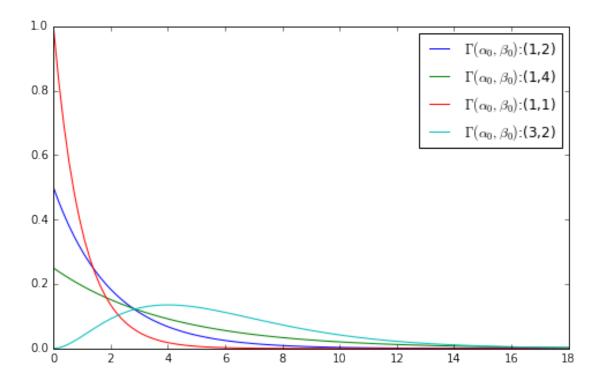
7.4

8 мая 2016 г.

```
Задача 4
In [18]: %matplotlib inline
        import numpy as np
        import math as mt
        import matplotlib
        import matplotlib.pyplot as plt
        from pylab import *
        from scipy.stats import *
In [19]: data = np.loadtxt('6.csv', delimiter=',', skiprows=3)
        print(len(data))
1000
   Для Exp(\theta) априорное распределение \Gamma(\alpha_0,\beta_0) with mean =\frac{\alpha_0}{\beta_0}. Байесовская оценка для параметра \theta: \theta^* = \frac{\alpha_0 + n}{\beta_0 + \sum_{i=1}^n x_i}.
In [20]: def BayesEst(x, alpha, beta):
            # Байесовская оценка для экспоненциального распределения
            return (alpha + len(x))/(beta + sum(x))
    Задача состоит в том, чтобы верно подобрать параметры \alpha_0 \beta_0.
In [21]: x = linspace(0.18,100)
        params = [(1,2),(1,4),(1,1),(3,2)]
        figure(figsize=(8,5))
        for p in params:
            plot(x, gamma.pdf(x, p[0], scale=p[1]), \setminus
                label = '\$\backslash Gamma(\backslash alpha 0, \backslash beta 0)\$:(\{\},\{\}) '.format(p[0], p[1]))
        legend()
        show()
```

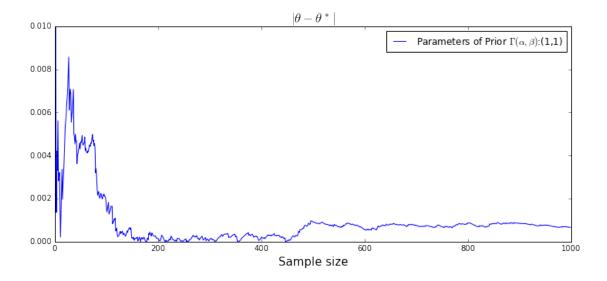


Поскольку в начальный момент времени мы ничего не знаем о "скорости выхода из строя" серверов, то нам не подходят параметры Гамма распределения, при которых образуется явный "горб" над каким-то конкретным числом. Нам следует этого избегать.

Значит, нужно брать параметр $\alpha_0=1,$ а за параметр β_0 можно взять число 2, при котором график плотности выглядит не очень крутым.

```
In [22]: # Истинное значение theta
      lmd = 1./66.
      t 0 = 200
      t = 70000
      param = (1,1)
      # Сюда запишу время между i-м моментом выхода из строя сервера и (i+1)-м,
      # то есть delta - график "разности времен"
      delta = []
      for i in range(len(data)-1):
         delta.append(data[i+1] - data[i])
      # Сюда запишу оценки для параметра theta
      est = np.array([BayesEst(delta[:(j+1)], param[0], param[1]) for j in range(len(data))])
      # Строю график модуля разности истинного значения theta и байесовской оценки
      figure(figsize=(12,5))
      y\lim((0,0.01))
      xlabel("Sample size", fontsize=15)
```

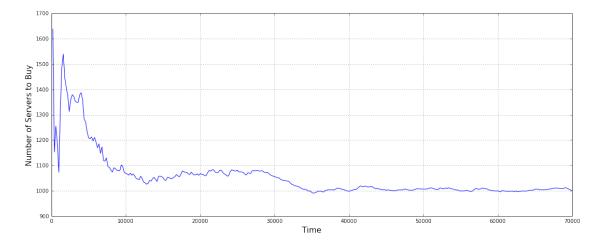
```
plot(abs(lmd-est), label="Parameters of Prior $\Gamma(\\alpha,\\beta)$:({},{})"\
    .format(param[0], param[1]))
title("$|\\theta - \\theta^*|$", fontsize=17)
legend()
show()
```

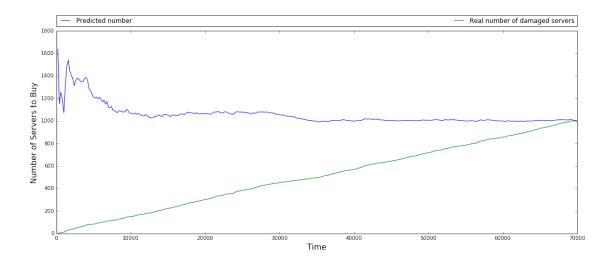


Исправлена задача 6.1 под новые условия.

Теперь вместо λ будет стоять оценка θ^* в выражении для предсказанного числа серверов, которые необходимо заменить.

```
In [23]: condition expect = [] # Здесь будут предсказанные значения количества серверов
      time = [] # Сюда записываю время с шагом t 0
      quant = [] # Количество серверов, вышедших из строя, на данный момент
      plt.figure(figsize=(18,7))
      for i in range(t//t 0):
         time.append(t 0*(i+1))
         quant.append(shape(np.where(data <= time[-1]))[1]) # Нахожу это количество подсчетом
                                              # числа записей времени, меньших
                                              # текущего времени
         condition expect.append(((t-time[-1])*est[quant[-1]-1]) + quant[-1]) # Предсказанное значение
      plt.xlabel('Time', fontsize=15)
      plt.ylabel('Number of Servers to Buy', fontsize=15)
      plt.plot(time,condition expect)
      plt.grid()
      plt.show()
      plt.figure(figsize=(18,7))
```





Каждые $t_0=200$ секунд вывожу значение предсказания. В самом конце оно совпадает с действительным значением N=1000.

In [24]: print('\n'.join(map(str,condition_expect)))

 $1637.53218541\\1153.03741702$

- 1255.27968819
- 1187.74150019
- 1072.48625837
- 1315.534249
- 1487.65375756
- 1539.15326911
- 1444.61244213
- 1407.20322234
- 1374.9692205
- 1312.95279233
- 1357.95933558
- 1379.01055923
- 1373.02480774
- 1010.02400114
- 1354.47769677
- 1348.88199883
- 1349.32507889
- 1378.02031752
- 1387.04126344
- 1357.34317399
- 1283.72360534
- 1270.88084309
- 1233.23047978
- 1208.8747368
- 1204.76539754
- 1212.25979855
- 1196.38333281
- 1210.34100193
- 1192.01605338
- 1169.53196834
- 1184.84471033
- 1147.99999733
- 1172.70369785
- 1119.84208215
- 1116.64575808
- 1129.45549982
- 1095.53430323
- 1092.40438559
- 1081.59282461
- 1073.55991889
- 1090.94357688
- 1087.5419352
- 1080.95431648
- 1080.30969453
- 1079.47476452
- 1101.92897054
- 1094.81908763
- 1071.89473007
- 1068.83195688

- 1066.08336161
- 1061.71514547
- 1069.86680594
- 1061.18454279
- 1066.61571659
- 1058.24015512
- 1048.86526347
- 1045.80386846
- 1043.98311233
- 1057.58813311
- 1047.52966041
- 1034.36631384
- 1031.41018081
- 1025.80657021
- 1029.63575163
- 1040.5199748
- 1037.98811107
- 1047.77462691
- 1052.75018909
- 1045.41051675
- 1036.62244471
- 1056.95642979
- 1057.43397135
- 1056.07232912
- 1051.92193683
- 1042.69081891
- 1041.13822362
- 1052.74677311
- 1052.25419942
- 1048.0318878
- 1047.292533
- 1052.42608995
- 1055.11188391
- 1063.6500488
- 1058.92335546
- 1054.90349311
- 1063.90408194
- 1078.27333432
- 1074.49258961
- 1073.017345
- 1072.87369082
- 1066.6862453
- 1063.75739496
- 1073.46053908
- 1066.23371487
- 1062.58847134
- 1063.21471907
- 1066.39934783

- 1061.09239095
- 1067.53436155
- 1064.96232345
- 1064.35180882
- 1059.73265165
- 1059.65736854
- 1071.15640555
- 1079.67589119
- 1077.2102095
- 1082.23363108
- 1082.75918455
- 1074.17558215
- 1071.10818389
- 1072.06253135
- 1012.00200100
- 1079.99694773
- 1081.53308483
- 1073.90288294
- 1067.32000163
- 1064.27162555
- 1058.4840107
- 1058.38634462
- 1072.91793695
- 1082.0340234
- 1081.55143546
- 1078.46129759
- 1077.4356959
- 1081.08275234
- 1074.09248291
- 1074.32211111
- 1073.88438613
- 1072.00123651
- 1065.73496577
- 1062.20861233
- 1070.91562865
- 1069.38721919
- 1068.61223351
- 1078.85393447
- 1078.47369516
- 1078.25626462
- 1080.56144996
- 1000.00144990
- 1078.73387947
- 1077.12051743
- 1078.68259683
- 1077.79547962
- 1073.58600162
- 1071.64756419
- 1073.06141375
- 1068.69597412

- 1063.28134213
- 1060.25039956
- 1057.60970988
- 1056.42380273
- 1053.40668372
- 1051.24393463
- 1050.83384043
- 1045.40826049
- 1042.42148365
- 1039.65563289
- 1040.52626917
- 1038.43086627
- 1038.41870275
- 1035.03809996
- 1027.75029711
- 1024.81511036
- 1021.97742263
- 1019.05775727
- 1018.40572978
- 1016.38836954
- 1013.34192055
- 1009.48589474
- 1006.36154095
- 1005.50030516
- 1005.93643581
- 1001.2223301
- 998.361530492
- 999.481280192
- 993.396252914
- 990.559702897
- 991.774072513
- 993.988342525
- 998.064014669
- 998.236023331
- 998.170020862
- 996.422856063
- 994.905741475
- 1000.72244128
- 1001.66844371
- 1003.88084746
- 1003.95107679
- 1003.77045993 1004.05637576
- 1002.97214727
- 1006.59787924
- 1009.7919795
- 1010.18932062
- 1008.63144056

- 1005.99851357
- 1005.28077036
- 1003.6552708
- 1000.26125649
- 999.442289679
- 998.009817468
- 999.784775159
- 1001.19179955
- 1003.79319246
- 1005.47482802
- 1005.75758684
- 1010.62697575
- 1010.02001010
- 1016.64906753
- 1019.14562281
- 1016.92819327
- 1017.0246319
- 1018.7980393
- 1015.86865911
- 1014.65891127
- 1015.94158562
- 1017.45200236
- 1014.54495049
- 1010.80946875
- 1007.92368327
- 1009.31736825
- 1007.70475918
- 1005.824623
- 1004.05224038
- 1004.65045195
- 1004.38267271
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- 1003.67444624
- 1002.61980423
- 1000.9592655
- 1000.76709406
- 1000.25955171
- 999.831831068
- 1001.5877666
- 1003.12128079
- 1002.97057966
- 1003.59331007
- 1003.68542244
- 1005.75260655
- 1006.45990709
- 1004.79410654
- 1002.69396436
- 1001.99615728
- 1001.80604878

- 1002.22681339
- 1004.78919392
- 1006.52987126
- 1008.43604664
- 1007.36397634
- 1007.58637826
- 1006.3431899
- 1000.0401099
- 1007.06004439
- 1006.31839394
- 1006.54314271
- 1008.20769178
- 1009.86891271
- 1011.39599099
- 1011.04007255
- 1008.7603907
- 1006.04830341
- 1004.92564485
- 1005.20643382
- 1010.57356421
- 1010.43071122
- 1008.24008025
- 1008.33009951
- 1011.27780097
- 1008.8507814
- 1011.78384689
- 1008.89488488
- 1007.68733027
- 1006.63286746
- 1004.99050015
- 1003.14801414
- 1003.0859268
- 1000.7838727
- 998.681277921
- 1000.12780621
- 999.051662943
- 1000 4100 2000
- 1000.41287069
- 1001.34672491
- 1000.37988767
- 998.138038252
- 997.268516275
- 998.729728798
- 1003.79762101
- 1008.83424457
- 1008.41052355
- 1005.52910911
- 1006.66876227
- 1008.28819459
- 1010.68431017

- 1008.38393299
- 1008.45948833
- 1006.58658146
- 1003.71664143
- 1001.56908378
- 1001.73271144
- 999.73263592
- 999.761723351
- 999.026550962
- 999.885144872
- 997.027441975
- 995.941643463
- 1000.78065978
- 999.640266853
- 998.557206944
- 990.001200944
- 997.819097696
- 997.768510279
- 998.159132052
- 998.084017588
- 998.43736513
- 996.262118312
- 999.401752572
- 996.549074873
- 996.862283673
- 998.060485952
- 998.234719159
- 999.405844607
- 998.559507142
- 998.678310619
- 999.889022337
- 1001.15099794
- 1002.44455634
- 1001.40807682
- 1002.70554151
- 1006.04968118
- 1006.21740522
- 1006.31939304
- 1004.23362275
- 1004.43592685
- 1004.55464309
- 1003.64933163
- 1004.77452223
- 1004.92738586
- 1006.13397922
- 1006.25871127
- 1008.44815446
- 1009.60944038
- 1009.72732339

```
1009.92706171
1010.00343886
1009.14078857
1009.23980826
1008.34065498
1011.4700524
1011.59248778
1008.69436584
1005.79624389
1002.89812195
1000.0
In [25]: for i in range(len(est)):
         print("lambda = \{:.4f\}, \{:.4f\} - bayes estimate, \{\}/\{\}".format(lmd, est[i], i+1, len(est)))
lambda = 0.0152, 0.2476 - bayes estimate, 1/1000
lambda = 0.0152, 0.0962 - bayes estimate, 2/1000
lambda = 0.0152, 0.0234 - bayes estimate, 3/1000
lambda = 0.0152, 0.0165 - bayes estimate, 4/1000
lambda = 0.0152, 0.0193 - bayes estimate, 5/1000
lambda = 0.0152, 0.0185 - bayes estimate, 6/1000
lambda = 0.0152, 0.0208 - bayes estimate, 7/1000
lambda = 0.0152, 0.0180 - bayes estimate, 8/1000
lambda = 0.0152, 0.0180 - bayes estimate, 9/1000
lambda = 0.0152, 0.0184 - bayes estimate, 10/1000
lambda = 0.0152, 0.0170 - bayes estimate, 11/1000
lambda = 0.0152, 0.0154 - bayes estimate, 12/1000
lambda = 0.0152, 0.0164 - bayes estimate, 13/1000
lambda = 0.0152, 0.0175 - bayes estimate, 14/1000
lambda = 0.0152, 0.0185 - bayes estimate, 15/1000
lambda = 0.0152, 0.0171 - bayes estimate, 16/1000
lambda = 0.0152, 0.0179 - bayes estimate, 17/1000
lambda = 0.0152, 0.0183 - bayes estimate, 18/1000
lambda = 0.0152, 0.0188 - bayes estimate, 19/1000
lambda = 0.0152, 0.0196 - bayes estimate, 20/1000
lambda = 0.0152, 0.0204 - bayes estimate, 21/1000
lambda = 0.0152, 0.0207 - bayes estimate, 22/1000
lambda = 0.0152, 0.0210 - bayes estimate, 23/1000
lambda = 0.0152, 0.0215 - bayes estimate, 24/1000
lambda = 0.0152, 0.0218 - bayes estimate, 25/1000
lambda = 0.0152, 0.0223 - bayes estimate, 26/1000
lambda = 0.0152, 0.0229 - bayes estimate, 27/1000
lambda = 0.0152, 0.0237 - bayes estimate, 28/1000
lambda = 0.0152, 0.0213 - bayes estimate, 29/1000
lambda = 0.0152, 0.0219 - bayes estimate, 30/1000
lambda = 0.0152, 0.0222 - bayes estimate, 31/1000
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1010.8597944

```
lambda = 0.0152, 0.0220 - bayes estimate, 32/1000
lambda = 0.0152, 0.0207 - bayes estimate, 33/1000
lambda = 0.0152, 0.0210 - bayes estimate, 34/1000
lambda = 0.0152, 0.0212 - bayes estimate, 35/1000
lambda = 0.0152, 0.0217 - bayes estimate, 36/1000
lambda = 0.0152, 0.0222 - bayes estimate, 37/1000
lambda = 0.0152, 0.0201 - bayes estimate, 38/1000
lambda = 0.0152, 0.0200 - bayes estimate, 39/1000
lambda = 0.0152, 0.0197 - bayes estimate, 40/1000
lambda = 0.0152, 0.0201 - bayes estimate, 41/1000
lambda = 0.0152, 0.0198 - bayes estimate, 42/1000
lambda = 0.0152, 0.0198 - bayes estimate, 43/1000
lambda = 0.0152, 0.0188 - bayes estimate, 44/1000
lambda = 0.0152, 0.0192 - bayes estimate, 45/1000
lambda = 0.0152, 0.0192 - bayes estimate, 46/1000
lambda = 0.0152, 0.0195 - bayes estimate, 47/1000
lambda = 0.0152, 0.0195 - bayes estimate, 48/1000
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lambda = 0.0152, 0.0197 - bayes estimate, 72/1000
lambda = 0.0152, 0.0200 - bayes estimate, 73/1000
lambda = 0.0152, 0.0201 - bayes estimate, 74/1000
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lambda = 0.0152, 0.0199 - bayes estimate, 76/1000
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lambda = 0.0152, 0.0183 - bayes estimate, 80/1000
lambda = 0.0152, 0.0185 - bayes estimate, 81/1000
lambda = 0.0152, 0.0182 - bayes estimate, 82/1000
lambda = 0.0152, 0.0176 - bayes estimate, 83/1000
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lambda = 0.0152, 0.0173 - bayes estimate, 97/1000
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lambda = 0.0152, 0.0156 - bayes estimate, 127/1000
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lambda = 0.0152, 0.0156 - bayes estimate, 128/1000
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lambda = 0.0152, 0.0145 - bayes estimate, 991/1000
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