In [1]:
```
import pandas as pd
import numpy as np
```

In [2]:
```
names=[
    'CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM',
    'AGE',  'DIS', 'RAD', 'TAX', 'PTRATIO', 'B', 'LSTAT', 'PRICE'
]
df = pd.read_csv('https://archive.ics.uci.edu/ml/machine-learning-databases/housi
ng/housing.data',header=None,delim_whitespace=True,names=names,na_values='?')
```

In [3]:
```
df.head(6)
```

Out[3]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT	PR
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296.0	15.3	396.90	4.98	24.
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242.0	17.8	396.90	9.14	21.
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242.0	17.8	392.83	4.03	34.
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222.0	18.7	394.63	2.94	33.
4	0.06905	0.0	2.18	0	0.458	7.147	54.2	6.0622	3	222.0	18.7	396.90	5.33	36.
5	0.02985	0.0	2.18	0	0.458	6.430	58.7	6.0622	3	222.0	18.7	394.12	5.21	28.

In [4]:
```
df.shape
```

Out[4]:
```
(506, 14)
```

In [5]:
```
sample=df.iloc[:,0].size
attribute=df.columns.size
print('num samples={0:1.0f}, num attributes={1:1.0f}'.format(sample,attribute))
```

```
num samples=506, num attributes=14
```

In [6]:
```
y=np.array(df.PRICE)
print(y)
```

```
[ 24.   21.6  34.7  33.4  36.2  28.7  22.9  27.1  16.5  18.9  15.   18.9
  21.7  20.4  18.2  19.9  23.1  17.5  20.2  18.2  13.6  19.6  15.2  14.5
  15.6  13.9  16.6  14.8  18.4  21.   12.7  14.5  13.2  13.1  13.5  18.9
  20.   21.   24.7  30.8  34.9  26.6  25.3  24.7  21.2  19.3  20.   16.6
  14.4  19.4  19.7  20.5  25.   23.4  18.9  35.4  24.7  31.6  23.3  19.6
  18.7  16.   22.2  25.   33.   23.5  19.4  22.   17.4  20.9  24.2  21.7
  22.8  23.4  24.1  21.4  20.   20.8  21.2  20.3  28.   23.9  24.8  22.9
  23.9  26.6  22.5  22.2  23.6  28.7  22.6  22.   22.9  25.   20.6  28.4
  21.4  38.7  43.8  33.2  27.5  26.5  18.6  19.3  20.1  19.5  19.5  20.4
  19.8  19.4  21.7  22.8  18.8  18.7  18.5  18.3  21.2  19.2  20.4  19.3
  22.   20.3  20.5  17.3  18.8  21.4  15.7  16.2  18.   14.3  19.2  19.6
  23.   18.4  15.6  18.1  17.4  17.1  13.3  17.8  14.   14.4  13.4  15.6
  11.8  13.8  15.6  14.6  17.8  15.4  21.5  19.6  15.3  19.4  17.   15.6
  13.1  41.3  24.3  23.3  27.   50.   50.   50.   22.7  25.   50.   23.8
  23.8  22.3  17.4  19.1  23.1  23.6  22.6  29.4  23.2  24.6  29.9  37.2
  39.8  36.2  37.9  32.5  26.4  29.6  50.   32.   29.8  34.9  37.   30.5
  36.4  31.1  29.1  50.   33.3  30.3  34.6  34.9  32.9  24.1  42.3  48.5
  50.   22.6  24.4  22.5  24.4  20.   21.7  19.3  22.4  28.1  23.7  25.
  23.3  28.7  21.5  23.   26.7  21.7  27.5  30.1  44.8  50.   37.6  31.6
  46.7  31.5  24.3  31.7  41.7  48.3  29.   24.   25.1  31.5  23.7  23.3
  22.   20.1  22.2  23.7  17.6  18.5  24.3  20.5  24.5  26.2  24.4  24.8
  29.6  42.8  21.9  20.9  44.   50.   36.   30.1  33.8  43.1  48.8  31.
  36.5  22.8  30.7  50.   43.5  20.7  21.1  25.2  24.4  35.2  32.4  32.
  33.2  33.1  29.1  35.1  45.4  35.4  46.   50.   32.2  22.   20.1  23.2
  22.3  24.8  28.5  37.3  27.9  23.9  21.7  28.6  27.1  20.3  22.5  29.
  24.8  22.   26.4  33.1  36.1  28.4  33.4  28.2  22.8  20.3  16.1  22.1
  19.4  21.6  23.8  16.2  17.8  19.8  23.1  21.   23.8  23.1  20.4  18.5
  25.   24.6  23.   22.2  19.3  22.6  19.8  17.1  19.4  22.2  20.7  21.1
  19.5  18.5  20.6  19.   18.7  32.7  16.5  23.9  31.2  17.5  17.2  23.1
  24.5  26.6  22.9  24.1  18.6  30.1  18.2  20.6  17.8  21.7  22.7  22.6
  25.   19.9  20.8  16.8  21.9  27.5  21.9  23.1  50.   50.   50.   50.
  50.   13.8  13.8  15.   13.9  13.3  13.1  10.2  10.4  10.9  11.3  12.3
   8.8   7.2  10.5   7.4  10.2  11.5  15.1  23.2   9.7  13.8  12.7  13.1
  12.5   8.5   5.    6.3   5.6   7.2  12.1   8.3   8.5   5.   11.9  27.9
  17.2  27.5  15.   17.2  17.9  16.3   7.    7.2   7.5  10.4   8.8   8.4
  16.7  14.2  20.8  13.4  11.7   8.3  10.2  10.9  11.    9.5  14.5  14.1
  16.1  14.3  11.7  13.4   9.6   8.7   8.4  12.8  10.5  17.1  18.4  15.4
  10.8  11.8  14.9  12.6  14.1  13.   13.4  15.2  16.1  17.8  14.9  14.1
  12.7  13.5  14.9  20.   16.4  17.7  19.5  20.2  21.4  19.9  19.   19.1
  19.1  20.1  19.9  19.6  23.2  29.8  13.8  13.3  16.7  12.   14.6  21.4
  23.   23.7  25.   21.8  20.6  21.2  19.1  20.6  15.2   7.    8.1  13.6
  20.1  21.8  24.5  23.1  19.7  18.3  21.2  17.5  16.8  22.4  20.6  23.9
  22.   11.9]
```

In [7]:
```
ybar=np.mean(y)
p=np.mean(y>40)*100
print( 'The mean house price is {0:1.2f} thousands of dollars'.format(ybar))
print( 'Only {0:1.1f} percent are above $40k.'.format(p))
```

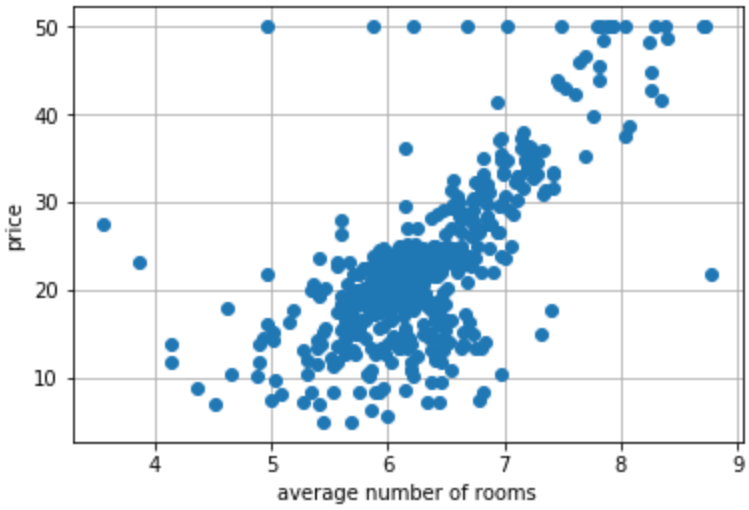
```
The mean house price is 22.53 thousands of dollars
Only 6.1 percent are above $40k.
```

In [8]:
```
import matplotlib
import matplotlib.pyplot as plt
%matplotlib inline
```

In [9]:
```
x=np.array(df.RM)
print(x)
```

```
[ 6.575  6.421  7.185  6.998  7.147  6.43   6.012  6.172  5.631  6.004
  6.377  6.009  5.889  5.949  6.096  5.834  5.935  5.99   5.456  5.727
  5.57   5.965  6.142  5.813  5.924  5.599  5.813  6.047  6.495  6.674
  5.713  6.072  5.95   5.701  6.096  5.933  5.841  5.85   5.966  6.595
  7.024  6.77   6.169  6.211  6.069  5.682  5.786  6.03   5.399  5.602
  5.963  6.115  6.511  5.998  5.888  7.249  6.383  6.816  6.145  5.927
  5.741  5.966  6.456  6.762  7.104  6.29   5.787  5.878  5.594  5.885
  6.417  5.961  6.065  6.245  6.273  6.286  6.279  6.14   6.232  5.874
  6.727  6.619  6.302  6.167  6.389  6.63   6.015  6.121  7.007  7.079
  6.417  6.405  6.442  6.211  6.249  6.625  6.163  8.069  7.82   7.416
  6.727  6.781  6.405  6.137  6.167  5.851  5.836  6.127  6.474  6.229
  6.195  6.715  5.913  6.092  6.254  5.928  6.176  6.021  5.872  5.731
  5.87   6.004  5.961  5.856  5.879  5.986  5.613  5.693  6.431  5.637
  6.458  6.326  6.372  5.822  5.757  6.335  5.942  6.454  5.857  6.151
  6.174  5.019  5.403  5.468  4.903  6.13   5.628  4.926  5.186  5.597
  6.122  5.404  5.012  5.709  6.129  6.152  5.272  6.943  6.066  6.51   6.25
  7.489  7.802  8.375  5.854  6.101  7.929  5.877  6.319  6.402  5.875
  5.88   5.572  6.416  5.859  6.546  6.02   6.315  6.86   6.98   7.765
  6.144  7.155  6.563  5.604  6.153  7.831  6.782  6.556  7.185  6.951
  6.739  7.178  6.8    6.604  7.875  7.287  7.107  7.274  6.975  7.135
  6.162  7.61   7.853  8.034  5.891  6.326  5.783  6.064  5.344  5.96
  5.404  5.807  6.375  5.412  6.182  5.888  6.642  5.951  6.373  6.951
  6.164  6.879  6.618  8.266  8.725  8.04   7.163  7.686  6.552  5.981
  7.412  8.337  8.247  6.726  6.086  6.631  7.358  6.481  6.606  6.897
  6.095  6.358  6.393  5.593  5.605  6.108  6.226  6.433  6.718  6.487
  6.438  6.957  8.259  6.108  5.876  7.454  8.704  7.333  6.842  7.203
  7.52   8.398  7.327  7.206  5.56   7.014  8.297  7.47   5.92   5.856
  6.24   6.538  7.691  6.758  6.854  7.267  6.826  6.482  6.812  7.82
  6.968  7.645  7.923  7.088  6.453  6.23   6.209  6.315  6.565  6.861
  7.148  6.63   6.127  6.009  6.678  6.549  5.79   6.345  7.041  6.871
  6.59   6.495  6.982  7.236  6.616  7.42   6.849  6.635  5.972  4.973
  6.122  6.023  6.266  6.567  5.705  5.914  5.782  6.382  6.113  6.426
  6.376  6.041  5.708  6.415  6.431  6.312  6.083  5.868  6.333  6.144
  5.706  6.031  6.316  6.31   6.037  5.869  5.895  6.059  5.985  5.968
  7.241  6.54   6.696  6.874  6.014  5.898  6.516  6.635  6.939  6.49
  6.579  5.884  6.728  5.663  5.936  6.212  6.395  6.127  6.112  6.398
  6.251  5.362  5.803  8.78   3.561  4.963  3.863  4.97   6.683  7.016
  6.216  5.875  4.906  4.138  7.313  6.649  6.794  6.38   6.223  6.968
  6.545  5.536  5.52   4.368  5.277  4.652  5.     4.88   5.39   5.713
  6.051  5.036  6.193  5.887  6.471  6.405  5.747  5.453  5.852  5.987
  6.343  6.404  5.349  5.531  5.683  4.138  5.608  5.617  6.852  5.757
  6.657  4.628  5.155  4.519  6.434  6.782  5.304  5.957  6.824  6.411
  6.006  5.648  6.103  5.565  5.896  5.837  6.202  6.193  6.38   6.348
  6.833  6.425  6.436  6.208  6.629  6.461  6.152  5.935  5.627  5.818
  6.406  6.219  6.485  5.854  6.459  6.341  6.251  6.185  6.417  6.749
  6.655  6.297  7.393  6.728  6.525  5.976  5.936  6.301  6.081  6.701
  6.376  6.317  6.513  6.209  5.759  5.952  6.003  5.926  5.713  6.167
  6.229  6.437  6.98   5.427  6.162  6.484  5.304  6.185  6.229  6.242
  6.75   7.061  5.762  5.871  6.312  6.114  5.905  5.454  5.414  5.093
  5.983  5.983  5.707  5.926  5.67   5.39   5.794  6.019  5.569  6.027
  6.593  6.12   6.976  6.794  6.03 ]
```

In [10]:
```
plt.plot(x,y,'o')
plt.xlabel('average number of rooms')
plt.ylabel('price')
plt.grid(True)
```



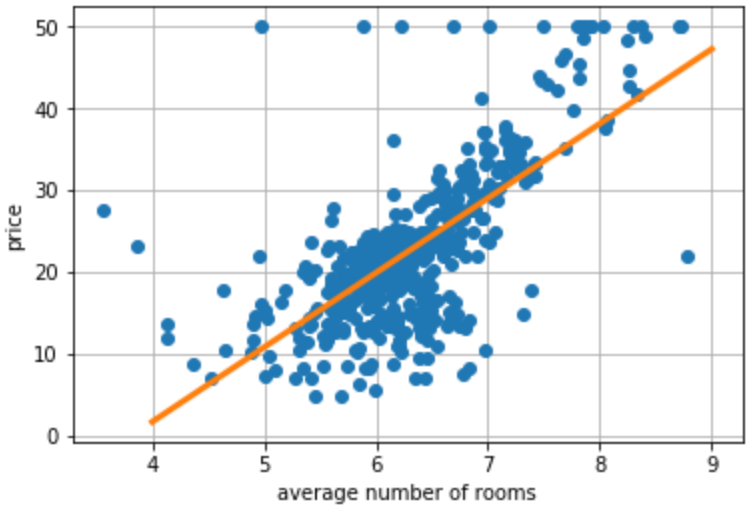
In [11]:
```
def fit_linear(x,y):
    """
    Given vectors of data points (x,y), performs a fit for the linear model:
       yhat = beta0 + beta1*x,
    The function returns beta0, beta1 and rsq, where rsq is the coefficient of de
termination.
    """
    xbar = np.mean(x)
    syy = np.mean((y-ybar)**2)
    sxy = np.mean((y-ybar)*(x-xbar))
    sxx = np.mean((x-xbar)**2)
    beta1 = sxy/sxx
    beta0 = ybar - beta1*xbar
    rxy=sxy/(np.sqrt(sxx)*np.sqrt(syy))
    rsq=rxy**2
    return beta0, beta1, rsq
```

In [12]:
```
fit_linear(x,y)
```

Out[12]:
```
(-34.670620776438568, 9.1021089811803098, 0.48352545599133401)
```

In [13]:
```
# Points on the regression line
xplt = np.array([4,9])
xbar = np.mean(x)
syy = np.mean((y-ybar)**2)
sxy = np.mean((y-ybar)*(x-xbar))
sxx = np.mean((x-xbar)**2)
beta1 = sxy/sxx
beta0 = ybar - beta1*xbar
yplt = beta1*xplt + beta0

plt.plot(x,y,'o')                    # Plot the data points
plt.plot(xplt,yplt,'-',linewidth=3)  # Plot the regression line
plt.xlabel('average number of rooms')
plt.ylabel('price')
plt.grid(True)
```



In [14]:
```
for i in range(0,len(names)-1):
    x=np.array(df.iloc[:,i])
    beta0,beta1,rsq=fit_linear(x,y)
    print('{:8}{:7.3f}'.format(names[i],rsq))
```

```
CRIM      0.151
ZN        0.130
INDUS     0.234
CHAS      0.031
NOX       0.183
RM        0.484
AGE       0.142
DIS       0.062
RAD       0.146
TAX       0.220
PTRATIO   0.258
B         0.111
LSTAT     0.544
```