCalls': 'True', 'MaryCalls': 'True'})
print("\nP(Earthquake | JohnCalls=True, MaryCalls=True):")
print(q3)

q4 = infer.query(['Alarm'], evidence={'Burglary': 'True', 'Earthquake': 'True'})
print("\nP(Alarm | Burglary=True, Earthquake=True):")
print(q4)

q5 = infer.query(['Burglary'], evidence={'JohnCalls': 'True', 'MaryCalls': 'True'})
print("\nP(Burglary | JohnCalls=True, MaryCalls=True):")
print(q5)
```

```
Network Structure (Edges):
[('Burglary', 'Alarm'), ('Alarm', 'JohnCalls'), ('Alarm', 'MaryCalls'), ('E
arthquake', 'Alarm')]
```



```
Conditional Probability Tables (CPDs):

 +-----------------+-------+
| Burglary(True)  | 0.001 |
+-----------------+-------+
| Burglary(False) | 0.999 |
+-----------------+-------+

 +-------------------+-------+
| Earthquake(True)  | 0.002 |
+-------------------+-------+
| Earthquake(False) | 0.998 |
+-------------------+-------+

 +--------------+------------------+-----+-------------------+
| Burglary     | Burglary(True)   | ... | Burglary(False)   |
+--------------+------------------+-----+-------------------+
| Earthquake   | Earthquake(True) | ... | Earthquake(False) |
+--------------+------------------+-----+-------------------+
| Alarm(True)  | 0.95             | ... | 0.001             |
+--------------+------------------+-----+-------------------+
| Alarm(False) | 0.05             | ... | 0.999             |
+--------------+------------------+-----+-------------------+

 +------------------+-------------+--------------+
| Alarm            | Alarm(True) | Alarm(False) |
+------------------+-------------+--------------+
| JohnCalls(True)  | 0.9         | 0.05         |
+------------------+-------------+--------------+
| JohnCalls(False) | 0.1         | 0.95         |
+------------------+-------------+--------------+

 +------------------+-------------+--------------+
| Alarm            | Alarm(True) | Alarm(False) |
+------------------+-------------+--------------+
| MaryCalls(True)  | 0.7         | 0.01         |
+------------------+-------------+--------------+
| MaryCalls(False) | 0.3         | 0.99         |
+------------------+-------------+--------------+

P(Burglary | JohnCalls=True):
+-----------------+-----------------+
| Burglary        |   phi(Burglary) |
+=================+=================+
| Burglary(True)  |          0.0163 |
+-----------------+-----------------+
| Burglary(False) |          0.9837 |
+-----------------+-----------------+

P(Burglary | JohnCalls=False, MaryCalls=True):
+-----------------+-----------------+
| Burglary        |   phi(Burglary) |
+=================+=================+
| Burglary(True)  |          0.0069 |
+-----------------+-----------------+
| Burglary(False) |          0.9931 |
+-----------------+-----------------+

P(Earthquake | JohnCalls=True, MaryCalls=True):
+-------------------+-------------------+
| Earthquake        |   phi(Earthquake) |
+===================+===================+
| Earthquake(True)  |            0.1761 |
+-------------------+-------------------+
| Earthquake(False) |            0.8239 |
+-------------------+-------------------+
P(Alarm | Burglary=True, Earthquake=True):
+--------------+--------------+
| Alarm        |   phi(Alarm) |
+==============+==============+
| Alarm(True)  |       0.9500 |
+--------------+--------------+
| Alarm(False) |       0.0500 |
+--------------+--------------+

P(Burglary | JohnCalls=True, MaryCalls=True):
+-----------------+-----------------+
| Burglary        |   phi(Burglary) |
+=================+=================+
| Burglary(True)  |          0.2842 |
+-----------------+-----------------+
| Burglary(False) |          0.7158 |
+-----------------+-----------------+
```