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In [ ]:
```
import graphviz
import numpy as np
import pandas as pd
from sklearn import tree
from sklearn import preprocessing
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import train_test_split
from yellowbrick.classifier import ClassificationReport

import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
data = pd.read_csv('grades.csv')
```

In [3]:
```
data.head()
```

Out[3]:

	PUPIL_SEX	PUPIL_CLASS	TEACHER_RIGHT	TEACHER_CHK	TEACHER_QUEST	TEACHER_CORR
0	F	8A	65	0	4	2
1	F	8A	70	4	0	4
2	F	8A	85	0	0	4
3	M	8A	55	0	0	1
4	M	8A	40	1	2	0

В данных отсутствуют пропуски

In [4]:
```
data.isnull().sum().sort_values(ascending=False)
```

Out[4]:
```
PUPIL_SEX        0
PUPIL_CLASS      0
TEACHER_RIGHT    0
TEACHER_CHK      0
TEACHER_QUEST    0
TEACHER_CORR     0
PUPIL_CORR       0
PUPIL_STRIP      0
GRADE            0
dtype: int64
```

In [5]:
```
X = data[['PUPIL_SEX',
          'PUPIL_CLASS',
          'TEACHER_RIGHT',
          'TEACHER_CHK',
          'TEACHER_QUEST',
          'TEACHER_CORR',
```

```
           'PUPIL_CORR',
           'PUPIL_STRIP']]

y = data['GRADE']
```

Кодируем категориальные признаки

In [6]:
```
le = preprocessing.LabelEncoder()

X['PUPIL_SEX'] = le.fit_transform(data['PUPIL_SEX'])
print({sex: i for i, sex in enumerate(le.inverse_transform([0, 1]))})

X['PUPIL_CLASS'] = le.fit_transform(data['PUPIL_CLASS'])
print({cl: i for i, cl in enumerate(le.inverse_transform([0, 1]))})

y = le.fit_transform(data['GRADE'])
print({grade: i for i, grade in enumerate(le.inverse_transform([0, 1, 2, 3, 4, 5
```

```
{'F': 0, 'M': 1}
{'8A': 0, '8B': 1}
{'2': 0, '3': 1, '3-': 2, '4': 3, '4-': 4, '5': 5, '5-': 6}
```

Строим дерево решений на всех данных

Такое дерево идеально разобьет имеющиеся данные на классы, но не сможет давать качественные результаты на новых данных

In [7]:
```
tree_clf = tree.DecisionTreeClassifier()
tree_clf = tree_clf.fit(X, y)
```

In [8]:
```
dot_data = tree.export_graphviz(tree_clf, out_file=None,
                                feature_names=data.columns.values[:-1],
                                class_names=le.inverse_transform([0, 1, 2, 3, 4,
                                filled=True, rounded=True,
                                special_characters=True)
graph = graphviz.Source(dot_data)
graph.render("grades-100")
```

Out[8]: 'grades-100.pdf'

In [9]:
```
def build_tree(X, y, test_size, criterion):
    class_names = le.inverse_transform([0, 1, 2, 3, 4, 5, 6])

    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=test_siz

    print(y_train.shape, y_test.shape)

    param_grid = [{
             'max_depth':[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15],
             'min_samples_leaf':[1, 2, 3, 4, 5, 6, 7, 8, 9, 10],
            }]

    tree_clf = tree.DecisionTreeClassifier(criterion=criterion, random_state=1)

    grid_search = GridSearchCV(tree_clf, param_grid, cv=2, n_jobs=12)
```

```
    grid_search.fit(X_train, y_train)

    max_depth = grid_search.best_params_['max_depth']
    min_samples_leaf = grid_search.best_params_['min_samples_leaf']
    tree_clf_unf = tree.DecisionTreeClassifier(criterion=criterion, max_depth=ma
                                               min_samples_leaf=min_samples_leaf,
                                               random_state=1)
    tree_clf = tree_clf_unf.fit(X_train, y_train)

    dot_data = tree.export_graphviz(tree_clf, out_file=None,
                                    feature_names=data.columns.values[:-1],
                                    class_names=class_names,
                                    filled=True, rounded=True,
                                    special_characters=True)
    graph = graphviz.Source(dot_data)
    graph.render(f"grades-{int(100 * (1 - test_size))}:{int(100 * test_size)}-{c


    vis = ClassificationReport(tree_clf_unf, classes=class_names)

    vis.fit(X_train, y_train)
    acc = vis.score(X_test, y_test)
    print(f'Accuracy {round(acc, 5)} with split = {int(100 * (1 - test_size))}:{
    vis.show()
    print('-----------------------------------------------------------------')
```

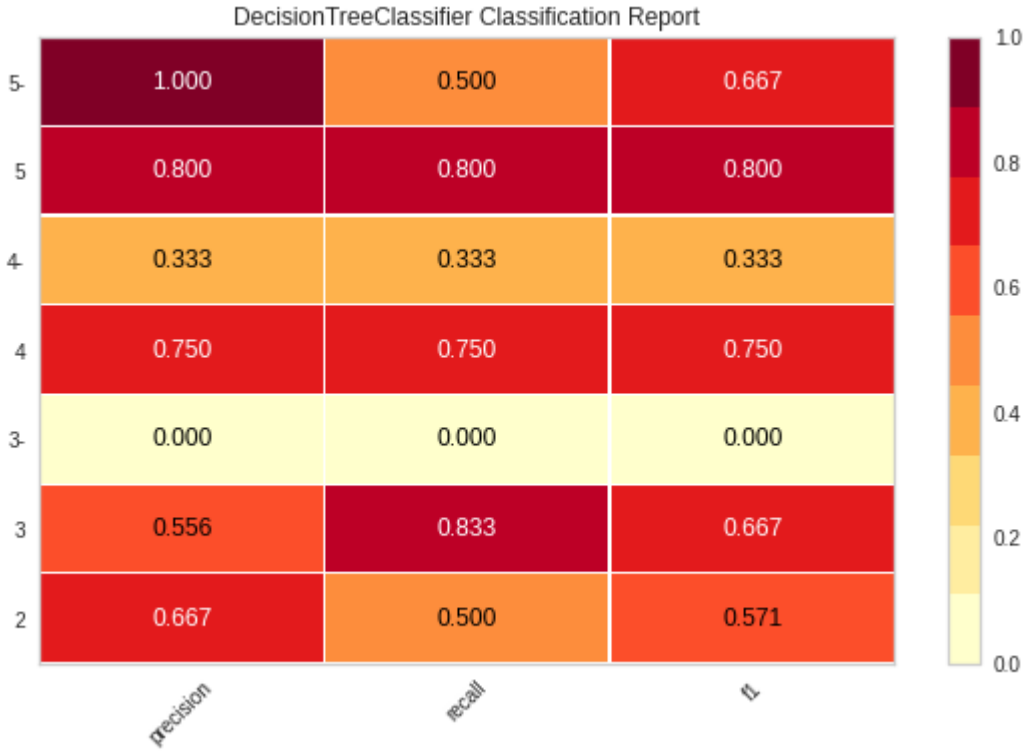
Строим дерево решений для части данных (метрика entropy)

Видно, что наиболее удачным является разбиение данных в соотношении 70 на 30 (70 - обучение, 30 - тестирование), с точностью (accuracy) 68%. При выделении большего кол-ва данных на обучающую выборку (80% - 90%) точность снижается, что говорит о переобучении.

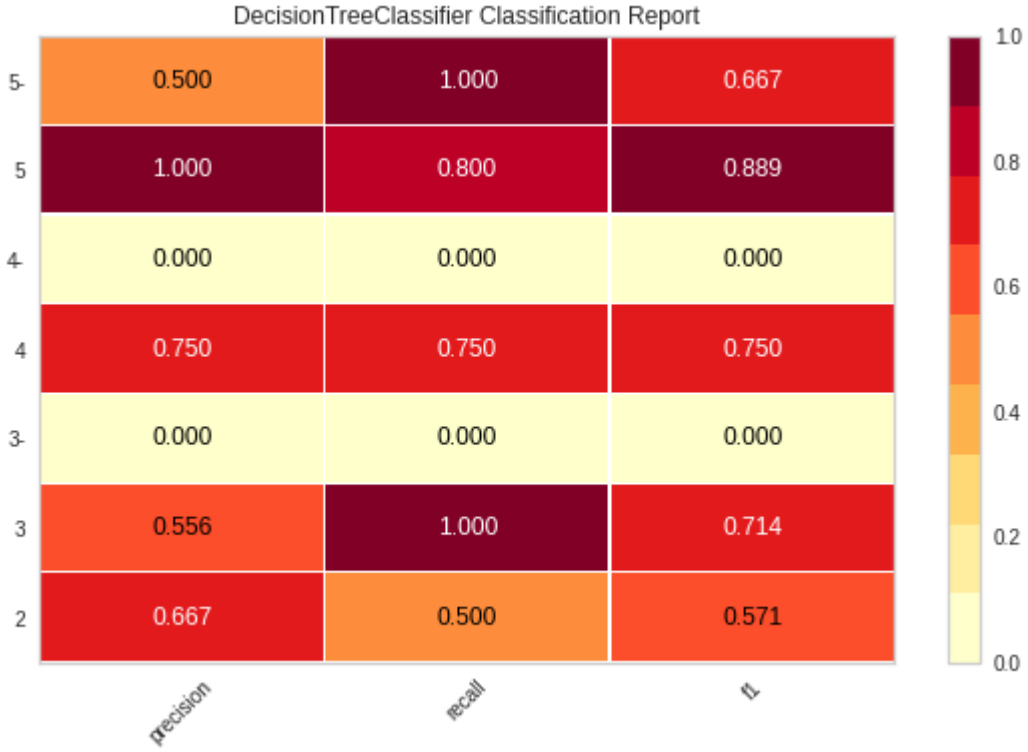
Так же можно заметить, что в отчетах классификации у некоторых классов возникают нули, это означает, что данных класс не был предсказан ни разу и невозможно посчитать для него метрику. Это происходит из-за малого количества данных

In [10]:
```
for spl in range(4, 0, -1):
    build_tree(X, y, round(spl * 0.1, 1), 'entropy')
```

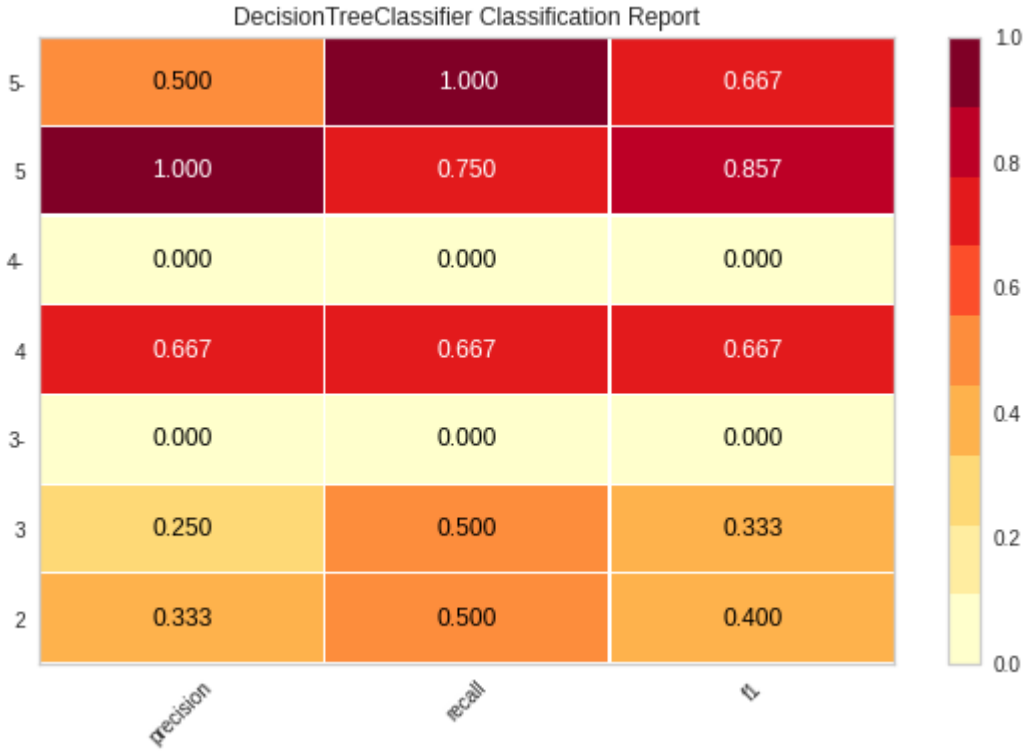
```
(43,) (29,)
Accuracy 0.65517 with split = 60:40 and criterion = entropy
```



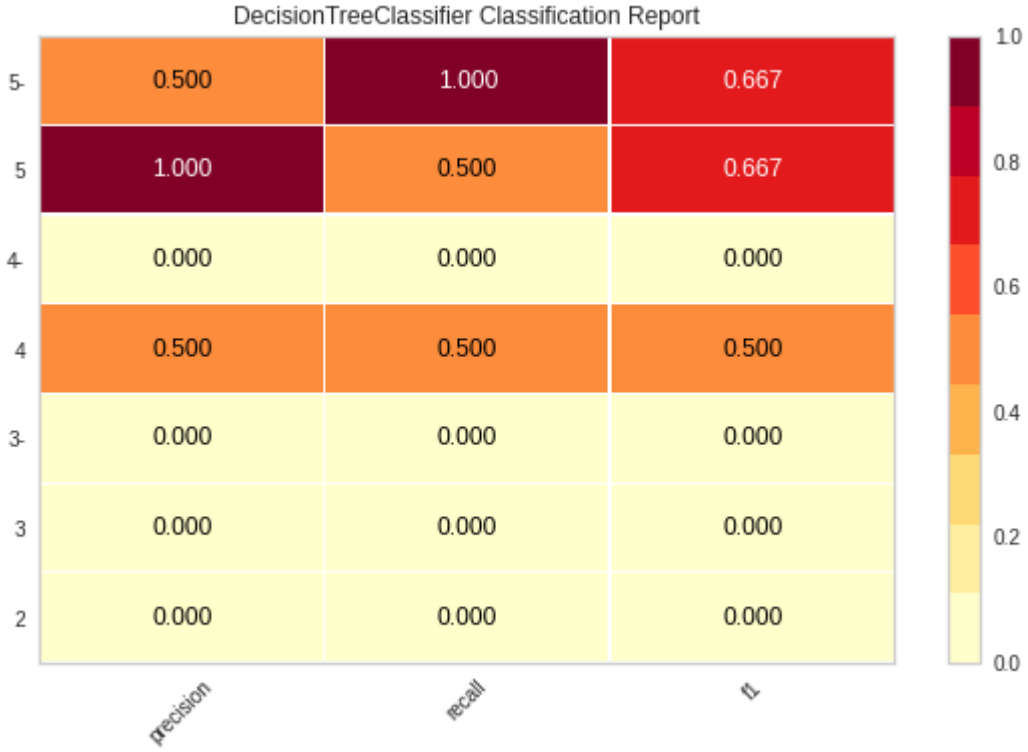
```
(50,) (22,)
Accuracy 0.68182 with split = 70:30 and criterion = entropy
```



```
(57,) (15,)
Accuracy 0.53333 with split = 80:20 and criterion = entropy
```



```
(64,) (8,)
Accuracy 0.375 with split = 90:10 and criterion = entropy
```



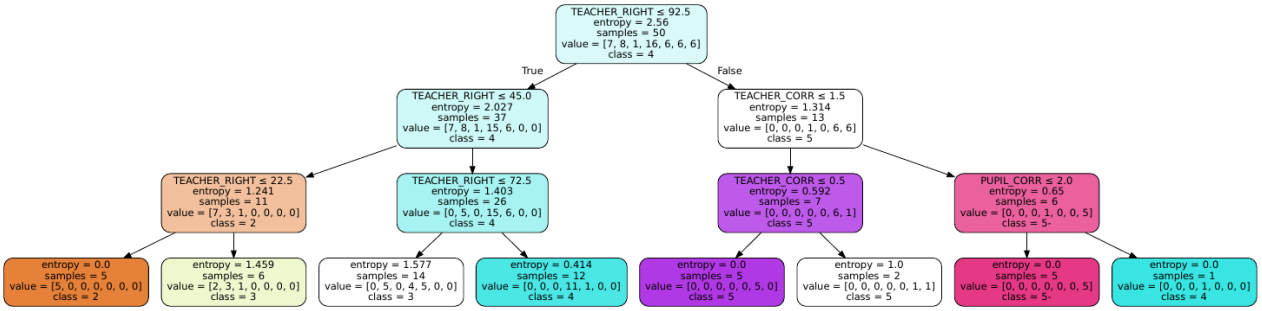
Построенное дерево решений с лучшими результатами классификации

Accuracy - 68%, Criterion - entropy, train test split - 70/30

In [4]:

```
from IPython.display import Image
Image(filename='grades-70:30-entropy.png')
```

Out[4]:



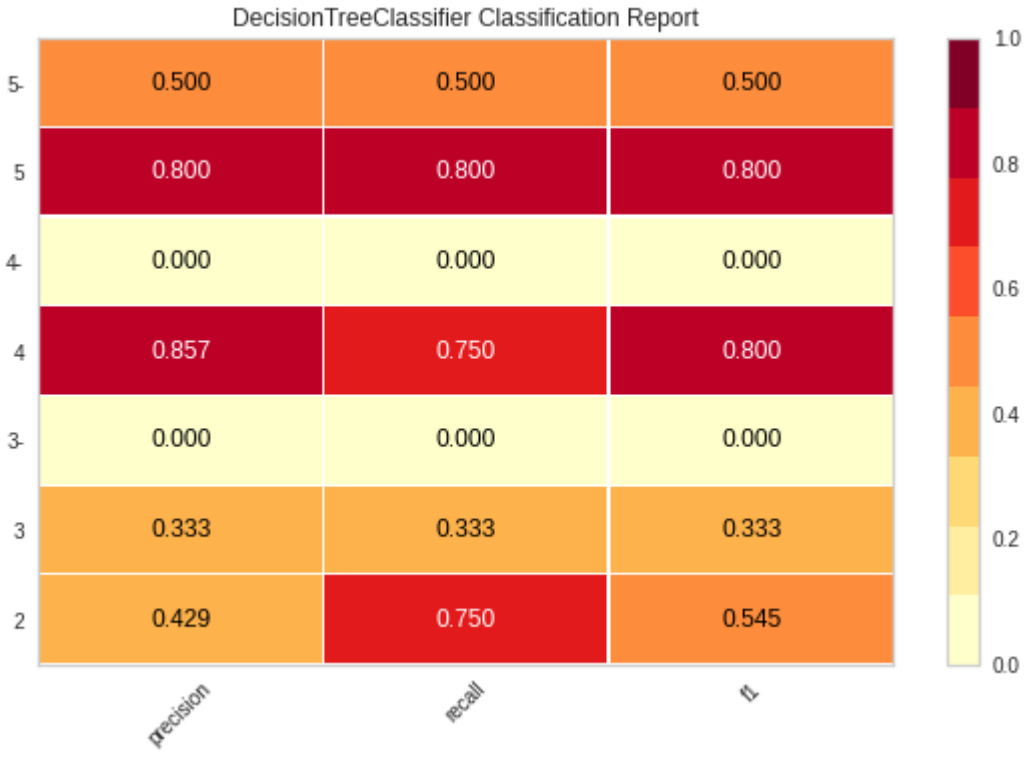
Строим дерево решений для части данных (метрика gini)

Для метрики "gini" получаем примерно схожие результаты

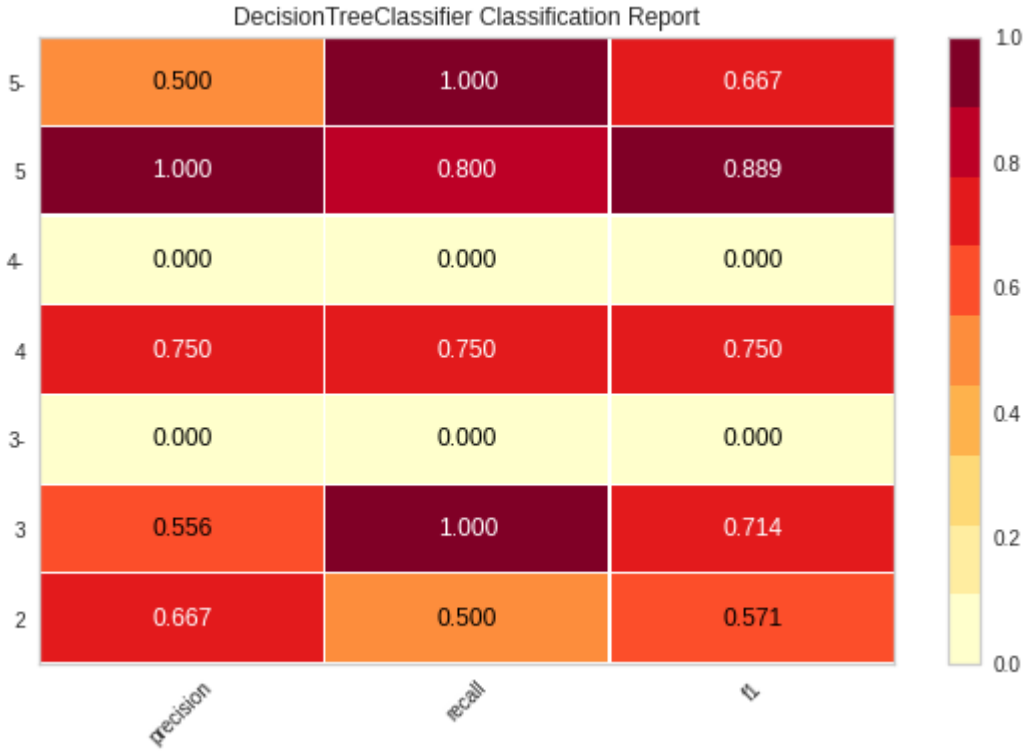
In [11]:

```
for spl in range(4, 0, -1):
    build_tree(X, y, round(spl * 0.1, 1), 'gini')
```

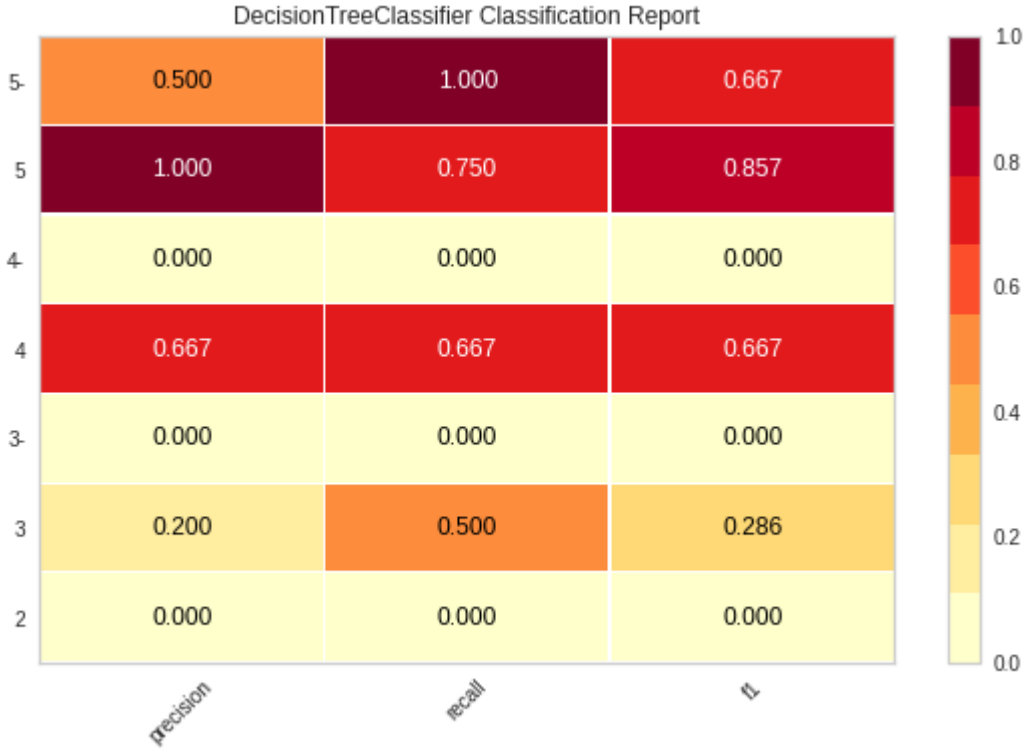
```
(43,) (29,)
Accuracy 0.55172 with split = 60:40 and criterion = gini
```



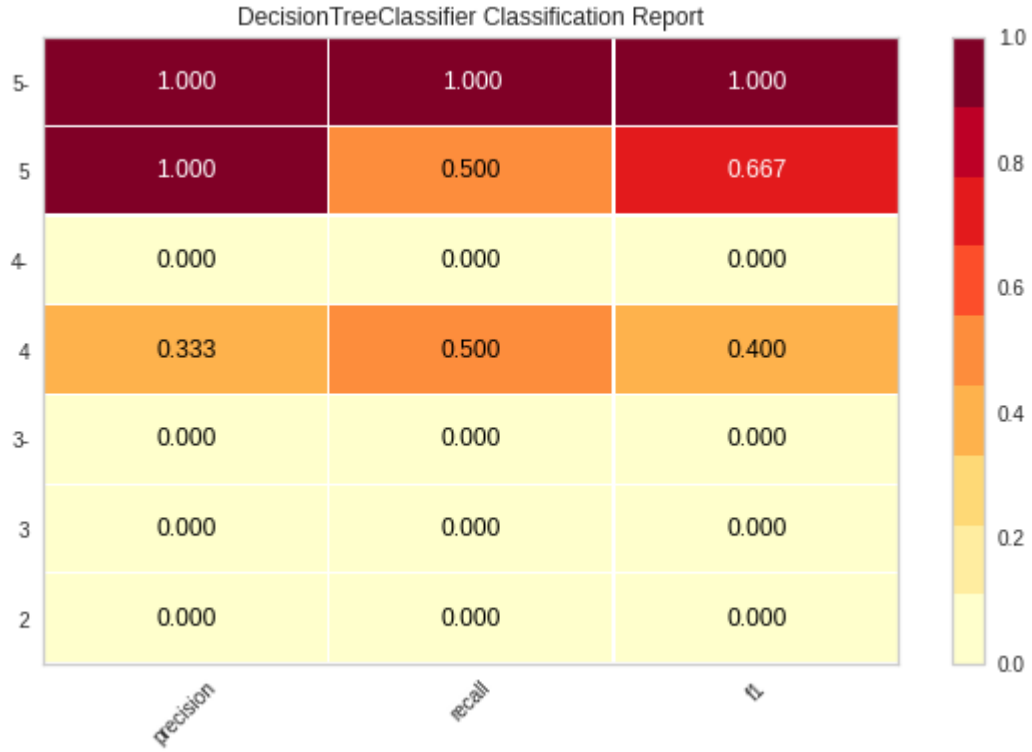

```
----------------------------------------------------------------------
(50,) (22,)
Accuracy 0.68182 with split = 70:30 and criterion = gini
```



```
(57,) (15,)
Accuracy 0.46667 with split = 80:20 and criterion = gini
```



```
(64,) (8,)
Accuracy 0.375 with split = 90:10 and criterion = gini
```



Построенное дерево решений с лучшими результатами классификации

Accuracy - 68%, Criterion - gini, train test split - 70/30

In [8]:
```
Image(filename='grades-70:30-gini.png')
```

Out[8]: