Carga de librerias

```
In [16]: pip install requests tsplib95
```

```
Requirement already satisfied: requests in c:\users\alexi\anaconda3\lib\site-pack
ages (2.32.3)
Requirement already satisfied: tsplib95 in c:\users\alexi\anaconda3\lib\site-pack
ages (0.7.1)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\alexi\anacond
a3\lib\site-packages (from requests) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in c:\users\alexi\anaconda3\lib\site-
packages (from requests) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\alexi\anaconda3\lib
\site-packages (from requests) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\alexi\anaconda3\lib
\site-packages (from requests) (2024.8.30)
Requirement already satisfied: Click>=6.0 in c:\users\alexi\anaconda3\lib\site-pa
ckages (from tsplib95) (8.1.7)
Requirement already satisfied: Deprecated~=1.2.9 in c:\users\alexi\anaconda3\lib
\site-packages (from tsplib95) (1.2.18)
Requirement already satisfied: networkx~=2.1 in c:\users\alexi\anaconda3\lib\site
-packages (from tsplib95) (2.8.8)
Requirement already satisfied: tabulate~=0.8.7 in c:\users\alexi\anaconda3\lib\si
te-packages (from tsplib95) (0.8.10)
Requirement already satisfied: colorama in c:\users\alexi\anaconda3\lib\site-pack
ages (from Click>=6.0->tsplib95) (0.4.6)
Requirement already satisfied: wrapt<2,>=1.10 in c:\users\alexi\anaconda3\lib\sit
e-packages (from Deprecated~=1.2.9->tsplib95) (1.14.1)
Note: you may need to restart the kernel to use updated packages.
```

Carga de los datos del problema

```
In [6]: import urllib.request
        import tsplib95
        import math
        import random
        import gzip
        import shutil

        # Archivo y URL
        file = "swiss42.tsp"
        url = "http://comopt.ifi.uni-heidelberg.de/software/TSPLIB95/tsp/swiss42.tsp.gz"

        # Descargar el archivo
        urllib.request.urlretrieve(url, file + '.gz')

        # Descomprimir
        with gzip.open(file + '.gz', 'rb') as f_in:
            with open(file, 'wb') as f_out:
                shutil.copyfileobj(f_in, f_out)

        # Cargar la instancia TSP
        problem = tsplib95.load(file)

        # Acceder a datos
```

```
print("Nombre del problema:", problem.name)
print("Número de nodos:", len(list(problem.get_nodes())))
print("Distancia entre nodo 0 y 1:", problem.get_weight(0, 1))
```

```
Nombre del problema: swiss42
Número de nodos: 42
Distancia entre nodo 0 y 1: 15
```

In [7]:

```
#Carga de datos y generación de objeto problem
###############################################################################
problem = tsplib95.load(file)

#Nodos
Nodos = list(problem.get_nodes())

#Aristas
Aristas = list(problem.get_edges())
```

In [8]:

```
Aristas
```

```
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            (21, 13),
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            (22, 2),
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            (22, 4),
            (22, 5),
            (22, 6),
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            (23, 3),
            (23, 4),
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            ...]
```

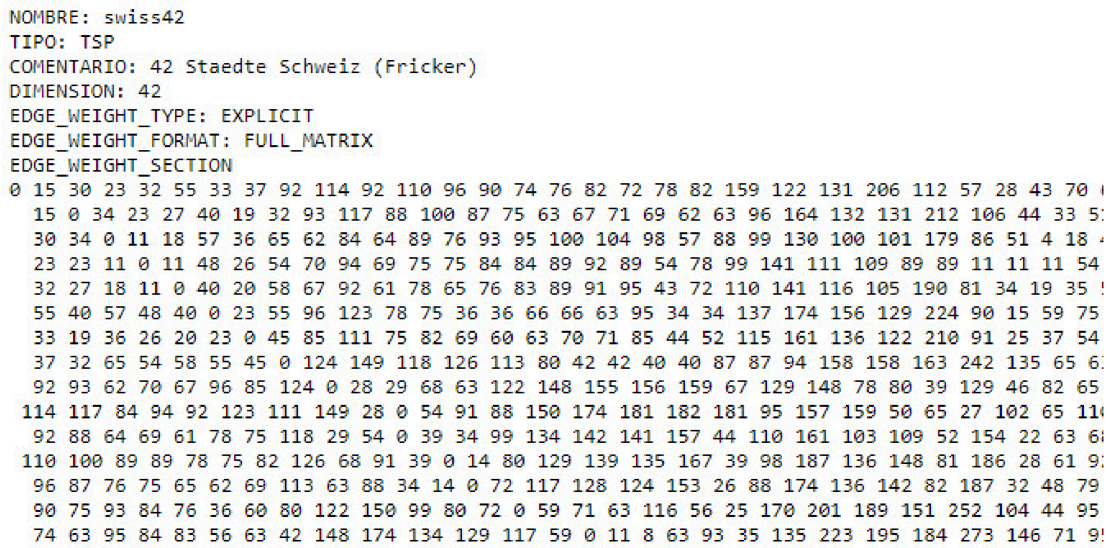

```
NOMBRE: swiss42
TIPO: TSP
COMENTARIO: 42 Staedte Schweiz (Fricker)
DIMENSION: 42
EDGE_WEIGHT_TYPE: EXPLICIT
EDGE_WEIGHT_FORMAT: FULL_MATRIX
EDGE_WEIGHT_SECTION
0 15 30 23 32 55 33 37 92 114 92 110 96 90 74 76 82 72 78 82 159 122 131 206 112 57 28 43 70
  15 0 34 23 27 40 19 32 93 117 88 100 87 75 63 67 71 69 62 63 96 164 132 131 212 106 44 33
  30 34 0 11 18 57 36 65 62 84 64 89 76 93 95 100 104 98 57 88 99 130 100 101 179 86 51 4 18
  23 23 11 0 11 48 26 54 70 94 69 75 75 84 84 89 92 89 54 78 99 141 111 109 89 89 11 11 11 54
  32 27 18 11 0 40 20 58 67 92 61 78 65 76 83 89 91 95 43 72 110 141 116 105 190 81 34 19 35
  55 40 57 48 40 0 23 55 96 123 78 75 36 36 66 66 63 95 34 34 137 174 156 129 224 90 15 59 75
  33 19 36 26 20 23 0 45 85 111 75 82 69 60 63 70 71 85 44 52 115 161 136 122 210 91 25 37 54
  37 32 65 54 58 55 45 0 124 149 118 126 113 80 42 42 40 40 87 87 94 158 158 163 242 135 65
  92 93 62 70 67 96 85 124 0 28 29 68 63 122 148 155 156 159 67 129 148 78 80 39 129 46 82 65
 114 117 84 94 92 123 111 149 28 0 54 91 88 150 174 181 182 181 95 157 159 50 65 27 102 65 11
  92 88 64 69 61 78 75 118 29 54 0 39 34 99 134 142 141 157 44 110 161 103 109 52 154 22 63
 110 100 89 89 78 75 82 126 68 91 39 0 14 80 129 139 135 167 39 98 187 136 148 81 186 28 61
  96 87 76 75 65 62 69 113 63 88 34 14 0 72 117 128 124 153 26 88 174 136 142 82 187 32 48 79
  90 75 93 84 76 36 60 80 122 150 99 80 72 0 59 71 63 116 56 25 170 201 189 151 252 104 44 95
  74 63 95 84 83 56 63 42 148 174 134 129 117 59 0 11 8 63 93 35 135 223 195 184 273 146 71
```

In [9]:

```
#Probamos algunas funciones del objeto problem

#Distancia entre nodos
problem.get_weight(0, 1)

#Todas las funciones
#Documentación: https://tsplib95.readthedocs.io/en/v0.6.1/modules.html

#dir(problem)
```

Out[9]:

```
15
```

Funcionas basicas

In [10]:

```
#Funcionas basicas
###############################################################################

#Se genera una solucion aleatoria con comienzo en en el nodo 0
def crear_solucion(Nodos):
  solucion = [Nodos[0]]
  for n in Nodos[1:]:
    solucion = solucion + [random.choice(list(set(Nodos) - set({Nodos[0]}) - set
  return solucion

#Devuelve la distancia entre dos nodos
def distancia(a,b, problem):
  return problem.get_weight(a,b)

#Devuelve la distancia total de una trayectoria/solucion
def distancia_total(solucion, problem):
  distancia_total = 0
  for i in range(len(solucion)-1):
    distancia_total += distancia(solucion[i] ,solucion[i+1] ,  problem)
  return distancia_total + distancia(solucion[len(solucion)-1] ,solucion[0], prc

sol_temporal = crear_solucion(Nodos)

distancia_total(sol_temporal, problem), sol_temporal
```

Out[10]:

```
(4893,
 [0,
  20,
  31,
  37,
  38,
  29,
  26,
  1,
  28,
  17,
  12,
  6,
  3,
  30,
  8,
  35,
  11,
  40,
  4,
  13,
  27,
  39,
  14,
  21,
  23,
  25,
  32,
  18,
  10,
  34,
  36,
  24,
  9,
  16,
  15,
  5,
  33,
  19,
  2,
  41,
  7,
  22])
```

BUSQUEDA ALEATORIA

In [11]:

```
################################################################################
# BUSQUEDA ALEATORIA
################################################################################

def busqueda_aleatoria(problem, N):
  #N es el numero de iteraciones
  Nodos = list(problem.get_nodes())

  mejor_solucion = []
  #mejor_distancia = 10e100                         #Inicializamos con un valor
  mejor_distancia = float('inf')                    #Inicializamos con un valor
  for i in range(N):                                #Criterio de parada: repetir
    solucion = crear_solucion(Nodos)                #Genera una solucion aleator
    distancia = distancia_total(solucion, problem)  #Calcula el valor objetivo(a

    if distancia < mejor_distancia:                 #Compara con la mejor obteni
      mejor_solucion = solucion
      mejor_distancia = distancia


  print("Mejor solución:" , mejor_solucion)
  print("Distancia     :" , mejor_distancia)
  return mejor_solucion


#Busqueda aleatoria con 5000 iteraciones
solucion = busqueda_aleatoria(problem, 10000)
```

```
Mejor solución: [0, 1, 32, 15, 10, 33, 30, 31, 3, 4, 6, 41, 19, 13, 12, 16, 26, 2
4, 40, 21, 22, 34, 36, 27, 37, 14, 5, 9, 23, 28, 8, 38, 39, 18, 11, 25, 35, 7, 1
7, 2, 20, 29]
Distancia     : 3768
```

BUSQUEDA LOCAL

In [12]:

```
################################################################################
# BUSQUEDA LOCAL
################################################################################
def genera_vecina(solucion):
  #Generador de soluciones vecinas: 2-opt (intercambiar 2 nodos) Si hay N nodos
  #Se puede modificar para aplicar otros generadores distintos que 2-opt
  #print(solucion)
  mejor_solucion = []
  mejor_distancia = 10e100
  for i in range(1,len(solucion)-1):          #Recorremos todos los nodos en buc
    for j in range(i+1, len(solucion)):

      #Se genera una nueva solución intercambiando los dos nodos i,j:
      #  (usamos el operador + que para listas en python las concatena) : ej.: [
      vecina = solucion[:i] + [solucion[j]] + solucion[i+1:j] + [solucion[i]] +

      #Se evalua la nueva solución ...
      distancia_vecina = distancia_total(vecina, problem)

      #... para guardarla si mejora las anteriores
      if distancia_vecina <= mejor_distancia:
        mejor_distancia = distancia_vecina
        mejor_solucion = vecina
  return mejor_solucion


#solucion = [1, 47, 13, 41, 40, 19, 42, 44, 37, 5, 22, 28, 3, 2, 29, 21, 50, 34,
print("Distancia Solucion Incial:" , distancia_total(solucion, problem))


nueva_solucion = genera_vecina(solucion)
print("Distancia Mejor Solucion Local:", distancia_total(nueva_solucion, problem
Distancia Solucion Incial: 3768
Distancia Mejor Solucion Local: 3459
```

In [ ]:

```
#Busqueda Local:
#  - Sobre el operador de vecindad 2-opt(funcion genera_vecina)
#  - Sin criterio de parada, se para cuando no es posible mejorar.
def busqueda_local(problem):
  mejor_solucion = []

  #Generar una solucion inicial de referencia(aleatoria)
  solucion_referencia = crear_solucion(Nodos)
  mejor_distancia = distancia_total(solucion_referencia, problem)

  iteracion=0             #Un contador para saber las iteraciones que hacemos
  while(1):
    iteracion +=1         #Incrementamos el contador
    #print('#',iteracion)

    #Obtenemos la mejor vecina ...
    vecina = genera_vecina(solucion_referencia)

    #... y la evaluamos para ver si mejoramos respecto a lo encontrado hasta el
    distancia_vecina = distancia_total(vecina, problem)

    #Si no mejoramos hay que terminar. Hemos llegado a un minimo local(según nue
    if distancia_vecina < mejor_distancia:
      #mejor_solucion = copy.deepcopy(vecina)   #Con copia profunda. Las copias
      mejor_solucion = vecina                   #Guarda la mejor solución encont
      mejor_distancia = distancia_vecina

    else:
      print("En la iteracion ", iteracion, ", la mejor solución encontrada es:"
      print("Distancia     :" , mejor_distancia)
      return mejor_solucion

    solucion_referencia = vecina


sol = busqueda_local(problem )
```

```
En la iteracion  35 , la mejor solución encontrada es: [0, 39, 24, 40, 21, 9, 14,
16, 19, 10, 8, 4, 6, 5, 13, 26, 28, 29, 30, 32, 31, 35, 36, 1, 3, 27, 2, 18, 12,
11, 25, 41, 23, 22, 38, 34, 33, 20, 17, 37, 15, 7]
Distancia     : 2040
```

SIMULATED ANNEALING

In [14]:

```
################################################################################
# SIMULATED ANNEALING
################################################################################

#Generador de 1 solucion vecina 2-opt 100% aleatoria (intercambiar 2 nodos)
#Mejorable eligiendo otra forma de elegir una vecina.
def genera_vecina_aleatorio(solucion):

  #Se eligen dos nodos aleatoriamente
  i,j = sorted(random.sample( range(1,len(solucion)) , 2))
  #Devuelve una nueva solución pero intercambiando los dos nodos elegidos al aza
  return solucion[:i] + [solucion[j]] + solucion[i+1:j] + [solucion[i]] + soluci


#Funcion de probabilidad para aceptar peores soluciones
def probabilidad(T,d):
  if random.random() <  math.exp( -1*d / T)   :
    return True
  else:
    return False

#Funcion de descenso de temperatura
def bajar_temperatura(T):
  return T*0.99
```

In [ ]:

```
def recocido_simulado(problem, TEMPERATURA ):
  #problem = datos del problema
  #T = Temperatura

  solucion_referencia = crear_solucion(Nodos)
  distancia_referencia = distancia_total(solucion_referencia, problem)

  mejor_solucion = []             #x* del seudocodigo
  mejor_distancia = 10e100        #F* del seudocodigo


  N=0
  while TEMPERATURA > .0001:
    N+=1
    #Genera una solución vecina
    vecina =genera_vecina_aleatorio(solucion_referencia)

    #Calcula su valor(distancia)
    distancia_vecina = distancia_total(vecina, problem)

    #Si es la mejor solución de todas se guarda(siempre!!!)
    if distancia_vecina < mejor_distancia:
        mejor_solucion = vecina
        mejor_distancia = distancia_vecina

    #Si la nueva vecina es mejor se cambia
    #Si es peor se cambia según una probabilidad que depende de T y delta(distan
    if distancia_vecina < distancia_referencia or probabilidad(TEMPERATURA, abs(
      #solucion_referencia = copy.deepcopy(vecina)
      solucion_referencia = vecina
      distancia_referencia = distancia_vecina

    #Bajamos la temperatura
    TEMPERATURA = bajar_temperatura(TEMPERATURA)

  print("La mejor solución encontrada es " , end="")
  print(mejor_solucion)
  print("con una distancia total de " , end="")
  print(mejor_distancia)
  return mejor_solucion

sol  = recocido_simulado(problem, 10000000)
```

```
La mejor solución encontrada es [0, 32, 34, 20, 33, 38, 22, 29, 8, 23, 41, 12, 1
0, 9, 39, 30, 31, 35, 36, 18, 11, 25, 21, 24, 40, 26, 13, 16, 15, 19, 5, 3, 2, 4,
6, 14, 37, 17, 7, 1, 27, 28]
con una distancia total de 2151
```