

# DATA MINING

# LECTURE 2

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## **Classification**

Basic Concepts

Decision Trees

# Catching tax-evasion

<i>Tid</i>	Refund	Marital Status	Taxable Income	Cheat
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes

Tax-return data for year 2011

A new tax return for 2012  
Is this a cheating tax return?

Refund	Marital Status	Taxable Income	Cheat
No	Married	80K	?

An instance of the classification problem: learn a method for discriminating between records of different **classes** (**cheaters** vs **non-cheaters**)

# What is classification?

- **Classification** is the task of *learning a target function  $f$*  that maps attribute set  $x$  to one of the predefined class labels  $y$

categorical  
categorical  
continuous  
class

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One of the attributes is the **class attribute**  
In this case: Cheat

Two **class labels** (or **classes**): **Yes (1)**, **No (0)**

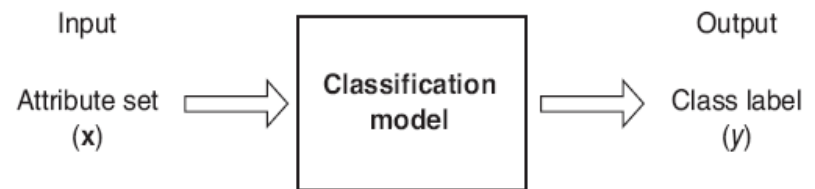


Figure 4.2. Classification as the task of mapping an input attribute set  $x$  into its class label  $y$ .

# Why classification?

- The target function  $f$  is known as a **classification model**
- **Descriptive modeling:** **Explanatory tool** to distinguish between objects of different classes (e.g., understand why people cheat on their taxes)
- **Predictive modeling:** Predict a class of a **previously unseen** record

# Examples of Classification Tasks

- Predicting tumor cells as benign or malignant
- Classifying credit card transactions as legitimate or fraudulent
- Categorizing news stories as finance, weather, entertainment, sports, etc
- Identifying spam email, spam web pages, adult content
- Understanding if a web query has commercial intent or not

# General approach to classification

- **Training set** consists of records with **known class labels**
- Training set is used to **build** a classification model
- A **labeled test set** of **previously unseen** data records is used to **evaluate** the quality of the model.
- The classification model is **applied** to new records with **unknown class labels**

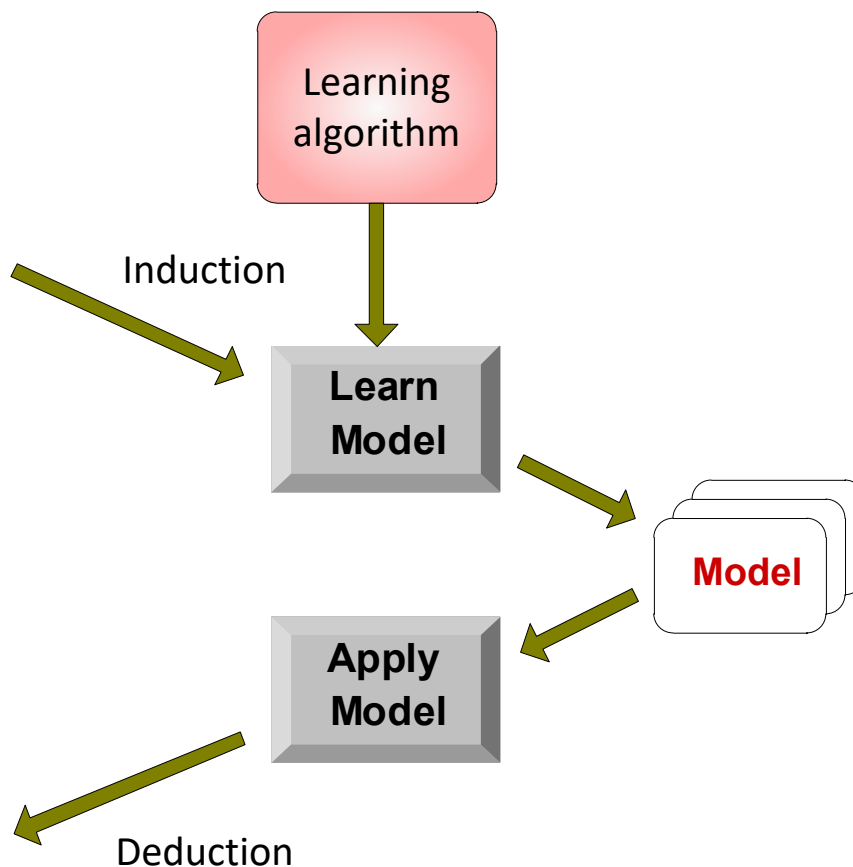
# Illustrating Classification Task

Tid	Attrib1	Attrib2	Attrib3	Class
1	Yes	Large	125K	No
2	No	Medium	100K	No
3	No	Small	70K	No
4	Yes	Medium	120K	No
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7	Yes	Large	220K	No
8	No	Small	85K	Yes
9	No	Medium	75K	No
10	No	Small	90K	Yes

Training Set

Tid	Attrib1	Attrib2	Attrib3	Class
11	No	Small	55K	?
12	Yes	Medium	80K	?
13	Yes	Large	110K	?
14	No	Small	95K	?
15	No	Large	67K	?

Test Set



# Evaluation of classification models

- Counts of **test records** that are correctly (or incorrectly) predicted by the classification model
- **Confusion matrix**

		Predicted Class	
		Class = 1	Class = 0
Actual Class	Class = 1	$f_{11}$	$f_{10}$
	Class = 0	$f_{01}$	$f_{00}$

$$\text{Accuracy} = \frac{\# \text{ correct predictions}}{\text{total \# of predictions}} = \frac{f_{11} + f_{00}}{f_{11} + f_{10} + f_{01} + f_{00}}$$

$$\text{Error rate} = \frac{\# \text{ wrong predictions}}{\text{total \# of predictions}} = \frac{f_{10} + f_{01}}{f_{11} + f_{10} + f_{01} + f_{00}}$$



# Classification Techniques

- Decision Tree based Methods
- Rule-based Methods
- Memory based reasoning
- Neural Networks
- Naïve Bayes and Bayesian Belief Networks
- Support Vector Machines

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# Decision Trees

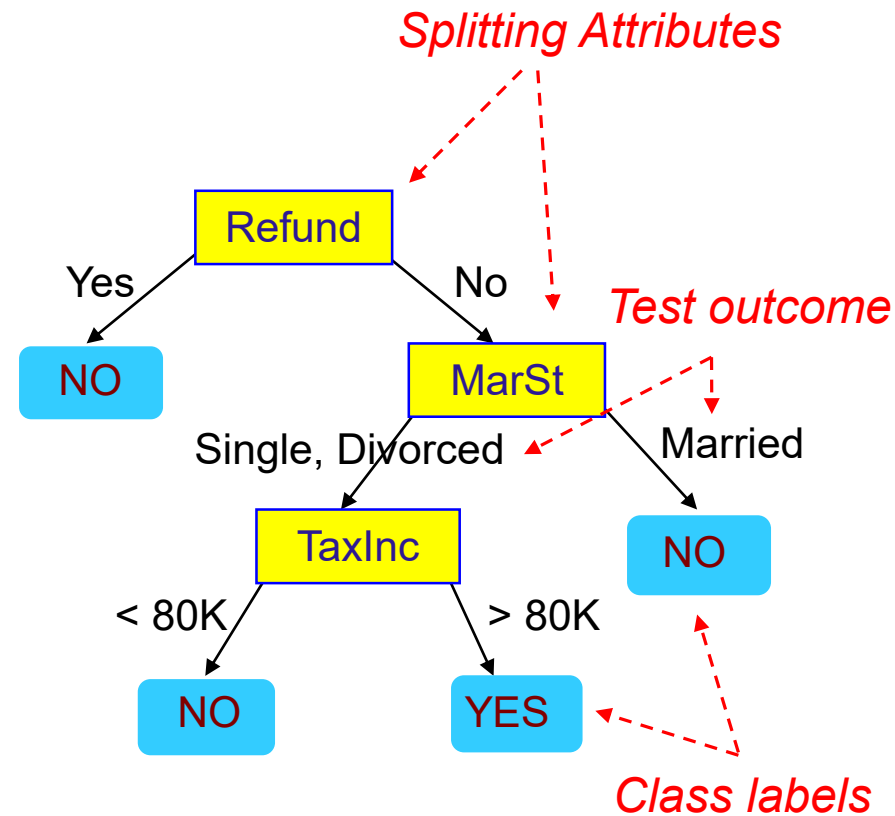
- Decision tree
  - A **flow-chart-like tree** structure
  - **Internal node** denotes a **test on an attribute**
  - **Branch** represents an **outcome of the test**
  - **Leaf nodes** represent **class labels** or class distribution

# Example of a Decision Tree

categorical  
categorical  
continuous  
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Training Data

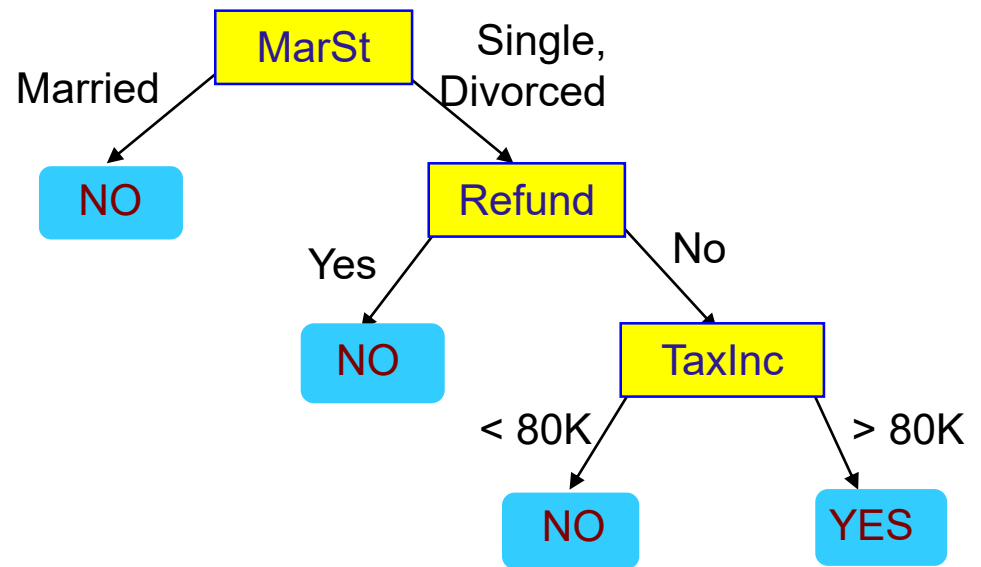


Model: Decision Tree

# Another Example of Decision Tree

categorical  
categorical  
continuous  
class

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There could be more than one tree that fits the same data!

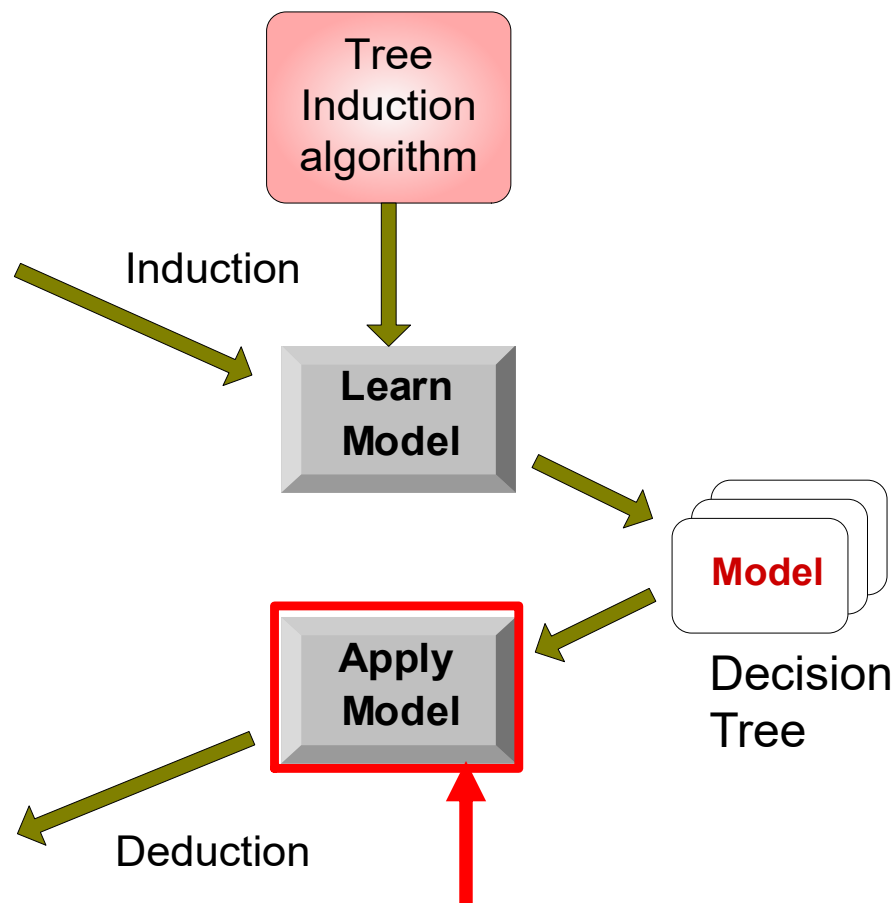
# Decision Tree Classification Task

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Training Set

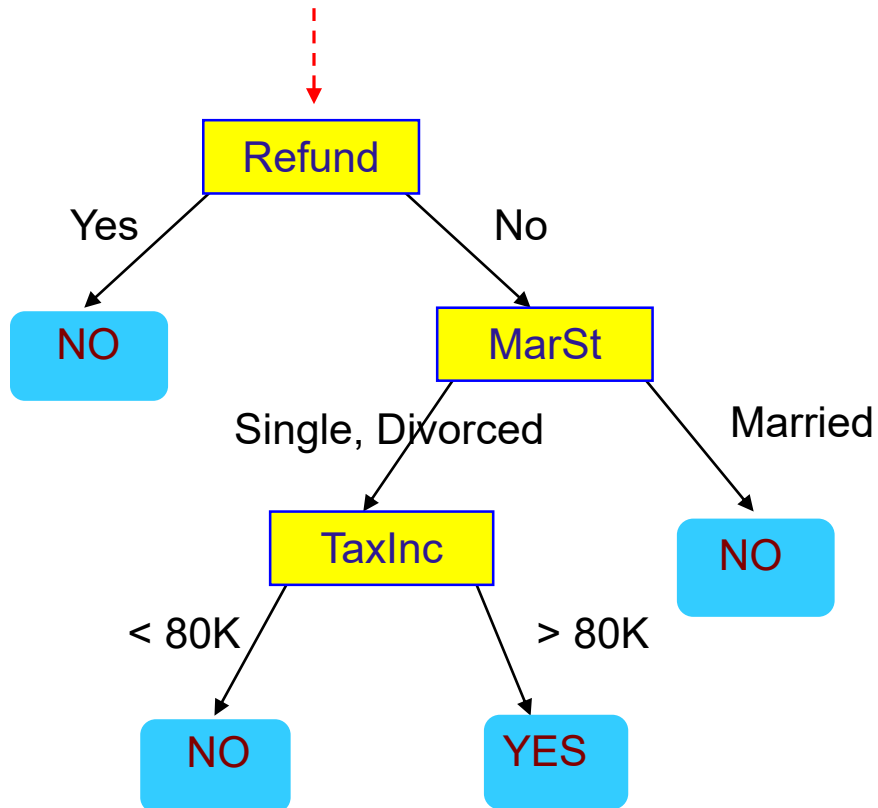
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Test Set



# Apply Model to Test Data

Start from the root of tree.



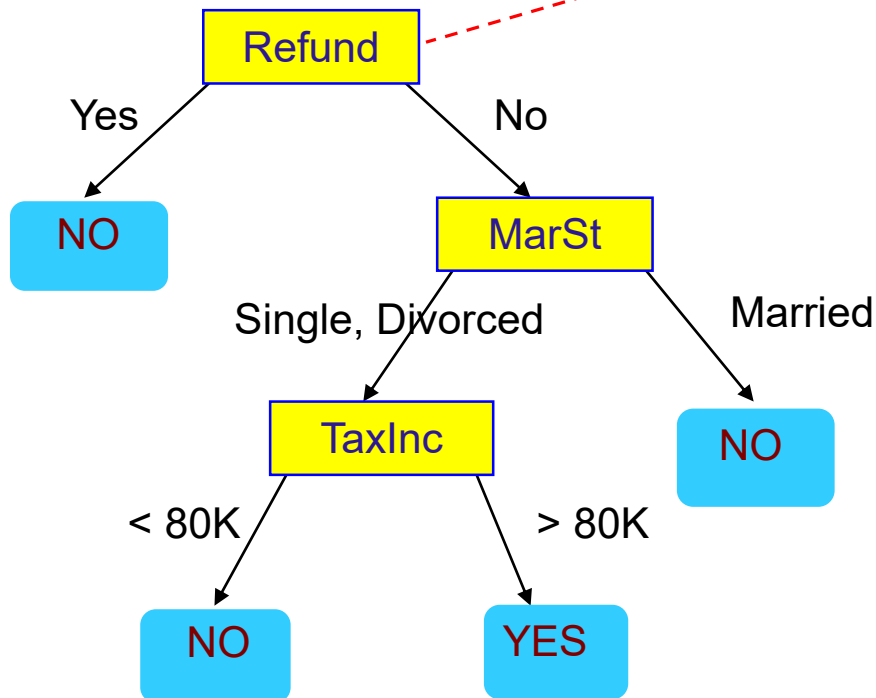
Test Data

Refund	Marital Status	Taxable Income	Cheat
No	Married	80K	?

# Apply Model to Test Data

Test Data

Refund	Marital Status	Taxable Income	Cheat
No	Married	80K	?

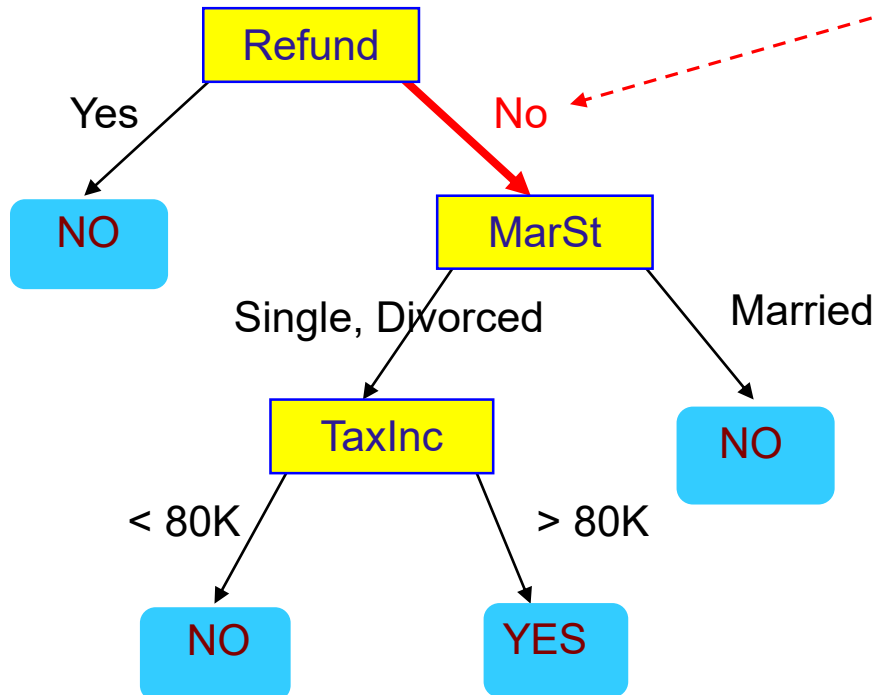




# Apply Model to Test Data

Test Data

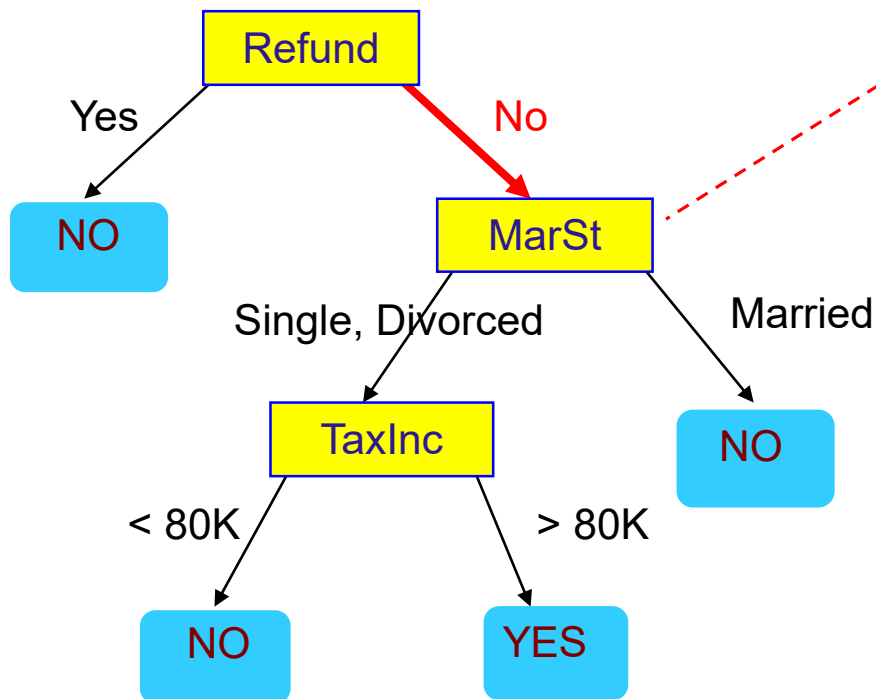
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# Apply Model to Test Data

Test Data

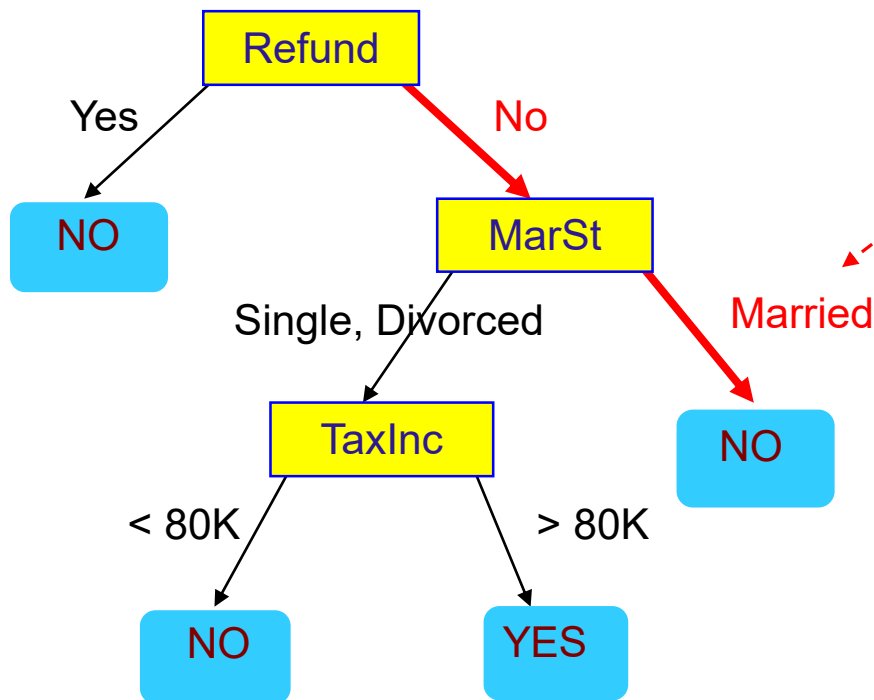
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# Apply Model to Test Data

Test Data

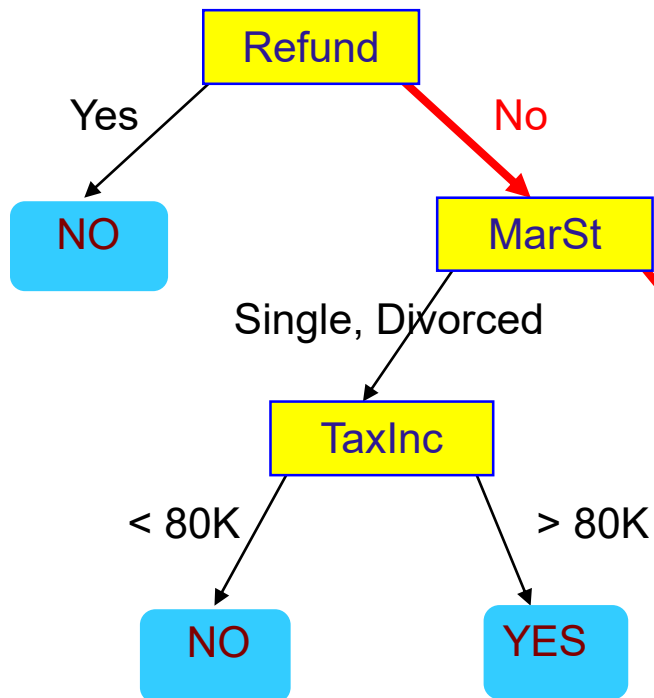
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# Apply Model to Test Data

Test Data

Refund	Marital Status	Taxable Income	Cheat
No	Married	80K	?



Assign Cheat to "No"

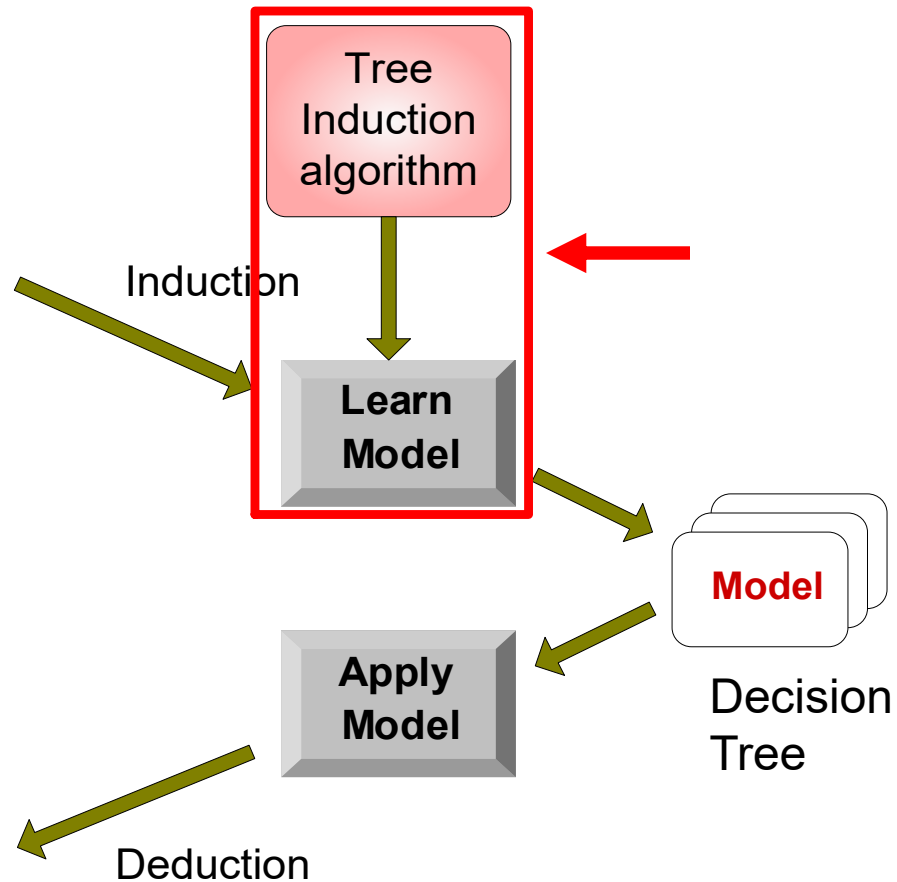
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Test Set



# Tree Induction

- Finding the best decision tree is **NP-hard**
- **Greedy** strategy.
  - Split the records based on an attribute test that optimizes **certain criterion**.
- Many Algorithms:
  - Hunt's Algorithm (one of the earliest)
  - CART
  - ID3, C4.5
  - SLIQ, SPRINT

# Decision Tree Based Classification

- Advantages:
  - Inexpensive to construct
  - Extremely fast at classifying unknown records
  - Easy to interpret for small-sized trees
  - Accuracy is comparable to other classification techniques for many simple data sets

# Example: C4.5

- Simple depth-first construction.
- Uses Information Gain
- Sorts Continuous Attributes at each node.
- Needs entire data to fit in memory.
- Unsuitable for Large Datasets.
  - Needs out-of-core sorting.
- You can download the software from:  
<http://www.cse.unsw.edu.au/~quinlan/c4.5r8.tar.gz>