In [30]:

```
# Necessary imports for this notebook
import os

import numpy as np
import pandas as pd

import datetime
import time

import random

# For plotting
%matplotlib inline

import matplotlib.pyplot as plt
import seaborn as sns

sns.set_style('darkgrid', {'axes.facecolor': '0.9'})
```

In [32]:

```
#Generation of customer profiles

def generate_customer_profiles_table(n_customers, random_state=0):

    np.random.seed(random_state)

    customer_id_properties=[]

    # Generate customer properties from random distributions
    for customer_id in range(n_customers):

        x_customer_id = np.random.uniform(0,100)
        y_customer_id = np.random.uniform(0,100)

        mean_amount = np.random.uniform(5,100) # Arbitrary (but sensible) value
        std_amount = mean_amount/2 # Arbitrary (but sensible) value

        mean_nb_tx_per_day = np.random.uniform(0,4) # Arbitrary (but sensible) value

        customer_id_properties.append([customer_id,
                                       x_customer_id, y_customer_id,
                                       mean_amount, std_amount,
                                       mean_nb_tx_per_day])

    customer_profiles_table = pd.DataFrame(customer_id_properties, columns=['CUSTOMER_ID
',
                                                                            'x_customer_id',
'y_customer_id',
                                                                            'mean_amount', 's
td_amount',
                                                                            'mean_nb_tx_per_d
ay'])

    return customer_profiles_table
```

In [33]:

```
n_customers = 5
customer_profiles_table = generate_customer_profiles_table(n_customers, random_state = 0
)
customer_profiles_table
```

Out[33]:

CUSTOMER_ID	x_customer_id	y_customer_id	mean_amount	std_amount	mean_nb_tx_per_day

0	CUSTOMER_ID	x_customer_id	y_customer_id	mean_amount	std_amount	mean_nb_tx_per_day
1	1	42.365480	64.589411	46.570785	23.285393	3.567092
2	2	96.366276	38.344152	80.213879	40.106939	2.115580
3	3	56.804456	92.559664	11.748426	5.874213	0.348517
4	4	2.021840	83.261985	78.924891	39.462446	3.480049

In [34]:

```
#Generation of terminal profiles: (where transactions are made)

def generate_terminal_profiles_table(n_terminals, random_state=0):

    np.random.seed(random_state)

    terminal_id_properties=[]

    # Generate terminal properties from random distributions
    for terminal_id in range(n_terminals):

        x_terminal_id = np.random.uniform(0,100)
        y_terminal_id = np.random.uniform(0,100)

        terminal_id_properties.append([terminal_id,
                                       x_terminal_id, y_terminal_id])

    terminal_profiles_table = pd.DataFrame(terminal_id_properties, columns=['TERMINAL_ID
',
                                                                            'x_terminal_id',
'y_terminal_id'])

    return terminal_profiles_table
```

In [35]:

```
n_terminals = 5
terminal_profiles_table = generate_terminal_profiles_table(n_terminals, random_state = 0
)
terminal_profiles_table
```

Out[35]:

	TERMINAL_ID	x_terminal_id	y_terminal_id
0	0	54.881350	71.518937
1	1	60.276338	54.488318
2	2	42.365480	64.589411
3	3	43.758721	89.177300
4	4	96.366276	38.344152

In [36]:

```
#Associating Customer to Terminal Profiles (customers within terminal radius)
def get_list_terminals_within_radius(customer_profile, x_y_terminals, r):

    # Use numpy arrays in the following to speed up computations

    # Location (x,y) of customer as numpy array
    x_y_customer = customer_profile[['x_customer_id','y_customer_id']].values.astype(flo
at)

    # Squared difference in coordinates between customer and terminal locations
    squared_diff_x_y = np.square(x_y_customer - x_y_terminals)

    # Sum along rows and compute suared root to get distance
    dist_x_y = np.sqrt(np.sum(squared_diff_x_y, axis=1))
```

```
    # Get the indices of terminals which are at a distance less than r
    available_terminals = list(np.where(dist_x_y<r)[0])

    # Return the list of terminal IDs
    return available_terminals
```

In [37]:

```
#gets a list of terminals that are within radius of 50km.(near customer)

# We first get the geographical locations of all terminals as a numpy array
x_y_terminals = terminal_profiles_table[['x_terminal_id','y_terminal_id']].values.astype(
float)
# And get the list of terminals within radius of $50$ for the last customer
get_list_terminals_within_radius(customer_profiles_table.iloc[4], x_y_terminals=x_y_termi
nals, r=50)
```

Out[37]:

```
[2, 3]
```

In [38]:

```
terminal_profiles_table
```

Out[38]:

	TERMINAL_ID	x_terminal_id	y_terminal_id
0	0	54.881350	71.518937
1	1	60.276338	54.488318
2	2	42.365480	64.589411
3	3	43.758721	89.177300
4	4	96.366276	38.344152

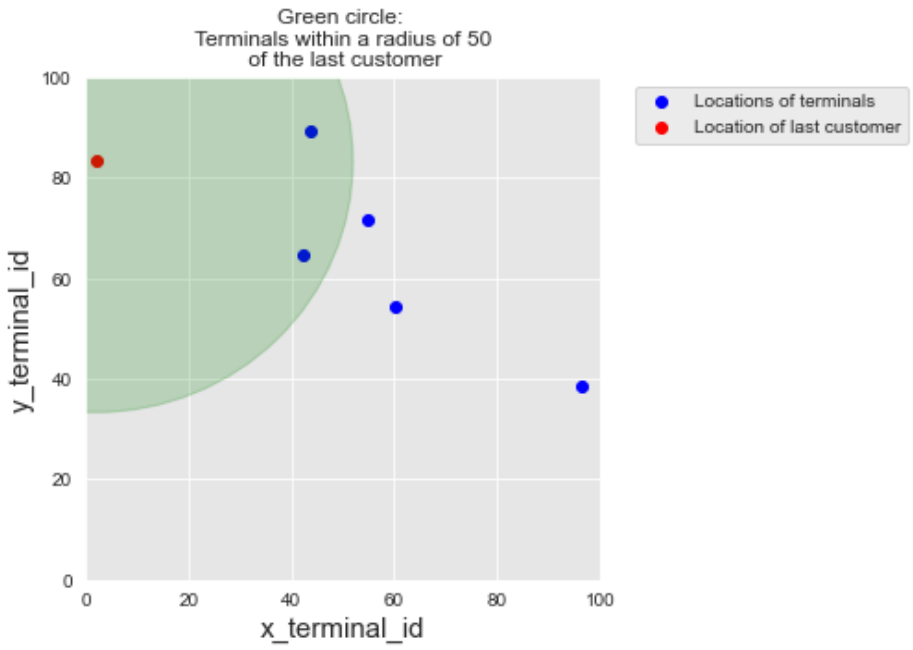
In [39]:

```
#plot figure locating customer to terminal


terminals_available_to_customer_fig, ax = plt.subplots(figsize=(5,5))

# Plot locations of terminals
ax.scatter(terminal_profiles_table.x_terminal_id.values,
           terminal_profiles_table.y_terminal_id.values,
           color='blue', label = 'Locations of terminals')

# Plot location of the last customer
customer_id=4
ax.scatter(customer_profiles_table.iloc[customer_id].x_customer_id,
           customer_profiles_table.iloc[customer_id].y_customer_id,
           color='red',label="Location of last customer")

ax.legend(loc = 'upper left', bbox_to_anchor=(1.05, 1))

# Plot the region within a radius of 50 of the last customer
circ = plt.Circle((customer_profiles_table.iloc[customer_id].x_customer_id,
                   customer_profiles_table.iloc[customer_id].y_customer_id), radius=50,
color='g', alpha=0.2)
ax.add_patch(circ)

fontsize=15

ax.set_title("Green circle: \n Terminals within a radius of 50 \n of the last customer")
ax.set_xlim([0, 100])
ax.set_ylim([0, 100])

ax.set_xlabel('x_terminal_id', fontsize=fontsize)
```

```
ax.set_ylabel('y_terminal_id', fontsize=fontsize)
```

Out[39]:

```
Text(0, 0.5, 'y_terminal_id')
```



In [40]:

```
#applies the relationship between the customers location with the terminal
customer_profiles_table['available_terminals']=customer_profiles_table.apply(lambda x : g
et_list_terminals_within_radius(x, x_y_terminals=x_y_terminals, r=50), axis=1)
customer_profiles_table
```

Out[40]:

	CUSTOMER_ID	x_customer_id	y_customer_id	mean_amount	std_amount	mean_nb_tx_per_day	available_terminals
0	0	54.881350	71.518937	62.262521	31.131260	2.179533	[0, 1, 2, 3]
1	1	42.365480	64.589411	46.570785	23.285393	3.567092	[0, 1, 2, 3]
2	2	96.366276	38.344152	80.213879	40.106939	2.115580	[1, 4]
3	3	56.804456	92.559664	11.748426	5.874213	0.348517	[0, 1, 2, 3]
4	4	2.021840	83.261985	78.924891	39.462446	3.480049	[2, 3]

In [41]:

```
#Generating the transactions
# input: customer profile, start date, nb of days to make transaction
def generate_transactions_table(customer_profile, start_date = "2018-04-01", nb_days = 1
0):

    customer_transactions = []

    random.seed(int(customer_profile.CUSTOMER_ID))
    np.random.seed(int(customer_profile.CUSTOMER_ID))

    # For all days
    for day in range(nb_days):

        # Random number of transactions for that day
        nb_tx = np.random.poisson(customer_profile.mean_nb_tx_per_day)

        # If nb_tx positive, let us generate transactions
        if nb_tx>0:

            for tx in range(nb_tx):

                # Time of transaction: Around noon, std 20000 seconds. This choice aims
```

```
at simulating the fact that
                # most transactions occur during the day.
                time_tx = int(np.random.normal(86400/2, 20000))

                # If transaction time between 0 and 86400, let us keep it, otherwise, le
t us discard it
                if (time_tx>0) and (time_tx<86400):

                    # Amount is drawn from a normal distribution
                    amount = np.random.normal(customer_profile.mean_amount, customer_pro
file.std_amount)

                    # If amount negative, draw from a uniform distribution
                    if amount<0:
                        amount = np.random.uniform(0,customer_profile.mean_amount*2)

                    amount=np.round(amount,decimals=2)

                    if len(customer_profile.available_terminals)>0:

                        terminal_id = random.choice(customer_profile.available_terminals
)

                        customer_transactions.append([time_tx+day*86400, day,
                                                      customer_profile.CUSTOMER_ID,
                                                      terminal_id, amount])

    customer_transactions = pd.DataFrame(customer_transactions, columns=['TX_TIME_SECOND
S', 'TX_TIME_DAYS', 'CUSTOMER_ID', 'TERMINAL_ID', 'TX_AMOUNT'])

    if len(customer_transactions)>0:
        customer_transactions['TX_DATETIME'] = pd.to_datetime(customer_transactions["TX_
TIME_SECONDS"], unit='s', origin=start_date)
        customer_transactions=customer_transactions[['TX_DATETIME','CUSTOMER_ID', 'TERMI
NAL_ID', 'TX_AMOUNT','TX_TIME_SECONDS', 'TX_TIME_DAYS']]

    return customer_transactions
```

In [42]:

```
transaction_table_customer_0=generate_transactions_table(customer_profiles_table.iloc[0],

                                                         start_date = "2018-04-01",
                                                         nb_days = 5)
transaction_table_customer_0
```

Out[42]:

	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS
0	2018-04-01 07:19:05	0	3	123.59	26345	0
1	2018-04-01 19:02:02	0	3	46.51	68522	0
2	2018-04-01 18:00:16	0	0	77.34	64816	0
3	2018-04-02 15:13:02	0	2	32.35	141182	1
4	2018-04-02 14:05:38	0	3	63.30	137138	1
5	2018-04-02 15:46:51	0	3	13.59	143211	1
6	2018-04-02 08:51:06	0	2	54.72	118266	1
7	2018-04-02 20:24:47	0	3	51.89	159887	1
8	2018-04-03 12:15:47	0	2	117.91	216947	2
9	2018-04-03 08:50:09	0	1	67.72	204609	2
10	2018-04-03 09:25:49	0	1	28.46	206749	2
11	2018-04-03 15:33:14	0	2	50.25	228794	2
12	2018-04-03 07:41:24	0	1	93.26	200484	2
13	2018-04-04 01:15:35	0	0	46.40	263735	3

	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS
14	2018-04-04 09:33:58	0	2	23.26	293638	3
15	2018-04-05 16:19:09	0	1	71.96	404349	4
16	2018-04-05 07:41:19	0	2	52.69	373279	4

In [43]:

```
#Generates transactions for all customers
transactions_df=customer_profiles_table.groupby('CUSTOMER_ID').apply(lambda x : generate_
transactions_table(x.iloc[0], nb_days=5)).reset_index(drop=True)
transactions_df
```

Out[43]:

	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS
0	2018-04-01 07:19:05	0	3	123.59	26345	0
1	2018-04-01 19:02:02	0	3	46.51	68522	0
2	2018-04-01 18:00:16	0	0	77.34	64816	0
3	2018-04-02 15:13:02	0	2	32.35	141182	1
4	2018-04-02 14:05:38	0	3	63.30	137138	1
...	...	...	...	...	...	...
60	2018-04-05 07:41:19	4	2	111.38	373279	4
61	2018-04-05 06:59:59	4	3	80.36	370799	4
62	2018-04-05 17:23:34	4	2	53.25	408214	4
63	2018-04-05 12:51:38	4	2	36.44	391898	4
64	2018-04-05 12:38:46	4	3	17.53	391126	4

65 rows × 6 columns

In [44]:

```
#Generate transactions for all customers, terminals, and days.
def generate_dataset(n_customers = 10000, n_terminals = 1000000, nb_days=90, start_date=
"2018-04-01", r=5):

    start_time=time.time()
    customer_profiles_table = generate_customer_profiles_table(n_customers, random_state
= 0)
    print("Time to generate customer profiles table: {0:.2}s".format(time.time()-start_ti
me))

    start_time=time.time()
    terminal_profiles_table = generate_terminal_profiles_table(n_terminals, random_state
= 1)
    print("Time to generate terminal profiles table: {0:.2}s".format(time.time()-start_ti
me))

    start_time=time.time()
    x_y_terminals = terminal_profiles_table[['x_terminal_id','y_terminal_id']].values.ast
ype(float)
    customer_profiles_table['available_terminals'] = customer_profiles_table.apply(lambda
x : get_list_terminals_within_radius(x, x_y_terminals=x_y_terminals, r=r), axis=1)
    # With Pandarallel
    #customer_profiles_table['available_terminals'] = customer_profiles_table.parallel_ap
ply(lambda x : get_list_closest_terminals(x, x_y_terminals=x_y_terminals, r=r), axis=1)
    customer_profiles_table['nb_terminals']=customer_profiles_table.available_terminals.a
pply(len)
    print("Time to associate terminals to customers: {0:.2}s".format(time.time()-start_ti
me))

    start_time=time.time()
    transactions_df=customer_profiles_table.groupby('CUSTOMER_ID').apply(lambda x : gene
rate_transactions_table(x.iloc[0], nb_days=nb_days)).reset_index(drop=True)
```

```
    # With Pandarallel
    #transactions_df=customer_profiles_table.groupby('CUSTOMER_ID').parallel_apply(lambda
x : generate_transactions_table(x.iloc[0], nb_days=nb_days)).reset_index(drop=True)
    print("Time to generate transactions: {0:.2}s".format(time.time()-start_time))

    # Sort transactions chronologically
    transactions_df=transactions_df.sort_values('TX_DATETIME')
    # Reset indices, starting from 0
    transactions_df.reset_index(inplace=True,drop=True)
    transactions_df.reset_index(inplace=True)
    # TRANSACTION_ID are the dataframe indices, starting from 0
    transactions_df.rename(columns = {'index':'TRANSACTION_ID'}, inplace = True)

    return (customer_profiles_table, terminal_profiles_table, transactions_df)
```

In [45]:

```
#generate customer profiles that feature 5000 customers,
(customer_profiles_table, terminal_profiles_table, transactions_df)=\
    generate_dataset(n_customers = 5000,
                     n_terminals = 10000,
                     nb_days=183,
                     start_date="2018-04-01",
                     r=5)
```

```
Time to generate customer profiles table: 0.064s
Time to generate terminal profiles table: 0.055s
Time to associate terminals to customers: 2.0s
Time to generate transactions: 1.2e+02s
```

In [46]:

```
transactions_df.shape
```

Out[46]:

```
(1754155, 7)
```

In [47]:

```
transactions_df
```

Out[47]:

	TRANSACTION_ID	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS
0	0	2018-04-01 00:00:31	596	3156	57.16	31	0
1	1	2018-04-01 00:02:10	4961	3412	81.51	130	0
2	2	2018-04-01 00:07:56	2	1365	146.00	476	0
3	3	2018-04-01 00:09:29	4128	8737	64.49	569	0
4	4	2018-04-01 00:10:34	927	9906	50.99	634	0
...	...	...	...	...	...	...	...
1754150	1754150	2018-09-30 23:56:36	161	655	54.24	15810996	182
1754151	1754151	2018-09-30 23:57:38	4342	6181	1.23	15811058	182
1754152	1754152	2018-09-30 23:58:21	618	1502	6.62	15811101	182
1754153	1754153	2018-09-30 23:59:52	4056	3067	55.40	15811192	182
1754154	1754154	2018-09-30 23:59:57	3542	9849	23.59	15811197	182

	TRANSACTION_ID	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS

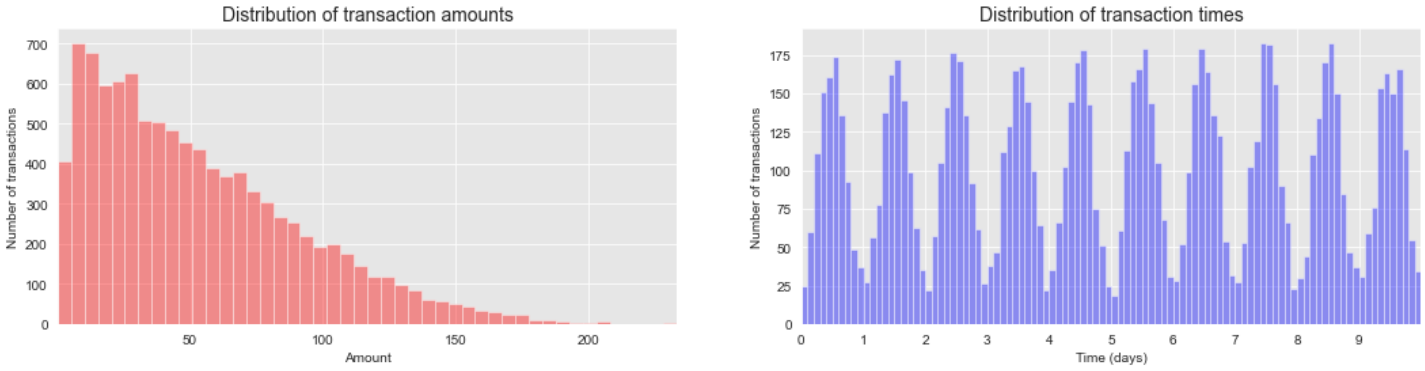
1754155 rows × 7 columns

In [51]:

```
#plot the distribution between transaction amount and  transaction times

distribution_amount_times_fig, ax = plt.subplots(1, 2, figsize=(18,4))

amount_val = transactions_df[transactions_df.TX_TIME_DAYS<10]['TX_AMOUNT'].sample(n=1000
0).values
time_val = transactions_df[transactions_df.TX_TIME_DAYS<10]['TX_TIME_SECONDS'].sample(n=
10000).values

sns.distplot(amount_val, ax=ax[0], color='r', hist = True, kde = False)
ax[0].set_title('Distribution of transaction amounts', fontsize=14)
ax[0].set_xlim([min(amount_val), max(amount_val)])
ax[0].set(xlabel = "Amount", ylabel="Number of transactions")

# We divide the time variables by 86400 to transform seconds to days in the plot
sns.distplot(time_val/86400, ax=ax[1], color='b', bins = 100, hist = True, kde = False)
ax[1].set_title('Distribution of transaction times', fontsize=14)
ax[1].set_xlim([min(time_val/86400), max(time_val/86400)])
ax[1].set_xticks(range(10))
ax[1].set(xlabel = "Time (days)", ylabel="Number of transactions")
```

Out[51]:

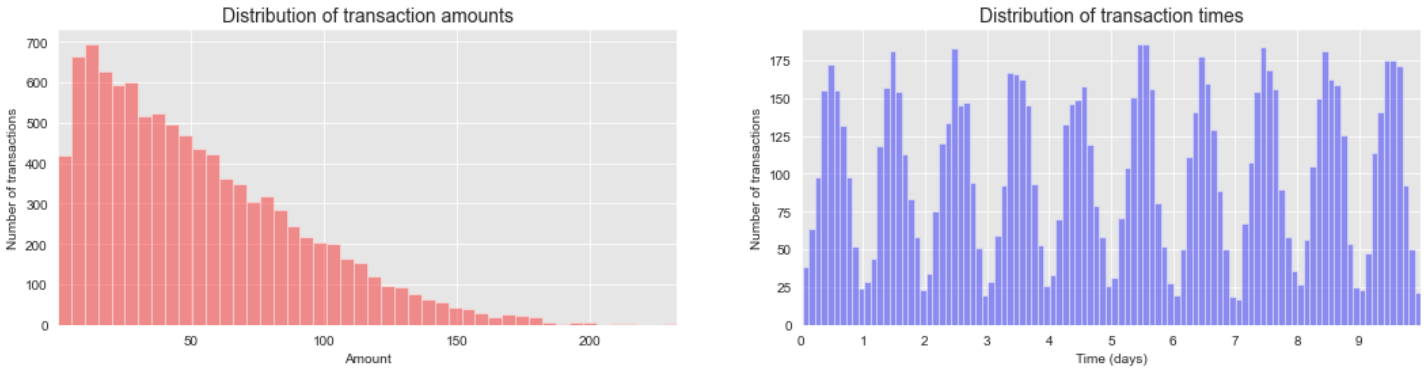
```
[Text(0.5, 0, 'Time (days)'), Text(0, 0.5, 'Number of transactions')]
```



In [50]:

```
distribution_amount_times_fig
```

Out[50]:



In [53]:

```
# adds fraudalent transactions to the dataset with scenarios
 #ex.1 Any transaction whose amount is more than 220 is a fraud. (uses a fraud pattern, t
hat is useful to validate implementation of fraud)
# ex.2 each day, a list of 2 terminals are drawn at random(transactions in 28days can be
marked as fraud)
# ex.3 each day, a list of 3 customers are drawn at random( 1/3 transactions taken out of
14 days can be marked as fraud)
```

```
def add_frauds(customer_profiles_table, terminal_profiles_table, transactions_df):

    # By default, all transactions are genuine
    transactions_df['TX_FRAUD']=0
    transactions_df['TX_FRAUD_SCENARIO']=0

    # Scenario 1
    transactions_df.loc[transactions_df.TX_AMOUNT>220, 'TX_FRAUD']=1
    transactions_df.loc[transactions_df.TX_AMOUNT>220, 'TX_FRAUD_SCENARIO']=1
    nb_frauds_scenario_1=transactions_df.TX_FRAUD.sum()
    print("Number of frauds from scenario 1: "+str(nb_frauds_scenario_1))

    # Scenario 2
    for day in range(transactions_df.TX_TIME_DAYS.max()):

        compromised_terminals = terminal_profiles_table.TERMINAL_ID.sample(n=2, random_s
tate=day)

        compromised_transactions=transactions_df[(transactions_df.TX_TIME_DAYS>=day) &
                                                 (transactions_df.TX_TIME_DAYS<day+2
8) &
                                                 (transactions_df.TERMINAL_ID.isin(c
ompromised_terminals))]

        transactions_df.loc[compromised_transactions.index,'TX_FRAUD']=1
        transactions_df.loc[compromised_transactions.index,'TX_FRAUD_SCENARIO']=2

    nb_frauds_scenario_2=transactions_df.TX_FRAUD.sum()-nb_frauds_scenario_1
    print("Number of frauds from scenario 2: "+str(nb_frauds_scenario_2))

    # Scenario 3
    for day in range(transactions_df.TX_TIME_DAYS.max()):

        compromised_customers = customer_profiles_table.CUSTOMER_ID.sample(n=3, random_s
tate=day).values

        compromised_transactions=transactions_df[(transactions_df.TX_TIME_DAYS>=day) &
                                                 (transactions_df.TX_TIME_DAYS<day+1
4) &
                                                 (transactions_df.CUSTOMER_ID.isin(c
ompromised_customers))]

        nb_compromised_transactions=len(compromised_transactions)


        random.seed(day)
        index_fauds = random.sample(list(compromised_transactions.index.values),k=int(nb
_compromised_transactions/3))

        transactions_df.loc[index_fauds,'TX_AMOUNT']=transactions_df.loc[index_fauds,'TX
_AMOUNT']*5
        transactions_df.loc[index_fauds,'TX_FRAUD']=1
        transactions_df.loc[index_fauds,'TX_FRAUD_SCENARIO']=3


    nb_frauds_scenario_3=transactions_df.TX_FRAUD.sum()-nb_frauds_scenario_2-nb_frauds_sc
enario_1
    print("Number of frauds from scenario 3: "+str(nb_frauds_scenario_3))

    return transactions_df
```

In [54]:

```
#number of fraud transactions
%time transactions_df = add_frauds(customer_profiles_table, terminal_profiles_table, tran
sactions_df)
```

```
Number of frauds from scenario 1: 978
Number of frauds from scenario 2: 9099
```

```
Number of frauds from scenario 3: 4604
Wall time: 1min 48s
```

In [56]:

```
```

Out[56]:

```
(1754155, 9)
```

In [57]:

```
#percentage of fraud transactions
transactions_df.TX_FRAUD.mean()
```

Out[57]:

```
0.008369271814634397
```

In [58]:

```
#number of fraud transactions  (amounts to 0.8% of the transactions)
transactions_df.TX_FRAUD.sum()
```

Out[58]:

```
14681
```

In [59]:

```
transactions_df.head()
```

Out[59]:

	TRANSACTION_ID	TX_DATETIME	CUSTOMER_ID	TERMINAL_ID	TX_AMOUNT	TX_TIME_SECONDS	TX_TIME_DAYS	TX_FI
0	0	2018-04-01 00:00:31	596	3156	57.16	31	0	
1	1	2018-04-01 00:02:10	4961	3412	81.51	130	0	
2	2	2018-04-01 00:07:56	2	1365	146.00	476	0	
3	3	2018-04-01 00:09:29	4128	8737	64.49	569	0	
4	4	2018-04-01 00:10:34	927	9906	50.99	634	0	

In [60]:

```
transactions_df[transactions_df.TX_FRAUD_SCENARIO==1].shape
```

Out[60]:

```
(973, 9)
```

In [61]:

```
transactions_df[transactions_df.TX_FRAUD_SCENARIO==2].shape
```

Out[61]:

```
(9077, 9)
```

In [62]:

```
transactions_df[transactions_df.TX_FRAUD_SCENARIO==3].shape
```

Out[62]:

```
(4631, 9)
```

(4631, 9)

In [64]:

```
def get_stats(transactions_df):
    #Number of transactions per day
    nb_tx_per_day=transactions_df.groupby(['TX_TIME_DAYS'])['CUSTOMER_ID'].count()
    #Number of fraudulent transactions per day
    nb_fraud_per_day=transactions_df.groupby(['TX_TIME_DAYS'])['TX_FRAUD'].sum()
    #Number of fraudulent cards per day
    nb_fraudcard_per_day=transactions_df[transactions_df['TX_FRAUD']>0].groupby(['TX_TIM
E_DAYS']).CUSTOMER_ID.nunique()

    return (nb_tx_per_day,nb_fraud_per_day,nb_fraudcard_per_day)

(nb_tx_per_day,nb_fraud_per_day,nb_fraudcard_per_day)=get_stats(transactions_df)

n_days=len(nb_tx_per_day)
tx_stats=pd.DataFrame({"value":pd.concat([nb_tx_per_day/50,nb_fraud_per_day,nb_fraudcard
_per_day])})
tx_stats['stat_type']=["nb_tx_per_day"]*n_days+["nb_fraud_per_day"]*n_days+["nb_fraudcard
_per_day"]*n_days
tx_stats=tx_stats.reset_index()
```

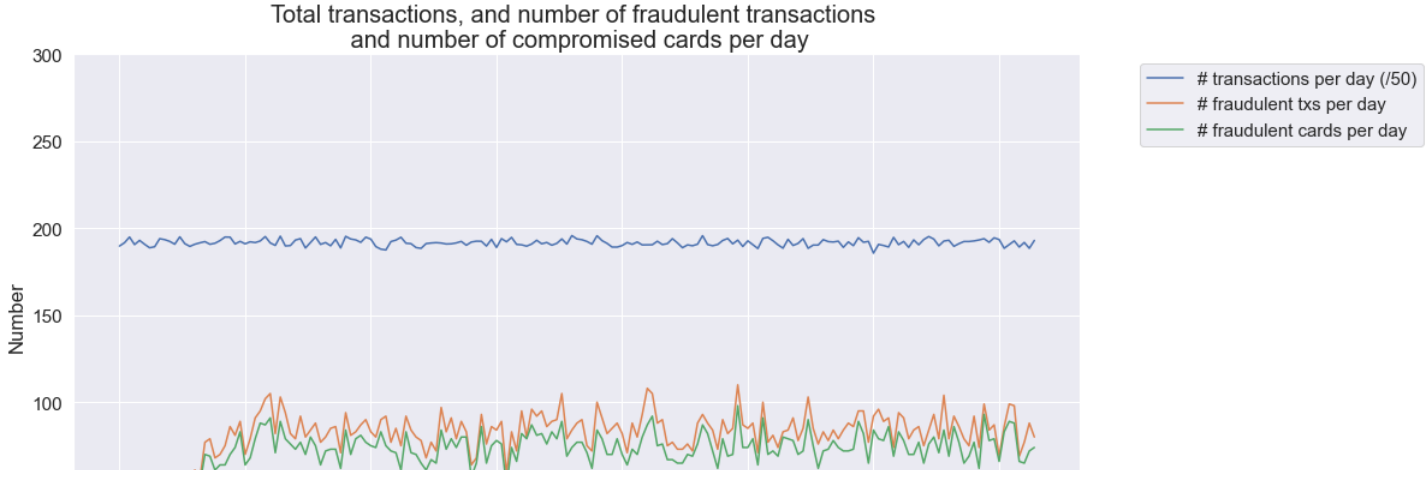
In [65]:

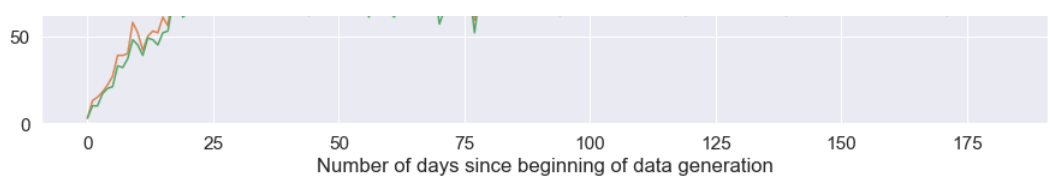
```
%%capture

sns.set(style='darkgrid')
sns.set(font_scale=1.4)

fraud_and_transactions_stats_fig = plt.gcf()

fraud_and_transactions_stats_fig.set_size_inches(15, 8)

sns_plot = sns.lineplot(x="TX_TIME_DAYS", y="value", data=tx_stats, hue="stat_type", hue_
order=["nb_tx_per_day","nb_fraud_per_day","nb_fraudcard_per_day"], legend=False)

sns_plot.set_title('Total transactions, and number of fraudulent transactions \n and numb
er of compromised cards per day', fontsize=20)
sns_plot.set(xlabel = "Number of days since beginning of data generation", ylabel="Number
")

sns_plot.set_ylim([0,300])

labels_legend = ["# transactions per day (/50)", "# fraudulent txs per day", "# fraudulen
t cards per day"]

sns_plot.legend(loc='upper left', labels=labels_legend,bbox_to_anchor=(1.05, 1), fontsize
=15)
```

In [66]:

```
fraud_and_transactions_stats_fig
```

Out[66]:





In [68]:

```
#saves dataset
DIR_OUTPUT = "./simulated-data-raw/"

if not os.path.exists(DIR_OUTPUT):
    os.makedirs(DIR_OUTPUT)

start_date = datetime.datetime.strptime("2018-04-01", "%Y-%m-%d")

for day in range(transactions_df.TX_TIME_DAYS.max()+1):

    transactions_day = transactions_df[transactions_df.TX_TIME_DAYS==day].sort_values('T
X_TIME_SECONDS')

    date = start_date + datetime.timedelta(days=day)
    filename_output = date.strftime("%Y-%m-%d")+'.pkl'

    # Protocol=4 required for Google Colab
    transactions_day.to_pickle(DIR_OUTPUT+filename_output, protocol=4)
```

In [ ]:

```

```