In [6]:

```
import pandas as pd
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import quandl
import scipy.optimize as sco
from scipy.optimize import minimize
from pandas_datareader import data as wb
plt.style.use('fivethirtyeight')
np.random.seed(777)
%matplotlib inline
%config InlineBackend.figure_format = 'retina'
```

In [14]:

```
num_stocks = int(input("Number of stocks in the portfolio?"))

number = ['first', 'second', 'thirth', 'fourth', 'fifth', 'sixth', 'se
stocks = []

for num in range (num_stocks):
    stocks.append(input("Name of the " + number[num] + " stock?"))
print(stocks)
```

```
Number of stocks in the portfolio?10
Name of the first stock?AA
Name of the second stock?AAPL
Name of the thirth stock?CSCO
Name of the fourth stock?CVS
Name of the fifth stock?DIS
Name of the sixth stock?GOOGL
Name of the seventh stock?JPM
Name of the eight stock?MSFT
Name of the ninth stock?V
Name of the tenth stock?WFC
['AA', 'AAPL', 'CSCO', 'CVS', 'DIS', 'GOOGL', 'JPM', 'MSFT', 'V', 'WF
C']
```

In [15]:

```
investment_duration = float(input('How many years would this portfolic
expected_daily_returns = []
for num in range(num_stocks):
    expected_daily_returns.append(float(input("The expected return of 

return_target = float(input("What is the target return in the investme
expected_annual_returns = [i*252 for i in expected_daily_returns]
print("Expected annual return: " + str(expected_annual_returns))
```

```
How many years would this portfolio investment hold? (can be fraction)
0.5
The expected return of AA in the investment period?0.23
The expected return of AAPL in the investment period?0.10
The expected return of CSCO in the investment period?0.07
The expected return of CVS in the investment period?0.15
The expected return of DIS in the investment period?0.044
The expected return of GOOGL in the investment period?0.055
The expected return of JPM in the investment period?0.13
The expected return of MSFT in the investment period?0.06
The expected return of V in the investment period?0.037
```

```
The expected return of WFC in the investment period?0.14
What is the target return in the investment period?0.11
Expected annual return: [0.46, 0.2, 0.14, 0.3, 0.088, 0.11, 0.26, 0.1
2, 0.074, 0.28]
```

In [16]:

```
rf = float(input('What is the term risk-free rate for the investment p
```

```
What is the term risk-free rate for the investment period?0.03
```

In [70]:

```
table = pd.DataFrame()
# Get data from yahoo source:
for i in stocks:
    stock_temp =wb.DataReader(i, data_source='yahoo',start='2019-3-1',
    table[i] = stock_temp['Adj Close']

table_rf = table.copy()
table_rf['rf'] = rf
table.head()
```

Out[70]:

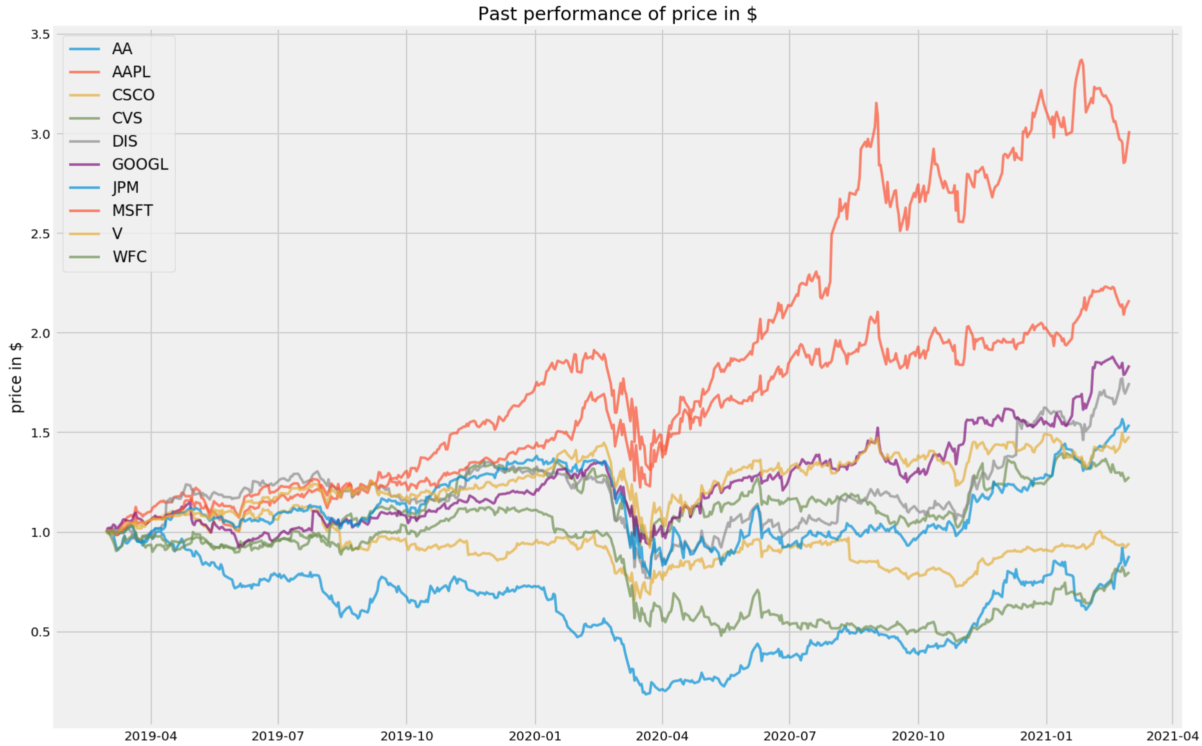
	AA	AAPL	CSCO	CVS	DIS	GOOGL	
Date							
2019-02-28	29.500000	42.399570	48.310696	54.246674	111.477608	1126.550049	97.17
2019-03-01	29.660000	42.845234	47.974754	54.528080	112.633484	1148.520020	97.23
2019-03-04	29.160000	43.060719	47.741455	52.492531	112.949623	1153.420044	97.0
2019-03-05	29.200001	42.982357	47.872097	51.554497	112.623604	1169.189941	96.93
2019-03-06	28.250000	42.735043	48.217377	50.653980	113.463341	1164.939941	96.57

In [71]:

```
plt.figure(figsize=(14, num_stocks))
for c in table.columns.values:
    plt.plot(table.index, table[c]/table.loc[table.index[0],c], lw=2,
plt.legend(loc='upper left', fontsize=12)
plt.ylabel('price in $')
plt.title('Past performance of price in $')
```

Out[71]:

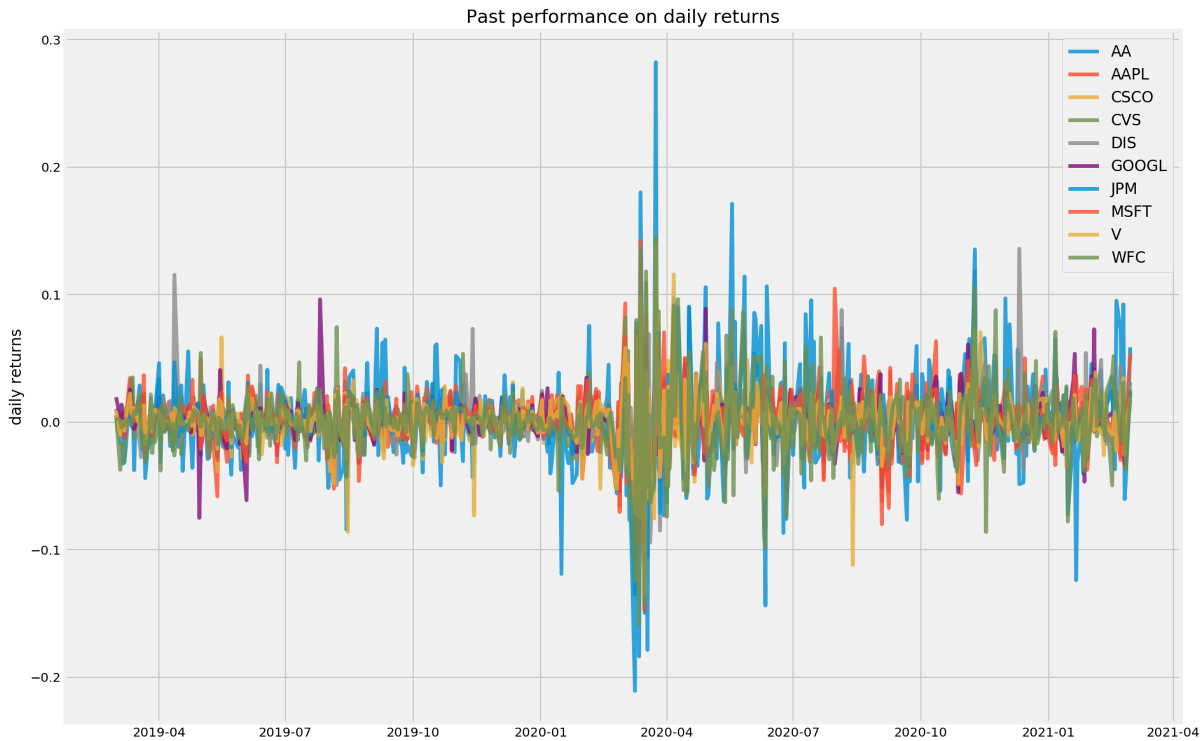
```
Text(0.5, 1.0, 'Past performance of price in $')
```



In [72]:

```
returns = table.pct_change()
plt.figure(figsize=(14, num_stocks))
for c in returns.columns.values:
    plt.plot(returns.index, returns[c], lw=3, alpha=0.8,label=c)
plt.legend(loc='upper right', fontsize=12)
plt.ylabel('daily returns')
plt.title('Past performance on daily returns')
```

Out[72]: Text(0.5, 1.0, 'Past performance on daily returns')



In [73]:

```
def portfolio_annualised_performance(weights, mean_returns, cov_matrix
    returns = np.sum(mean_returns*weights ) *252
    std = np.sqrt(np.dot(weights.T, np.dot(cov_matrix, weights))) * np
```

```
    return std, returns

def random_portfolios(num_portfolios, mean_returns, cov_matrix, risk_f
    results = np.zeros((3,num_portfolios))
    weights_record = []
    for i in range(num_portfolios):
        weights = np.random.random(num_stocks)
        weights /= np.sum(weights)
        weights_record.append(weights)
        portfolio_std_dev, portfolio_return = portfolio_annualised_per
        results[0,i] = portfolio_std_dev
        results[1,i] = portfolio_return
        results[2,i] = (portfolio_return - risk_free_rate) / portfolio
    return results, weights_record
```

In [74]:

```
returns = table.pct_change()
mean_returns = returns.mean()
cov_matrix = returns.cov()
expected_returns = pd.Series(expected_daily_returns, index = stocks)

returns_rf = returns.copy()
returns_rf['rf'] = rf/252
mean_returns_rf = returns_rf.mean()
cov_matrix_rf = returns_rf.cov()

expected_returns_rf = expected_returns.copy()
expected_returns_rf['rf'] = rf/252

num_portfolios = 100000
risk_free_rate = rf

print("mean_return(daily) in the past 2 years:")
print(mean_returns)
print('\n')
print("expected_returns(daily) in the investment period:")
print(expected_returns)
type(mean_returns)
```

```
mean_return(daily) in the past 2 years:
AA       0.000606
AAPL     0.002471
CSCO     0.000118
CVS      0.000699
DIS      0.001408
GOOGL    0.001418
JPM      0.001189
MSFT     0.001763
V        0.000996
WFC     -0.000005
dtype: float64


expected_returns(daily) in the investment period:
AA       0.001825
AAPL     0.000794
CSCO     0.000556
CVS      0.001190
DIS      0.000349
GOOGL    0.000437
```

```
JPM      0.001032
MSFT     0.000476
V        0.000294
WFC      0.001111
dtype: float64
```

Out[74]:

```
pandas.core.series.Series
```

In [75]:

```
def neg_sharpe_ratio(weights, mean_returns, cov_matrix, risk_free_rate
    p_var, p_ret = portfolio_annualised_performance(weights, mean_retu
    return -(p_ret - risk_free_rate) / p_var

def max_sharpe_ratio(mean_returns, cov_matrix, risk_free_rate):
    num_assets = len(mean_returns)
    args = (mean_returns, cov_matrix, risk_free_rate)
    constraints = ({'type': 'eq', 'fun': lambda x: np.sum(x) - 1})
    bound = (0.0,2.0)
    bounds = tuple(bound for asset in range(num_assets))
    result = sco.minimize(neg_sharpe_ratio, num_assets*[1./num_assets,
                        method='SLSQP', bounds=bounds, constraints=con
    return result
```

In [76]:

```
def portfolio_volatility(weights, mean_returns, cov_matrix):
    return portfolio_annualised_performance(weights, mean_returns, cov

def min_variance(mean_returns, cov_matrix):
    num_assets = len(mean_returns)
    args = (mean_returns, cov_matrix)
    constraints = ({'type': 'eq', 'fun': lambda x: np.sum(x) - 1})
    bound = (0.0,2.0)
    bounds = tuple(bound for asset in range(num_assets))

    result = sco.minimize(portfolio_volatility, num_assets*[1./num_ass
                        method='SLSQP', bounds=bounds, constraints=con

    return result
```

In [77]:

```
def efficient_return(mean_returns, cov_matrix, target, rf = False):
    num_assets = len(mean_returns)
    args = (mean_returns, cov_matrix)

    def portfolio_return(weights):
        return portfolio_annualised_performance(weights, mean_returns,

    constraints = ({'type': 'eq', 'fun': lambda x: portfolio_return(x)
                   {'type': 'eq', 'fun': lambda x: np.sum(x) - 1})

    if rf == True:
        bounds = tuple((0,2) for asset in range(num_assets-1)) + tuple
    else:
        bounds = tuple((0,2) for asset in range(num_assets))


    result = sco.minimize(portfolio_volatility, num_assets*[1./num_ass
    return result
```

```
def efficient_frontier(mean_returns, cov_matrix, returns_range, rf = R
    efficients = []
    for ret in returns_range:
        efficients.append(efficient_return(mean_returns, cov_matrix, r
    return efficients
```

In [78]:

```
def display_simulated_ef_with_random(mean_returns, cov_matrix, num_por
    results, weights = random_portfolios(num_portfolios,mean_returns,

    max_sharpe_idx = np.argmax(results[2])
    sdp, rp = results[0,max_sharpe_idx], results[1,max_sharpe_idx]
    max_sharpe_allocation = pd.DataFrame(weights[max_sharpe_idx],index
    max_sharpe_allocation.allocation = [round(i*100,2)for i in max_sha
    max_sharpe_allocation = max_sharpe_allocation.T

    min_vol_idx = np.argmin(results[0])
    sdp_min, rp_min = results[0,min_vol_idx], results[1,min_vol_idx]
    min_vol_allocation = pd.DataFrame(weights[min_vol_idx],index=table
    min_vol_allocation.allocation = [round(i*100,2)for i in min_vol_al
    min_vol_allocation = min_vol_allocation.T

    if return_target!=0:
        target_min_vol = efficient_return(expected_returns, cov_matrix
        target_sdp_min, target_rp_min = portfolio_annualised_performan
        target_min_vol_allocation = pd.DataFrame(target_min_vol.x,inde
        target_min_vol_allocation.allocation = [round(i*100,2)for i in
        target_min_vol_allocation = target_min_vol_allocation.T

    print ("-"*80)
    print ("Maximum Sharpe Ratio Portfolio Allocation\n")
    print ("Annualised Return:", round(rp,2))
    print ("Annualised Volatility:", round(sdp,2))
    print ("\n")
    print (max_sharpe_allocation)
    print ("-"*80)
    print ("Global Minimum Volatility Portfolio Allocation\n")
    print ("Annualised Return:", round(rp_min,2))
    print ("Annualised Volatility:", round(sdp_min,2))
    print ("\n")
    print (min_vol_allocation)

    if return_target!=0:
        print ("-"*80)
        print ("Optimal Portfolio for Target Return Allocation\n")
        print ("Annualised Return:", round(target_rp_min,2))
        print ("Annualised Volatility:", round(target_sdp_min,2))
        print ("\n")
        print (target_min_vol_allocation)

    plt.figure(figsize=(10, num_stocks))
    plt.scatter(results[0,:],results[1,:],c=results[2,:],cmap='YlGnBu'
    plt.colorbar()
    plt.scatter(sdp,rp,marker='*',color='r',s=500, label='Maximum Shar
    plt.scatter(sdp_min,rp_min,marker='*',color='g',s=500, label='Goba
    if return_target!=0:
        plt.scatter(efficient_return(expected_returns, cov_matrix, ret
    plt.title('Portfolio Optimization based on Simulation')
    plt.xlabel('annualised volatility')
```

```
    plt.ylabel('annualised returns')
    plt.legend(labelspacing=0.8)
```

In [79]:

```
def display_calculated_ef_with_random(mean_returns, cov_matrix, num_po

    results, _ = random_portfolios(num_portfolios,mean_returns, cov_ma

    max_sharpe = max_sharpe_ratio(mean_returns, cov_matrix, risk_free_
    sdp, rp = portfolio_annualised_performance(max_sharpe['x'], mean_r
    max_sharpe_allocation = pd.DataFrame(max_sharpe.x,index=table.colu
    max_sharpe_allocation.allocation = [round(i*100,2)for i in max_sha
    max_sharpe_allocation = max_sharpe_allocation.T

    min_vol = min_variance(mean_returns, cov_matrix)
    sdp_min, rp_min = portfolio_annualised_performance(min_vol['x'], r
    min_vol_allocation = pd.DataFrame(min_vol.x,index=table.columns,co
    min_vol_allocation.allocation = [round(i*100,2)for i in min_vol_al
    min_vol_allocation = min_vol_allocation.T

    if return_target!=0:
        if expected_return == True:
            target_min_vol = efficient_return(expected_returns_rf, cov
            target_sdp_min, target_rp_min = portfolio_annualised_perfo
            target_min_vol_allocation = pd.DataFrame(target_min_vol.x,
            target_min_vol_allocation.allocation = [round(i*100,2)for
            target_min_vol_allocation = target_min_vol_allocation.T
        else:
            target_min_vol = efficient_return(mean_returns_rf, cov_mat
            target_sdp_min, target_rp_min = portfolio_annualised_perfo
            target_min_vol_allocation = pd.DataFrame(target_min_vol.x,
            target_min_vol_allocation.allocation = [round(i*100,2)for
            target_min_vol_allocation = target_min_vol_allocation.T

    print ("-"*80)
    print ("Maximum Sharpe Ratio Portfolio Allocation\n")
    print ("Annualised Return:", round(rp,2))
    print ("Annualised Volatility:", round(sdp,2))
    print ("\n")
    print (max_sharpe_allocation)
    print ("-"*80)
    print ("Global Minimum Volatility Portfolio Allocation\n")
    print ("Annualised Return:", round(rp_min,2))
    print ("Annualised Volatility:", round(sdp_min,2))
    print ("\n")
    print (min_vol_allocation)

    if return_target!=0:
        print ("-"*80)
        print ("Optimal Portfolio for Target Return Allocation\n")
        print ("Annualised Return:", round(target_rp_min,2))
        print ("Annualised Volatility:", round(target_sdp_min,2))
        print ("\n")
        print (target_min_vol_allocation)

    plt.figure(figsize=(10, num_stocks))
    plt.scatter(results[0,:],results[1,:],c=results[2,:],cmap='YlGnBu'
    plt.colorbar()
    plt.scatter(sdp,rp,marker='*',color='r',s=500, label='Maximum Shar
```

```
    plt.scatter(sdp_min,rp_min,marker='*',color='g',s=500, label='Glob

    if return_target!=0:
        plt.scatter(target_sdp_min, return_target, marker='*',color='b

    target = np.linspace(rp_min, max(mean_returns)*252, 50)
    target_rf = np.linspace(risk_free_rate, rp * 2)

    efficient_portfolios = efficient_frontier(mean_returns, cov_matrix
    plt.plot([p['fun'] for p in efficient_portfolios], target, linesty

    if expected_return == True:
        capital_allocation_line = efficient_frontier(expected_returns_
        plt.plot([p['fun'] for p in capital_allocation_line], target_r
    else:
        capital_allocation_line = efficient_frontier(mean_returns_rf,
        plt.plot([p['fun'] for p in capital_allocation_line], target_r

    plt.title('Portfolio Optimization based on Efficient Frontier and
    plt.xlabel('annualised volatility')
    plt.ylabel('annualised returns')
    plt.legend(labelspacing=0.8)
```

In [80]:

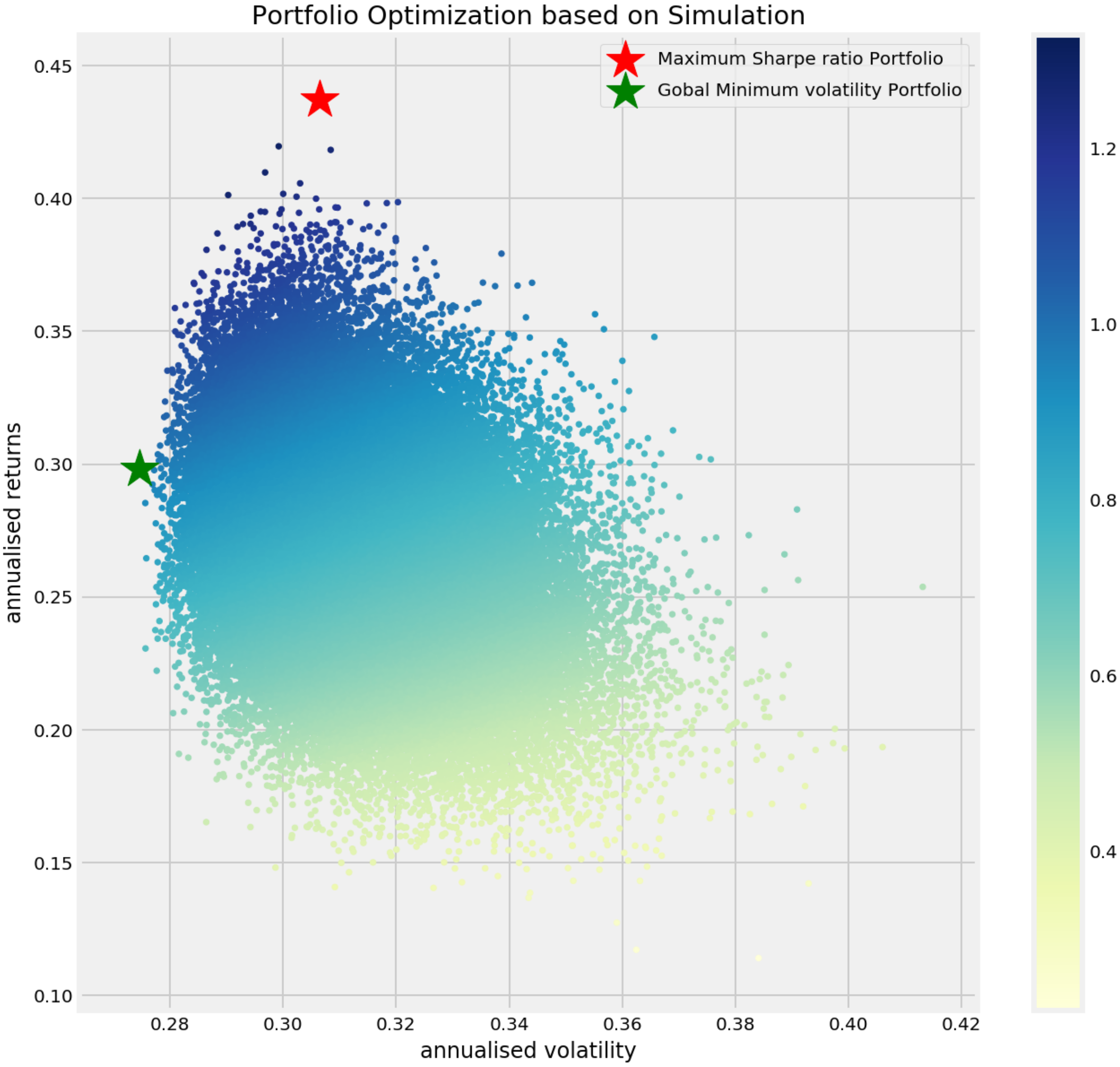
```
def display_ef_with_selected(mean_returns, cov_matrix, risk_free_rate,

    max_sharpe = max_sharpe_ratio(mean_returns, cov_matrix, risk_free_
    sdp, rp = portfolio_annualised_performance(max_sharpe['x'], mean_r
    max_sharpe_allocation = pd.DataFrame(max_sharpe.x,index=table.colu
    max_sharpe_allocation.allocation = [round(i*100,2)for i in max_sha
    max_sharpe_allocation = max_sharpe_allocation.T

    min_vol = min_variance(mean_returns, cov_matrix)
    sdp_min, rp_min = portfolio_annualised_performance(min_vol['x'], r
    min_vol_allocation = pd.DataFrame(min_vol.x,index=table.columns,co
    min_vol_allocation.allocation = [round(i*100,2)for i in min_vol_al
    min_vol_allocation = min_vol_allocation.T

    if return_target!=0:
        if expected_return == True:
            target_min_vol = efficient_return(expected_returns_rf, cov
            target_sdp_min, target_rp_min = portfolio_annualised_perfo
            target_min_vol_allocation = pd.DataFrame(target_min_vol.x,
            target_min_vol_allocation.allocation = [round(i*100,2)for
            target_min_vol_allocation = target_min_vol_allocation.T
        else:
            target_min_vol = efficient_return(mean_returns_rf, cov_mat
            target_sdp_min, target_rp_min = portfolio_annualised_perfo
            target_min_vol_allocation = pd.DataFrame(target_min_vol.x,
            target_min_vol_allocation.allocation = [round(i*100,2)for
            target_min_vol_allocation = target_min_vol_allocation.T


    an_vol = np.std(returns) * np.sqrt(252)
    an_rt = mean_returns * 252

    print ("-"*80)
    print ("Maximum Sharpe Ratio Portfolio Allocation\n")
    print ("Annualised Return:", round(rp,2))
```

```
    print ("Annualised Volatility:", round(sdp,2))
    print ("\n")
    print (max_sharpe_allocation)
    print ("-"*80)
    print ("Global Minimum Volatility Portfolio Allocation\n")
    print ("Annualised Return:", round(rp_min,2))
    print ("Annualised Volatility:", round(sdp_min,2))
    print ("\n")
    print (min_vol_allocation)

    if return_target!=0:
        print ("-"*80)
        print ("Optimal Portfolio for Target Return Allocation\n")
        print ("Annualised Return:", round(target_rp_min,2))
        print ("Annualised Volatility:", round(target_sdp_min,2))
        print ("\n")
        print (target_min_vol_allocation)

    print ("-"*80)
    print ("Individual Stock Returns and Volatility\n")
    for i, txt in enumerate(table.columns):
        print (txt,":","annuaised return",round(an_rt[i],2),", annuali
    print ("-"*80)

    fig, ax = plt.subplots(figsize=(10, num_stocks))
    ax.scatter(an_vol,an_rt,marker='o',s=200)

    for i, txt in enumerate(table.columns):
        ax.annotate(txt, (an_vol[i],an_rt[i]), xytext=(10,0), textcoo
    ax.scatter(sdp,rp,marker='*',color='r',s=500, label='Maximum Sharp
    ax.scatter(sdp_min,rp_min,marker='*',color='g',s=500, label='Globa

    if return_target!=0:
        plt.scatter(target_sdp_min, return_target, marker='*',color='b

    target = np.linspace(rp_min, max(mean_returns)*252, 50)
    target_rf = np.linspace(risk_free_rate, rp * 2)

    efficient_portfolios = efficient_frontier(mean_returns, cov_matrix
    plt.plot([p['fun'] for p in efficient_portfolios], target, linesty

    if expected_return == True:
        capital_allocation_line = efficient_frontier(expected_returns_
        plt.plot([p['fun'] for p in capital_allocation_line], target_r
    else:
        capital_allocation_line = efficient_frontier(mean_returns_rf,
        plt.plot([p['fun'] for p in capital_allocation_line], target_r

    ax.set_title('Portfolio Optimization based on Efficient Frontier a
    ax.set_xlabel('annualised volatility')
    ax.set_ylabel('annualised returns')
    ax.legend(labelspacing=0.8)
```

In [87]:

```
display_simulated_ef_with_random(mean_returns, cov_matrix, num_portfol
print ("-"*80)
print("\n\n***It is a optimization base on the past performance in ret
```

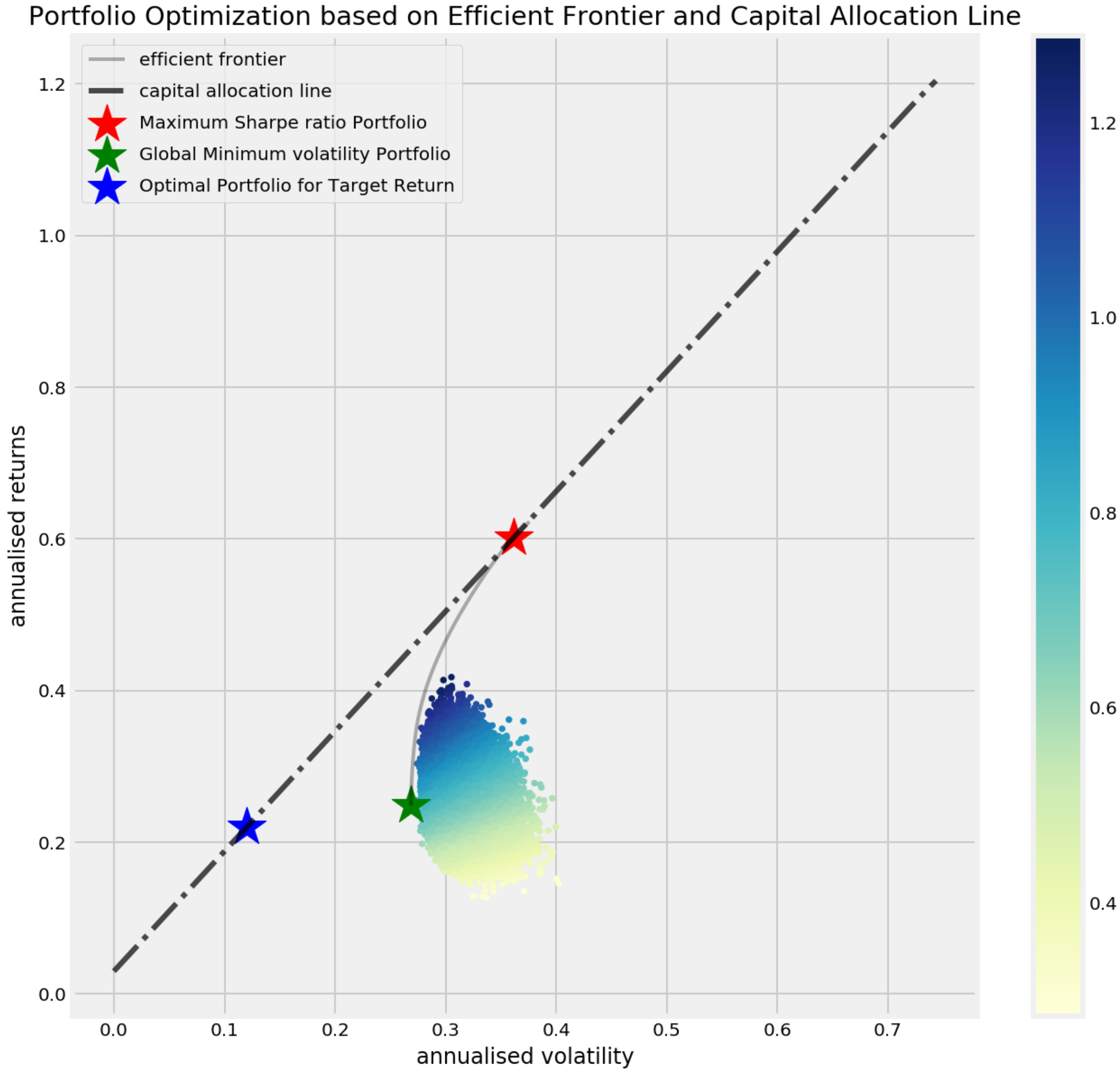
```
----------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.44
Annualised Volatility: 0.31


              AA   AAPL  CSCO   CVS   DIS  GOOGL   JPM   MSFT     V
WFC
allocation  5.15  34.14  0.25  7.96  0.88   20.8  7.47  23.07  0.12
0.15
-----------------------------------------------------------------------
----------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.3
Annualised Volatility: 0.27


              AA  AAPL  CSCO   CVS    DIS  GOOGL   JPM   MSFT     V
WFC
allocation  0.38  4.24  9.42  23.5  15.36  23.76  0.57  16.46  5.07
1.25
-----------------------------------------------------------------------
----------


***It is a optimization base on the past performance in return***
```



In [82]:

```
display_calculated_ef_with_random(mean_returns, cov_matrix, num_portfo
print ("-"*80)
print("\n\n***It is a optimization base on the past performance in ret
```

```
--------------------------------------------------------------------------------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.6
Annualised Volatility: 0.36


             AA   AAPL  CSCO  CVS   DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  92.33   0.0  0.0  7.67    0.0  0.0   0.0  0.0  0.0
--------------------------------------------------------------------------------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.25
Annualised Volatility: 0.27


             AA  AAPL   CSCO    CVS    DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  3.36  13.07  36.84  10.26  28.98  0.0   0.0  7.5  0.0
--------------------------------------------------------------------------------
Optimal Portfolio for Target Return Allocation

Annualised Return: 0.22
Annualised Volatility: 0.12


             AA  AAPL  CSCO  CVS   DIS  GOOGL  JPM  MSFT    V  WFC
rf
allocation  0.0  30.7   0.0  0.0  2.47    0.0  0.0   0.0  0.0  0.0  6
6.83
--------------------------------------------------------------------------------


***It is a optimization base on the past performance in return***
```



In [83]:

```
display_ef_with_selected(mean_returns, cov_matrix, risk_free_rate, exp
print ("-"*80)
print("\n\n***It is a optimization base on the past performance in ret
```

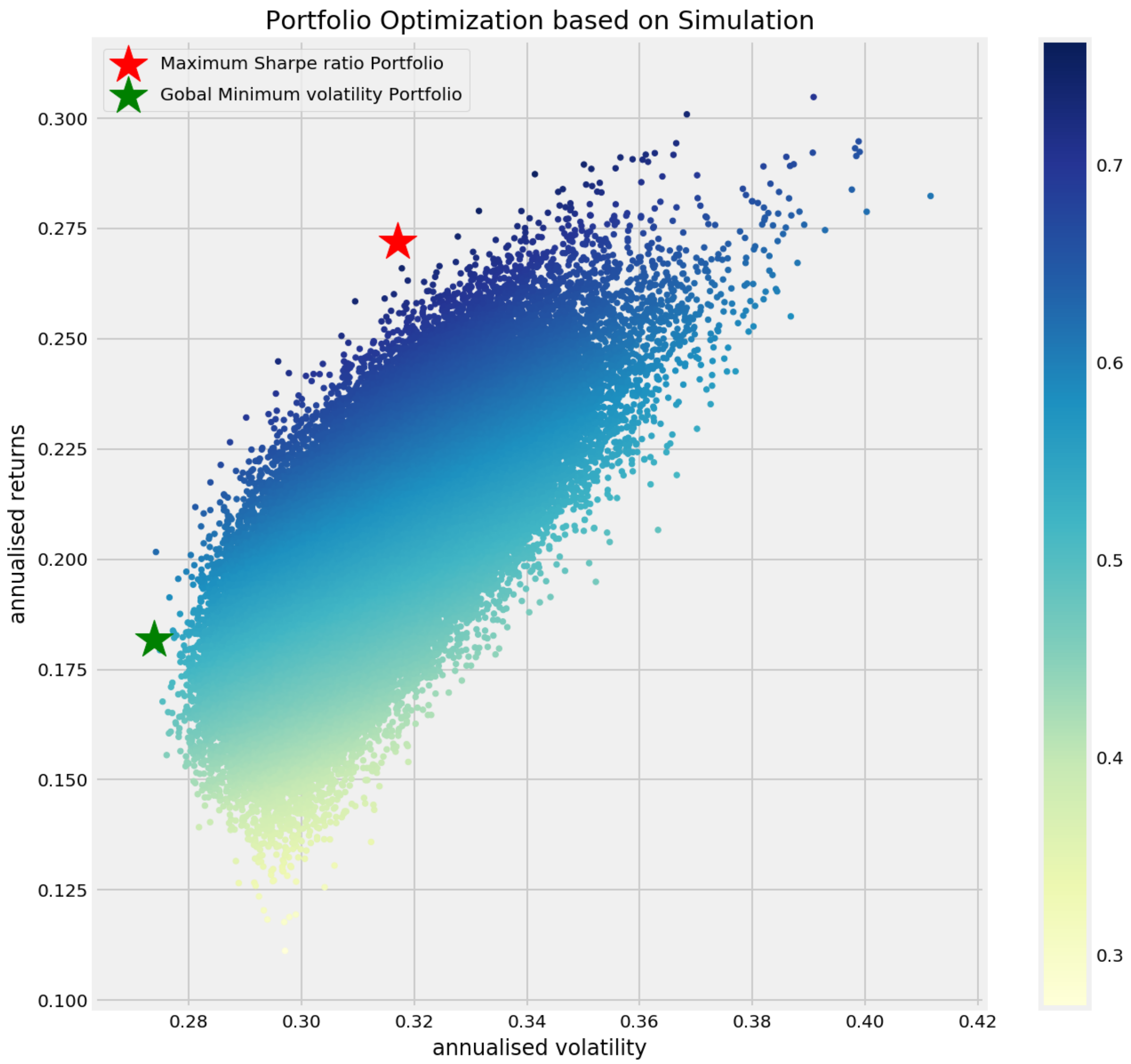
```
--------------------------------------------------------------------------------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.6
Annualised Volatility: 0.36


             AA   AAPL  CSCO  CVS   DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  92.33   0.0  0.0  7.67    0.0  0.0   0.0  0.0  0.0
--------------------------------------------------------------------------------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.25
Annualised Volatility: 0.27


             AA  AAPL   CSCO    CVS    DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  3.36  13.07  36.84  10.26  28.98  0.0   0.0  7.5  0.0
--------------------------------------------------------------------------------
```

```
Optimal Portfolio for Target Return Allocation

Annualised Return: 0.22
Annualised Volatility: 0.12


             AA  AAPL  CSCO  CVS   DIS  GOOGL  JPM  MSFT    V  WFC
rf
allocation  0.0  30.7   0.0  0.0  2.47    0.0  0.0   0.0  0.0  0.0  6
6.83
----------------------------------------------------------------------
----------
Individual Stock Returns and Volatility

AA : annuaised return 0.15 , annualised volatility: 0.66
AAPL : annuaised return 0.62 , annualised volatility: 0.38
CSCO : annuaised return 0.03 , annualised volatility: 0.34
CVS : annuaised return 0.18 , annualised volatility: 0.33
DIS : annuaised return 0.35 , annualised volatility: 0.39
GOOGL : annuaised return 0.36 , annualised volatility: 0.33
JPM : annuaised return 0.3 , annualised volatility: 0.41
MSFT : annuaised return 0.44 , annualised volatility: 0.34
V : annuaised return 0.25 , annualised volatility: 0.33
WFC : annuaised return -0.0 , annualised volatility: 0.47
----------------------------------------------------------------------
----------
----------------------------------------------------------------------
----------


***It is a optimization base on the past performance in return***
```

In [88]:

```
display_simulated_ef_with_random(expected_returns, cov_matrix, num_por
```

```
--------------------------------------------------------------------------------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.27
Annualised Volatility: 0.32


               AA    AAPL   CSCO    CVS    DIS   GOOGL    JPM   MSFT     V
WFC
allocation   14.5   17.77    0.8  33.13   5.47    3.66  18.26   0.36  2.19
3.87
--------------------------------------------------------------------------------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.18
Annualised Volatility: 0.27


              AA   AAPL   CSCO    CVS     DIS   GOOGL    JPM   MSFT     V   WF
C
allocation   1.1   2.68   8.86  32.46   18.06   20.83   3.57   5.23   6.3   0.9
1
```

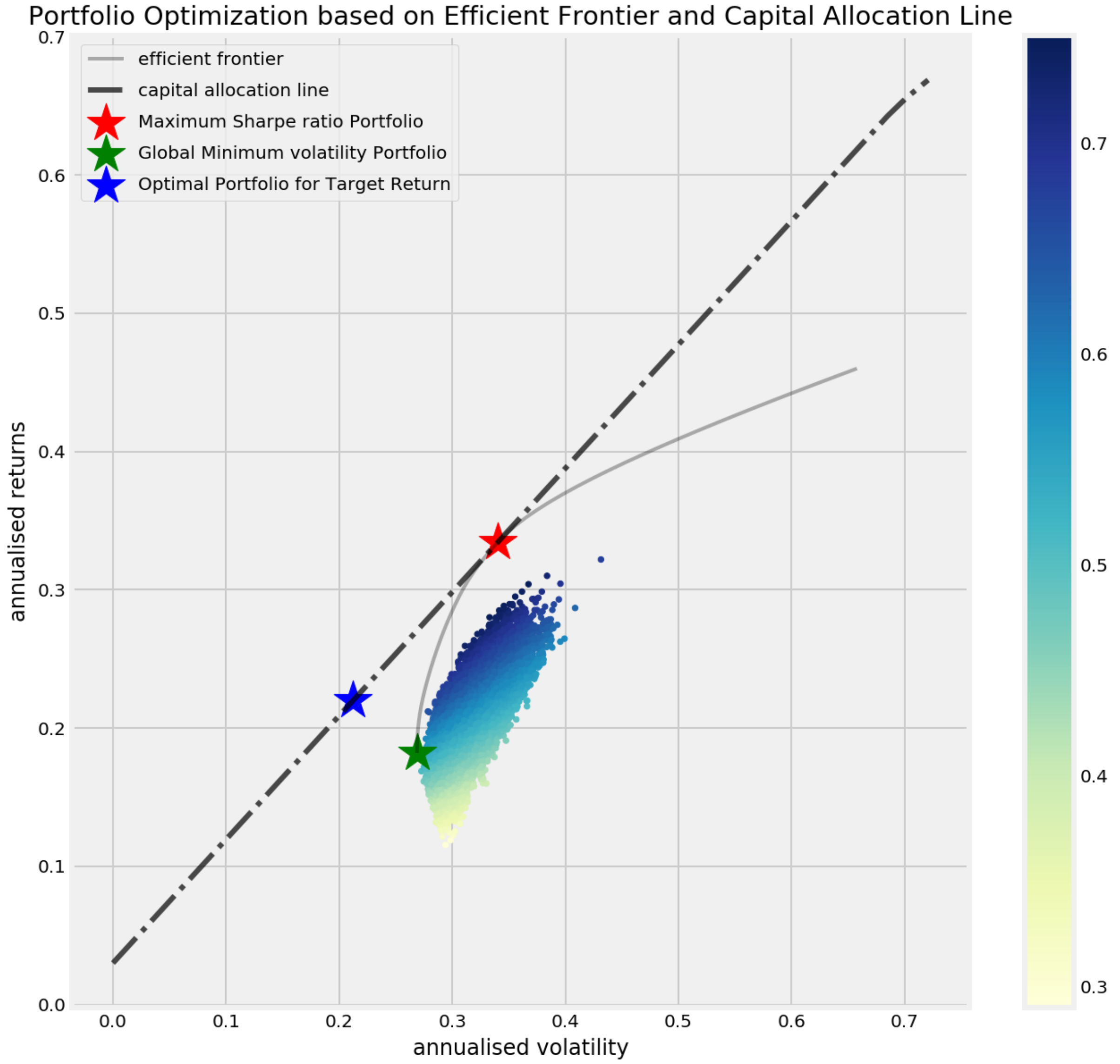


In [85]:

```
display_calculated_ef_with_random(expected_returns, cov_matrix, num_pc
```

```
----------------------------------------------------------------------
----------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.33
Annualised Volatility: 0.34


               AA  AAPL  CSCO    CVS  DIS  GOOGL  JPM  MSFT    V  WFC
allocation  22.07  0.95   0.0  76.97  0.0    0.0  0.0   0.0  0.0  0.0
----------------------------------------------------------------------
----------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.18
Annualised Volatility: 0.27


             AA  AAPL   CSCO    CVS    DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  3.36  13.07  36.84  10.26  28.98  0.0   0.0  7.5  0.0
----------------------------------------------------------------------
----------
Optimal Portfolio for Target Return Allocation

Annualised Return: 0.22
```

```
Annualised Volatility: 0.21


                    AA   AAPL  CSCO    CVS  DIS  GOOGL  JPM  MSFT    V  WFC
rf
allocation  13.68    0.7    0.0  48.14  0.0    0.0  0.0   0.0  0.0  0.0
37.48
```

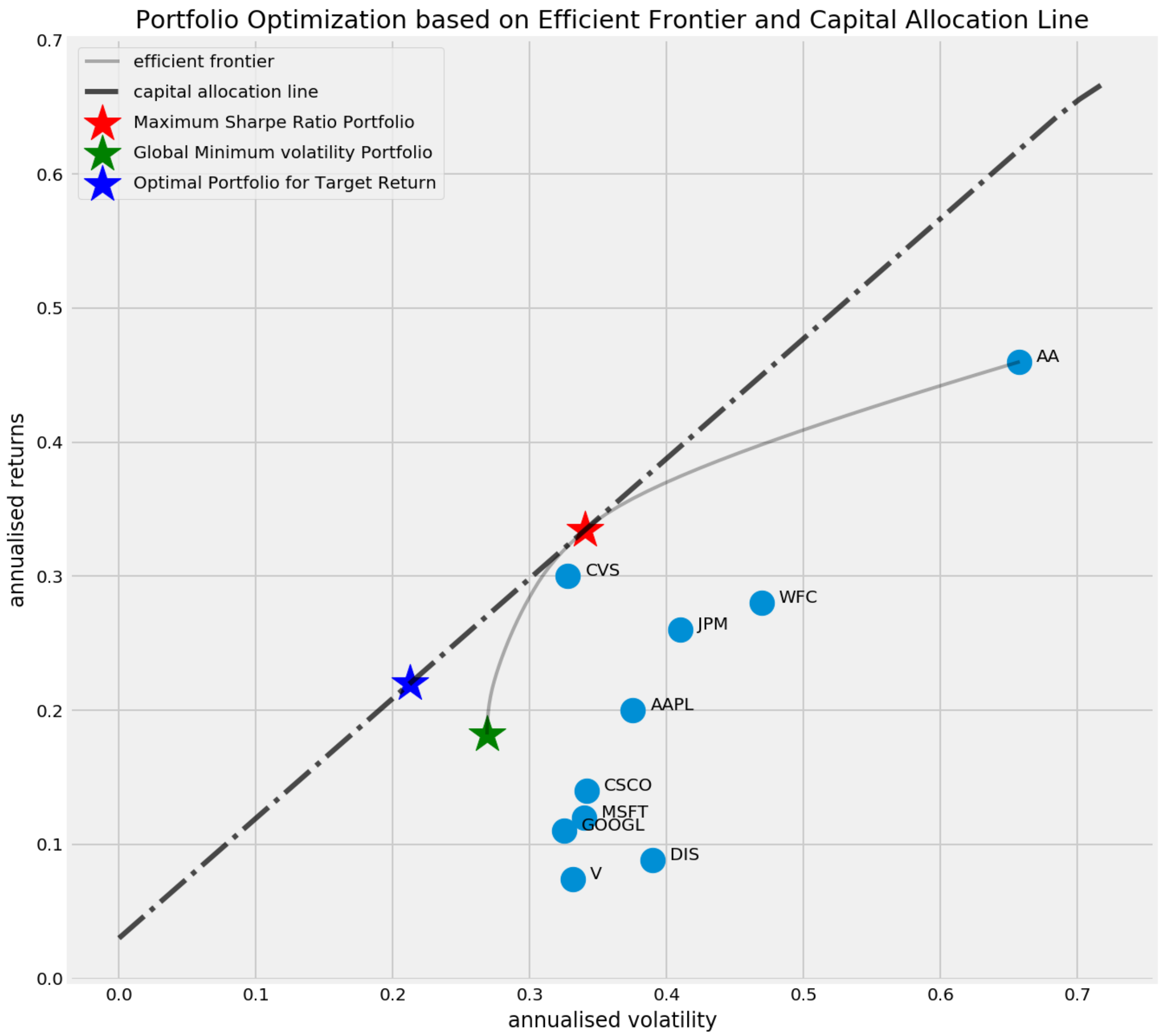


In [86]:

```
display_ef_with_selected(expected_returns, cov_matrix, risk_free_rate,
```

```
----------------------------------------------------------------------
----------
Maximum Sharpe Ratio Portfolio Allocation

Annualised Return: 0.33
Annualised Volatility: 0.34


                    AA   AAPL  CSCO    CVS  DIS  GOOGL  JPM  MSFT    V  WFC
allocation  22.07  0.95    0.0  76.97  0.0    0.0  0.0   0.0  0.0  0.0
----------------------------------------------------------------------
----------
Global Minimum Volatility Portfolio Allocation

Annualised Return: 0.18
Annualised Volatility: 0.27
```

```
              AA  AAPL   CSCO    CVS    DIS  GOOGL  JPM  MSFT    V  WFC
allocation  0.0  3.36  13.07  36.84  10.26  28.98  0.0   0.0  7.5  0.0
--------------------------------------------------------------------------------
Optimal Portfolio for Target Return Allocation

Annualised Return: 0.22
Annualised Volatility: 0.21


               AA  AAPL  CSCO    CVS  DIS  GOOGL  JPM  MSFT    V  WFC
rf
allocation  13.68   0.7   0.0  48.14  0.0    0.0  0.0   0.0  0.0  0.0
37.48
--------------------------------------------------------------------------------
Individual Stock Returns and Volatility

AA : annuaised return 0.46 , annualised volatility: 0.66
AAPL : annuaised return 0.2 , annualised volatility: 0.38
CSCO : annuaised return 0.14 , annualised volatility: 0.34
CVS : annuaised return 0.3 , annualised volatility: 0.33
DIS : annuaised return 0.09 , annualised volatility: 0.39
GOOGL : annuaised return 0.11 , annualised volatility: 0.33
JPM : annuaised return 0.26 , annualised volatility: 0.41
MSFT : annuaised return 0.12 , annualised volatility: 0.34
V : annuaised return 0.07 , annualised volatility: 0.33
WFC : annuaised return 0.28 , annualised volatility: 0.47
--------------------------------------------------------------------------------
```


Portfolio Optimization based on Efficient Frontier and Capital Allocation Line
efficient frontier
capital allocation line
Maximum Sharpe Ratio Portfolio
Global Minimum volatility Portfolio
Optimal Portfolio for Target Return
annualised returns
annualised volatility
AA
CVS
WFC
JPM
AAPL
CSCO
MSFT
GOOGL
DIS
V
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

In [ ]:

In [ ]:

In [ ]:

In [ ]: