APPENDICES

APPENDIX A

An example of m-GA's programming in MATLAB

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An example of m-GA's programming in MATLAB

An example of small problem.

```
clc
clear all
Pop    =  50;
MaxGen =  20;
Xov    =  0.9;
Mut    =  0.5;
seed   =  3333;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Chain1 =  24;
Chain2 =  36;
Chain3 =  24;
Nvar   =  Chain1+Chain2+Chain3;
GGAP   =  1;
t0     =  clock;
rand('seed',seed)
%Chain1
InitPop1   =  rand(Chain1,Pop);
[vp1,order1] =  sort(InitPop1);
chrom1     =  order1';
  for i  =  1:Pop
    CS1 =  [1000 1000 1000 1000];
    CP1 =  [1000 1000 1000 1000 1000 1000];
    TD  =  3000;
    for j  =  1:Chain1
chrom1(i,j);
      r =  floor((chrom1(i,j)-1)/6+1);
      if chrom1(i,j)==1,  c = 1;end
      if chrom1(i,j)==7,  c = 1;end
      if chrom1(i,j)==13, c = 1;end
      if chrom1(i,j)==19, c = 1;end
      if chrom1(i,j)==2,  c = 2;end
      if chrom1(i,j)==8,  c = 2;end
      if chrom1(i,j)==14, c = 2;end
      if chrom1(i,j)==21, c = 3;end
      if chrom1(i,j)==4,  c = 4;end
      if chrom1(i,j)==10, c = 4;end
      if chrom1(i,j)==16, c = 4;end
      if chrom1(i,j)==22, c = 4;end
      if chrom1(i,j)==5,  c = 5;end
      if chrom1(i,j)==11, c = 5;end
      if chrom1(i,j)==17, c = 5;end
      if chrom1(i,j)==23, c = 5;end
      if chrom1(i,j)==6,  c = 6;end
      if chrom1(i,j)==12, c = 6;end
      if chrom1(i,j)==18, c = 6;end
      if chrom1(i,j)==24, c = 6;end
        if TD > 0
          v1     =  min([CS1(1,r), CP1(1,c), TD]);
          xs1(r,c)  =  v1;
          CS1(1,r)  =  CS1(1,r) - v1;
          CP1(1,c)  =  CP1(1,c)-v1;
              TD =  TD-v1;
          else
              xs1(r,c) =  0;
        end
    end

    xs1;
    x1(i,1:6)  =  xs1(1,:);
    x1(i,7:12) =  xs1(2,:);
    x1(i,13:18) =  xs1(3,:);
    x1(i,19:24) =  xs1(4,:);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
        if chrom1(i,j)==20,  c = 2;end
        if chrom1(i,j)==3,   c = 3;end
        if chrom1(i,j)==9,   c = 3;end
        if chrom1(i,j)==15,  c = 3;end
%Chain2
InitPop2   =  rand(Chain2,Pop);
[vp2,order2]=  sort(InitPop2);
chrom2     =  order2';
     P1  =  [sum(x1(i, 1)+x1(i, 7)+x1(i, 13)+x1(i, 19))];
     P2  =  [sum(x1(i, 2)+x1(i, 8)+x1(i, 14)+x1(i, 20))];
     P3  =  [sum(x1(i, 3)+x1(i, 9)+x1(i, 15)+x1(i, 21))];
     P4  =  [sum(x1(i, 4)+x1(i, 10)+x1(i, 16)+x1(i, 22))];
     P5  =  [sum(x1(i, 5)+x1(i, 11)+x1(i, 17)+x1(i, 23))];
     P6  =  [sum(x1(i, 6)+x1(i, 12)+x1(i, 18)+x1(i, 24))];
     Plants  =  [P1 P2 P3 P4 P5 P6];
     CDCs    =  [1000 1000 1000 1000 1000 1000];
       for j  = 1:Chain2
       chrom2(i,j);
       r1   = floor((chrom2(i,j)-1)/6+1);
       if chrom2(i,j)==1,   c1 = 1;end
       if chrom2(i,j)==7,   c1 = 1;end
       if chrom2(i,j)==13,  c1 = 1;end
       if chrom2(i,j)==19,  c1 = 1;end
       if chrom2(i,j)==25,  c1 = 1;end
       if chrom2(i,j)==31,  c1 = 1;end
       if chrom2(i,j)==2,   c1 = 2;end
       if chrom2(i,j)==8,   c1 = 2;end
       if chrom2(i,j)==14,  c1 = 2;end
       if chrom2(i,j)==20,  c1 = 2;end
       if chrom2(i,j)==26,  c1 = 2;end
       if chrom2(i,j)==32,  c1 = 2;end
       if chrom2(i,j)==3,   c1 = 3;end
       if chrom2(i,j)==9,   c1 = 3;end
       if chrom2(i,j)==15,  c1 = 3;end
       if chrom2(i,j)==21,  c1 = 3;end
       if chrom2(i,j)==27,  c1 = 3;end
       if chrom2(i,j)==33,  c1 = 3;end
       if chrom2(i,j)==4,   c1 = 4;end
       if chrom2(i,j)==10,  c1 = 4;end
       if chrom2(i,j)==5,   c1 = 5;end
       if chrom2(i,j)==11,  c1 = 5;end
       if chrom2(i,j)==17,  c1 = 5;end
       if chrom2(i,j)==23,  c1 = 5;end
       if chrom2(i,j)==29,  c1 = 5;end
       if chrom2(i,j)==35,  c1 = 5;end
       if chrom2(i,j)==6,   c1 = 6;end
       if chrom2(i,j)==12,  c1 = 6;end
       if chrom2(i,j)==18,  c1 = 6;end
       if chrom2(i,j)==24,  c1 = 6;end
       if chrom2(i,j)==30,  c1 = 6;end
       if chrom2(i,j)==36,  c1 = 6;end
v2     =  min([Plants(1,r1), CDCs(1,c1)]);
          xs2(r1,c1)  =  v2;
          if xs2(r1,c1)>0
             Plants(1,r1) =  Plants(1,r1) - v2;
             CDCs(1,c1)  =  CDCs(1,c1)-v2;
          else
             xs2(r1,c1)  =  0;
          end
       end
       xs2;
       x2(i,1:6)   =  xs2(1,:);
       x2(i,7:12)  =  xs2(2,:);
       x2(i,13:18) =  xs2(3,:);
       x2(i,19:24) =  xs2(4,:);
       x2(i,25:30) =  xs2(5,:);
       x2(i,31:36) =  xs2(6,:);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Chain3
InitPop3   =  rand(Chain3,Pop);
[vp3,order3]=  sort(InitPop3);
 chrom3     =  order3';
DC1 =  [sum(x2(i, 1)+x2(i, 7)+x2(i, 13)+x2(i, 19)+x2(i,
25)+x2(i, 31))];
```

```
        if chrom2(i,j)==16,  c1 = 4;end
        if chrom2(i,j)==22,  c1 = 4;end
        if chrom2(i,j)==28,  c1 = 4;end
        if chrom2(i,j)==34,  c1 = 4;end
DC4 =  [sum(x2(i, 4)+x2(i, 10)+x2(i, 16)+x2(i, 22)+x2(i,
28)+x2(i, 34))];
DC5 =  [sum(x2(i, 5)+x2(i, 11)+x2(i, 17)+x2(i, 23)+x2(i,
29)+x2(i, 35))];
DC6 =  [sum(x2(i, 6)+x2(i, 12)+x2(i, 18)+x2(i, 24)+x2(i,
30)+x2(i, 36))];
CDCs1  =  [DC1 DC2 DC3 DC4 DC5 DC6];
        Cust   =  [800 700 650 850];
      for j = 1:Chain3
        chrom3(i,j);
        r2 = floor((chrom3(i,j)-1)/4+1);
        if chrom3(i,j)==1,  c2 = 1;end
        if chrom3(i,j)==5,  c2 = 1;end
        if chrom3(i,j)==9,  c2 = 1;end
        if chrom3(i,j)==13,  c2 = 1;end
        if chrom3(i,j)==17,  c2 = 1;end
        if chrom3(i,j)==21,  c2 = 1;end
        if chrom3(i,j)==2,  c2 = 2;end
        if chrom3(i,j)==6,  c2 = 2;end
        if chrom3(i,j)==10,  c2 = 2;end
        if chrom3(i,j)==14,  c2 = 2;end
        if chrom3(i,j)==18,  c2 = 2;end
        if chrom3(i,j)==22,  c2 = 2;end
        if chrom3(i,j)==3,  c2 = 3;end
        if chrom3(i,j)==7,  c2 = 3;end
        if chrom3(i,j)==11,  c2 = 3;end
        if chrom3(i,j)==15,  c2 = 3;end
        if chrom3(i,j)==19,  c2 = 3;end
        if chrom3(i,j)==23,  c2 = 3;end
        if chrom3(i,j)==4,  c2 = 4;end
        if chrom3(i,j)==8,  c2 = 4;end
        if chrom3(i,j)==12,  c2 = 4;end
        if chrom3(i,j)==16,  c2 = 4;end
        if chrom3(i,j)==20,  c2 = 4;end
        if chrom3(i,j)==24,  c2 = 4;end
DC2 =  [sum(x2(i, 2)+x2(i, 8)+x2(i, 14)+x2(i, 20)+x2(i,
26)+x2(i, 32))];
DC3 =  [sum(x2(i, 3)+x2(i, 9)+x2(i, 15)+x2(i, 21)+x2(i,
27)+x2(i, 33))];
            Cust(1,c2)  =  Cust(1,c2)-v3;
          else
            xs3(r2,c2)  =  0;
          end
      end
      xs3;
      x3(i,1:4)  =  xs3(1,:);
      x3(i,5:8)  =  xs3(2,:);
      x3(i,9:12)  =  xs3(3,:);
      x3(i,13:16) =  xs3(4,:);
      x3(i,17:20) =  xs3(5,:);
      x3(i,21:24) =  xs3(6,:);

    end
x1;
x2;
x3;
x=[x1(:,:) x2(:,:) x3(:,:)];
Chrom = x;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Check
for i = 1:Pop
   S1  = [x(i,1:6); x(i,7:12); x(i,13:18); x(i,19:24)];
   S2  = [x(i,25:30); x(i,31:36); x(i,37:42); x(i,43:48);
x(i,49:54); x(i,55:60)];
   S3  = [x(i,61:64); x(i,65:68); x(i,69:72); x(i,73:76);
x(i,77:80); x(i,81:84)];
End
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Evaluate
   a  =    [2 5 3 7 5 6 4 2 1 3 2 5 3 5 4 5 6 2 5 3 6 3 4 7];
   b  =    [6 5 4 3 4 5 4 3 5 2 3 4 3 2 2 1 2 3 5 4 3 2 4 5
3 6 5 4 3 5 1 5 7 6 3 4];
   c  =    [4 5 6 5 6 3 3 7 4 2 6 8 3 6 4 5 2 5 2 5 4 5 3 4];
   r  =    [2 2 2 2 2 2 3 3 3 3 3 3 4 4 4 4 4 4 5 5 5 5 5 5];
```

```
        v3      =  min([CDCs1(1,r2), Cust(1,c2)]);
        xs3(r2,c2)  =  v3;
          if xs3(r2,c2)>0
            CDCs1(1,r2)  =  CDCs1(1,r2) - v3
   Fj  =    [100 200 300 200 400 300];
   Fk  =    [300 200 200 100 300 400];
   A  =     a+r;
   B  =     b+m;
   C  =     c+h;
for i = 1:Pop
     Tj1(i)    =  [sum(x(i,1)+x(i,7)+x(i,13)+x(i,19))];
     Tj2(i)    =  [sum(x(i,2)+x(i,8)+x(i,14)+x(i,20))];
     Tj3(i)    =  [sum(x(i,3)+x(i,9)+x(i,15)+x(i,21))];
     Tj4(i)    =  [sum(x(i,4)+x(i,10)+x(i,16)+x(i,22))];
     Tj5(i)    =  [sum(x(i,5)+x(i,11)+x(i,17)+x(i,23))];
     Tj6(i)    =  [sum(x(i,6)+x(i,12)+x(i,18)+x(i,24))];
     if Tj1(i) > 0
       Tj1(i) = 1;
     else
       Tj1(i) = 0;
     end
     if Tj2(i) > 0
       Tj2(i) = 1;
     else
       Tj2(i) = 0;
     end
     if Tj3(i) > 0
       Tj3(i) = 1;
     else
       Tj3(i) = 0;
     end
     if Tj4(i) > 0
       Tj4(i) = 1;
     else
       Tj4(i) = 0;
     end
     if Tj5(i) > 0
       Tj5(i)= 1;
     else
```

```
   m  =     [15 15 15 15 15 15 16 16 16 16 16 16 14 14
14 14 14 14 13 13 13 13 13 13 14 14 14 14 14 14 15 15
15 15 15 15];
   h  =     [3 3 3 3 4 4 4 4 5 5 5 4 4 4 4 6 6 6 6 3 3 3 3];
       else
       Tj6(i) = 0;
     end
Tk1(i)    =  [sum(x2(i, 1)+x2(i, 7)+x2(i, 13)+x2(i,
19)+x2(i, 25)+x2(i, 31))];
     Tk2(i)    =  [sum(x2(i, 2)+x2(i, 8)+x2(i, 14)+x2(i,
20)+x2(i, 26)+x2(i, 32))];
     Tk3(i)    =  [sum(x2(i, 3)+x2(i, 9)+x2(i, 15)+x2(i,
21)+x2(i, 27)+x2(i, 33))];
     Tk4(i)    =  [sum(x2(i, 4)+x2(i, 10)+x2(i, 16)+x2(i,
22)+x2(i, 28)+x2(i, 34))];
     Tk5(i)    =  [sum(x2(i, 5)+x2(i, 11)+x2(i, 17)+x2(i,
23)+x2(i, 29)+x2(i, 35))];
     Tk6(i)    =  [sum(x2(i, 6)+x2(i, 12)+x2(i, 18)+x2(i,
24)+x2(i, 30)+x2(i, 36))];
     if Tk1(i) > 0
       Tk1(i) = 1;
     else
       Tk1(i) = 0;
     end
     if Tk2(i) > 0
       Tk2(i) = 1;
     else
       Tk2(i) = 0;
     end
     if Tk3(i) > 0
       Tk3(i) = 1;
     else
       Tk3(i) = 0;
     end
     if Tk4(i) > 0
       Tk4(i) = 1;
     else
       Tk4(i) = 0;
     end
```

```
        Tj5(i) = 0;
    end
    if Tj6(i) > 0
        Tj6(i) = 1;
    end
    if Tk6(i) > 0
        Tk6(i) = 1;
    else
        Tk6(i) = 0;
    end

    TJ(i,:) = [Tj1(i), Tj2(i), Tj3(i), Tj4(i), Tj5(i), Tj6(i)];
    TK(i,:) = [Tk1(i), Tk2(i), Tk3(i), Tk4(i), Tk5(i), Tk6(i)];
end
for i=1:Pop
  ObjV(i) = A(1,1)*x(i,1)+A(1,2)*x(i,2)+A(1,3)*x(i,3)+
A(1,4)*x(i,4)+A(1,5)*x(i,5)+A(1,6)*x(i,6)+A(1,7)*x(i,7)+
A(1,8)*x(i,8)+A(1,9)*x(i,9)+A(1,10)*x(i,10)+A(1,11)*x(i,11)+
A(1,12)*x(i,12)+A(1,13)*x(i,13)+A(1,14)*x(i,14)+
A(1,15)*x(i,15)+A(1,16)*x(i,16)+A(1,17)*x(i,17)+
A(1,18)*x(i,18)+A(1,19)*x(i,19)+A(1,20)*x(i,20)+
A(1,21)*x(i,21)+A(1,22)*x(i,22)+A(1,23)*x(i,23)+
A(1,24)*x(i,24)+B(1,1)*x(i,25)+B(1,2)*x(i,26)+
B(1,3)*x(i,27)+B(1,4)*x(i,28)+B(1,5)*x(i,29)+
B(1,6)*x(i,30)+B(1,7)*x(i,31)+B(1,8)*x(i,32)+
B(1,9)*x(i,33)+B(1,10)*x(i,34)+B(1,11)*x(i,35)+
B(1,12)*x(i,36)+B(1,13)*x(i,37)+B(1,14)*x(i,38)+
B(1,15)*x(i,39)+B(1,16)*x(i,40)+B(1,17)*x(i,41)+
B(1,18)*x(i,42)+B(1,19)*x(i,43)+B(1,20)*x(i,44)+
B(1,21)*x(i,45)+B(1,22)*x(i,46)+B(1,23)*x(i,47)+
B(1,24)*x(i,48)+B(1,25)*x(i,49)+B(1,26)*x(i,50)+
B(1,27)*x(i,51)+B(1,28)*x(i,52)+B(1,29)*x(i,53)+
B(1,30)*x(i,54)+B(1,31)*x(i,55)+B(1,32)*x(i,56)+
B(1,33)*x(i,57)+B(1,34)*x(i,58)+B(1,35)*x(i,59)+
B(1,36)*x(i,60)+C(1,1)*x(i,61)+C(1,2)*x(i,62)+
C(1,3)*x(i,63)+C(1,4)*x(i,64)+C(1,5)*x(i,65)+
C(1,6)*x(i,66)+C(1,7)*x(i,67)+C(1,8)*x(i,68)+
C(1,9)*x(i,69)+C(1,10)*x(i,70)+C(1,11)*x(i,71)+
C(1,12)*x(i,72)+C(1,13)*x(i,73)+C(1,14)*x(i,74)+
```

```
    if Tk5(i) > 0
        Tk5(i) = 1;
    else
        Tk5(i) = 0;
TJ(i,3)*Fj(1,3)+TJ(i,4)*Fj(1,4)+TJ(i,5)*Fj(1,5)+
TJ(i,6)*Fj(1,6)+TK(i,1)*Fk(1,1)+TK(i,2)*Fk(1,2)+
TK(i,3)*Fk(1,3)+TK(i,4)*Fk(1,4)+TK(i,5)*Fk(1,5)+
TK(i,6)*Fk(1,6);
end
ObjV=ObjV';
InitPop = [InitPop1' InitPop2' InitPop3'];
%Loop Crossover
gen = 0;
while gen < MaxGen,
    FitnV = ranking(ObjV);
    SelCh = select('sus',InitPop,FitnV,GGAP);
n = 0;
    while n < (Xov*Pop)/2
      a1 = floor(rand*Pop*GGAP+1);
      b1 = floor(rand*Pop*GGAP+1);
      parent1 = SelCh(a1,:);
      parent2 = SelCh(b1,:);
      c1 = floor(rand*83+1);
      offspring1 = [parent1(1,1:c1) parent2(1,c1+1:84)];
      offspring2 = [parent2(1,1:c1)
parent1(1,c1+1:84)];
      SelCh(a1,:) = offspring1;
      SelCh(b1,:) = offspring2;
      n = n+1;
    end
%Loop Mutation
n = 0;
    while n < (Mut*Pop)
      d1 = floor(rand*Pop+1);
parent = SelCh(d1,:);
e1 = floor(rand*83+1);
mut1 = parent(1,e1);
 mut2 = parent(1,e1+1);
parent(1,e1) = mut2;
```

```
C(1,15)*x(i,75)+C(1,16)*x(i,76)+C(1,17)*x(i,77)+
C(1,18)*x(i,78)+C(1,19)*x(i,79)+C(1,20)*x(i,80)+
C(1,21)*x(i,81)+C(1,22)*x(i,82)+C(1,23)*x(i,83)+
C(1,24)*x(i,84)+TJ(i,1)*Fj(1,1)+TJ(i,2)*Fj(1,2)+
InitPop1New = SelCh(:,1:24);
 [vp1New,oder1New] = sort(InitPop1New');
 chrom1New = oder1New';
%New Chromosome
for i  =  1:Pop
     CS1 =  [1000 1000 1000 1000];
     CP1 =  [1000 1000 1000 1000 1000 1000];
     TD  =  3000;
     for j  =  1:Chain1
       chrom1New(i,j);
       r =  floor((chrom1New(i,j)-1)/6+1);
       if chrom1New(i,j)==1,  c = 1;end
       if chrom1New(i,j)==7,  c = 1;end
       if chrom1New(i,j)==13,  c = 1;end
       if chrom1New(i,j)==19,  c = 1;end
       if chrom1New(i,j)==2,  c = 2;end
       if chrom1New(i,j)==8,  c = 2;end
       if chrom1New(i,j)==14,  c = 2;end
       if chrom1New(i,j)==20,  c = 2;end
       if chrom1New(i,j)==3,  c = 3;end
       if chrom1New(i,j)==9,  c = 3;end
       if chrom1New(i,j)==15,  c = 3;end
       if chrom1New(i,j)==21,  c = 3;end
       if chrom1New(i,j)==4,  c = 4;end
       if chrom1New(i,j)==10,  c = 4;end
       if chrom1New(i,j)==16,  c = 4;end
       if chrom1New(i,j)==22,  c = 4;end
       if chrom1New(i,j)==5,  c = 5;end
       if chrom1New(i,j)==11,  c = 5;end
       if chrom1New(i,j)==17,  c = 5;end
       if chrom1New(i,j)==23,  c = 5;end
       if chrom1New(i,j)==6,  c = 6;end
       if chrom1New(i,j)==12,  c = 6;end
       if chrom1New(i,j)==18,  c = 6;end
       if chrom1New(i,j)==24,  c = 6;end
 parent(1,e1+1) = mut1;
SelCh(d1,:) = parent;
n = n+1;
     end
              CS1(1,r)  =  CS1(1,r) - v1New;
              CP1(1,c)  =  CP1(1,c)-v1New;
                  TD =  TD-v1New;
              else
                xs1New(r,c) =  0;
          end
     end
     xs1New;
     x1New(i,1:6)  =  xs1New(1,:);
     x1New(i,7:12)  =  xs1New(2,:);
     x1New(i,13:18) =  xs1New(3,:);
     x1New(i,19:24) =  xs1New(4,:);
%Chain2
InitPop2New = SelCh(:,25:60);
 [vp2New,oder2New] = sort(InitPop2New');
 chrom2New = oder2New';
     P1  =  [sum(x1New(i, 1)+x1New(i, 7)+x1New(i,
13)+x1New(i, 19))];
     P2  =  [sum(x1New(i, 2)+x1New(i, 8)+x1New(i,
14)+x1New(i, 20))];
     P3  =  [sum(x1New(i, 3)+x1New(i, 9)+x1New(i,
15)+x1New(i, 21))];
     P4  =  [sum(x1New(i, 4)+x1New(i, 10)+x1New(i,
16)+x1New(i, 22))];
     P5  =  [sum(x1New(i, 5)+x1New(i, 11)+x1New(i,
17)+x1New(i, 23))];
     P6  =  [sum(x1New(i, 6)+x1New(i, 12)+x1New(i,
18)+x1New(i, 24))];
     Plants  =  [P1 P2 P3 P4 P5 P6];
     CDCs  =  [1000 1000 1000 1000 1000 1000];
     for j  = 1:Chain2
       chrom2New (i,j);
       r1  = floor((chrom2New(i,j)-1)/6+1);
       if chrom2New(i,j)==1,  c1 = 1;end
       if chrom2New(i,j)==7,  c1 = 1;end
```

```
        if TD > 0
            v1New      =  min([CS1(1,r), CP1(1,c),
TD]);
            xs1New(r,c)  =  v1New;
        if chrom2New(i,j)==2,  c1 = 2;end
        if chrom2New(i,j)==8,  c1 = 2;end
        if chrom2New(i,j)==14, c1 = 2;end
        if chrom2New(i,j)==20, c1 = 2;end
        if chrom2New(i,j)==26, c1 = 2;end
        if chrom2New(i,j)==32, c1 = 2;end
        if chrom2New(i,j)==3,  c1 = 3;end
        if chrom2New(i,j)==9,  c1 = 3;end
        if chrom2New(i,j)==15, c1 = 3;end
        if chrom2New(i,j)==21, c1 = 3;end
        if chrom2New(i,j)==27, c1 = 3;end
        if chrom2New(i,j)==33, c1 = 3;end
        if chrom2New(i,j)==4,  c1 = 4;end
        if chrom2New(i,j)==10, c1 = 4;end
        if chrom2New(i,j)==16, c1 = 4;end
        if chrom2New(i,j)==22, c1 = 4;end
        if chrom2New(i,j)==28, c1 = 4;end
        if chrom2New(i,j)==34, c1 = 4;end
        if chrom2New(i,j)==5,  c1 = 5;end
        if chrom2New(i,j)==11, c1 = 5;end
        if chrom2New(i,j)==17, c1 = 5;end
        if chrom2New(i,j)==23, c1 = 5;end
        if chrom2New(i,j)==29, c1 = 5;end
        if chrom2New(i,j)==35, c1 = 5;end
        if chrom2New(i,j)==6,  c1 = 6;end
        if chrom2New(i,j)==12, c1 = 6;end
        if chrom2New(i,j)==18, c1 = 6;end
        if chrom2New(i,j)==24, c1 = 6;end
        if chrom2New(i,j)==30, c1 = 6;end
        if chrom2New(i,j)==36, c1 = 6;end
          v2New      =  min([Plants(1,r1), CDCs(1,c1)]);
          xs2New(r1,c1) =  v2New;
          if xs2New(r1,c1)>0
            Plants(1,r1) =  Plants(1,r1) - v2New;
            CDCs(1,c1) =  CDCs(1,c1)-v2New;
        if chrom2New(i,j)==13, c1 = 1;end
        if chrom2New(i,j)==19, c1 = 1;end
        if chrom2New(i,j)==25, c1 = 1;end
        if chrom2New(i,j)==31, c1 = 1;end
      xs2New;
      x2New(i,1:6)  =  xs2New(1,:);
      x2New(i,7:12)  =  xs2New(2,:);
      x2New(i,13:18) =  xs2New(3,:);
      x2New(i,19:24) =  xs2New(4,:);
      x2New(i,25:30) =  xs2New(5,:);
      x2New(i,31:36) =  xs2New(6,:);
%Chain3
InitPop3New = SelCh(:,61:84);
 [vp3New,oder3New] = sort(InitPop3New');
 chrom3New = oder3New';
        DC1 =  [sum(x2New(i, 1)+x2New(i, 7)+x2New(i,
13)+x2New(i, 19)+x2New(i, 25)+x2New(i, 31))];
        DC2 =  [sum(x2New(i, 2)+x2New(i, 8)+x2New(i,
14)+x2New(i, 20)+x2New(i, 26)+x2New(i, 32))];
        DC3 =  [sum(x2New(i, 3)+x2New(i, 9)+x2New(i,
15)+x2New(i, 21)+x2New(i, 27)+x2New(i, 33))];
        DC4 =  [sum(x2New(i, 4)+x2New(i, 10)+x2New(i,
16)+x2New(i, 22)+x2New(i, 28)+x2New(i, 34))];
        DC5 =  [sum(x2New(i, 5)+x2New(i, 11)+x2New(i,
17)+x2New(i, 23)+x2New(i, 29)+x2New(i, 35))];
        DC6 =  [sum(x2New(i, 6)+x2New(i, 12)+x2New(i,
18)+x2New(i, 24)+x2New(i, 30)+x2New(i, 36))];
        CDCs1  =  [DC1 DC2 DC3 DC4 DC5 DC6];
        Cust  =  [800 700 650 850];
      for j = 1:Chain3
        chrom3New(i,j);
        r2 = floor((chrom3New(i,j)-1)/4+1);
        if chrom3New(i,j)==1,  c2 = 1;end
        if chrom3New(i,j)==5,  c2 = 1;end
        if chrom3New(i,j)==9,  c2 = 1;end
        if chrom3New(i,j)==13, c2 = 1;end
        if chrom3New(i,j)==17, c2 = 1;end
        if chrom3New(i,j)==21, c2 = 1;end
        if chrom3New(i,j)==2,  c2 = 2;end
```

```
        else
          xs2New(r1,c1) = 0;
        end
    end
      if chrom3New(i,j)==22, c2 = 2;end
      if chrom3New(i,j)==3, c2 = 3;end
      if chrom3New(i,j)==7, c2 = 3;end
      if chrom3New(i,j)==11, c2 = 3;end
      if chrom3New(i,j)==15, c2 = 3;end
      if chrom3New(i,j)==19, c2 = 3;end
      if chrom3New(i,j)==23, c2 = 3;end
      if chrom3New(i,j)==4, c2 = 4;end
      if chrom3New(i,j)==8, c2 = 4;end
      if chrom3New(i,j)==12, c2 = 4;end
      if chrom3New(i,j)==16, c2 = 4;end
      if chrom3New(i,j)==20, c2 = 4;end
      if chrom3New(i,j)==24, c2 = 4;end
      v3New = min([CDCs1(1,r2), Cust(1,c2)]);
      xs3New(r2,c2) = v3New;
        if xs3New(r2,c2)>0
          CDCs1(1,r2) = CDCs1(1,r2) - v3New;
          Cust(1,c2) = Cust(1,c2)-v3New;
        else
          xs3New(r2,c2) = 0;
        end
    end
    xs3New;
    x3New(i,1:4) = xs3New(1,:);
    x3New(i,5:8) = xs3New(2,:);
    x3New(i,9:12) = xs3New(3,:);
    x3New(i,13:16) = xs3New(4,:);
    x3New(i,17:20) = xs3New(5,:);
    x3New(i,21:24) = xs3New(6,:);
  end
x1New;
x2New;
x3New;
xNew=[x1New(:,:) x2New(:,:) x3New(:,:)];
Chrom = xNew;
      if chrom3New(i,j)==6, c2 = 2;end
      if chrom3New(i,j)==10, c2 = 2;end
      if chrom3New(i,j)==14, c2 = 2;end
      if chrom3New(i,j)==18, c2 = 2;end
  S2New = [xNew(i,25:30); xNew(i,31:36);
xNew(i,37:42); xNew(i,43:48); xNew(i,49:54);
xNew(i,55:60)];
  S3New = [xNew(i,61:64); xNew(i,65:68);
xNew(i,69:72); xNew(i,73:76); xNew(i,77:80);
xNew(i,81:84)];
end
%Evaluate%
  a = [2 5 3 7 5 6 4 2 1 3 2 5 3 5 4 5 6 2 5 3 6 3 4 7];
  b = [6 5 4 3 4 5 4 3 5 2 3 4 3 2 2 1 2 3 5 4 3 2 4 5
3 6 5 4 3 5 1 5 7 6 3 4];
  c = [4 5 6 5 6 3 3 7 4 2 6 8 3 6 4 5 2 5 2 5 4 5 3 4];
  r = [2 2 2 2 2 2 3 3 3 3 3 4 4 4 4 4 4 5 5 5 5 5];
  m = [15 15 15 15 15 15 16 16 16 16 16 16 14 14
14 14 14 14 13 13 13 13 13 13 14 14 14 14 14 14 15 15
15 15 15 15];
  h = [3 3 3 3 4 4 4 4 5 5 5 5 4 4 4 4 6 6 6 6 3 3 3 3];
  Fj = [100 200 300 200 400 300];
  Fk = [300 200 200 100 300 400];
  A = a+r;
  B = b+m;
  C = c+h;
for i = 1:Pop
    Tj1New(i) =
[sum(xNew(i,1)+xNew(i,7)+xNew(i,13)+xNew(i,19))];
    Tj2New(i) =
[sum(xNew(i,2)+xNew(i,8)+xNew(i,14)+xNew(i,20))];
    Tj3New(i) =
[sum(xNew(i,3)+xNew(i,9)+xNew(i,15)+xNew(i,21))];
    Tj4New(i) =
[sum(xNew(i,4)+xNew(i,10)+xNew(i,16)+xNew(i,22))];
    Tj5New(i) =
[sum(xNew(i,5)+xNew(i,11)+xNew(i,17)+xNew(i,23))];
    Tj6New(i) =
[sum(xNew(i,6)+xNew(i,12)+xNew(i,18)+xNew(i,24))];
```

```
%Check
for i = 1:Pop
   S1New  = [xNew(i,1:6); xNew(i,7:12); xNew(i,13:18);
xNew(i,19:24)];
      end
      if Tj2New(i) > 0
         Tj2New(i) = 1;
      else
         Tj2New(i) = 0;
      end
      if Tj3New(i) > 0
         Tj3New(i) = 1;
      else
         Tj3New(i) = 0;
      end
      if Tj4New(i) > 0
         Tj4New(i) = 1;
      else
         Tj4New(i) = 0;
      end
      if Tj5New(i) > 0
         Tj5New(i) = 1;
      else
         Tj5New(i) = 0;
      end
      if Tj6New(i) > 0
         Tj6New(i) = 1;
      else
         Tj6New(i) = 0;
      end
Tk1New(i)    =   [sum(x2New(i, 1)+x2New(i, 7)+x2New(i,
13)+x2New(i, 19)+x2New(i, 25)+x2New(i, 31))];
      Tk2New(i)    =   [sum(x2New(i, 2)+x2New(i,
8)+x2New(i, 14)+x2New(i, 20)+x2New(i, 26)+x2New(i,
32))];
      Tk3New(i)    =   [sum(x2New(i, 3)+x2New(i,
9)+x2New(i, 15)+x2New(i, 21)+x2New(i, 27)+x2New(i,
33))];
      Tk4New(i)    =   [sum(x2New(i, 4)+x2New(i,
      if Tj1New(i) > 0
         Tj1New(i) = 1;
      else
         Tj1New(i) = 0;
35))];
      Tk6New(i)    =   [sum(x2New(i, 6)+x2New(i,
12)+x2New(i, 18)+x2New(i, 24)+x2New(i, 30)+x2New(i,
36))];
      if Tk1New(i) > 0
         Tk1New(i) = 1;
      else
         Tk1New(i) = 0;
      end
      if Tk2New(i) > 0
         Tk2New(i) = 1;
      else
         Tk2New(i) = 0;
      end
      if Tk3New(i) > 0
         Tk3New(i) = 1;
      else
         Tk3New(i) = 0;
      end
      if Tk4New(i) > 0
         Tk4New(i) = 1;
      else
         Tk4New(i) = 0;
      end
      if Tk5New(i) > 0
         Tk5New(i) = 1;
      else
         Tk5New(i) = 0;
      end
      if Tk6New(i) > 0
         Tk6New(i) = 1;
      else
         Tk6New(i) = 0;
      end
      TJNew(i,:)  =  [Tj1New(i), Tj2New(i), Tj3New(i),
```

```
10)+x2New(i, 16)+x2New(i, 22)+x2New(i, 28)+x2New(i,
34))];
      Tk5New(i)    =  [sum(x2New(i, 5)+x2New(i,
11)+x2New(i, 17)+x2New(i, 23)+x2New(i, 29)+x2New(i,
   xNew = [x1New(:,:) x2New(:,:) x3New(:,:)];
chromNew = xNew;
InitPopNew = [InitPop1New InitPop2New InitPop3New];
  for i=1:Pop
   ObjVSel(i) =  A(1,1)*xNew(i,1)+A(1,2)*xNew(i,2)+
A(1,3)*xNew(i,3)+A(1,4)*xNew(i,4)+A(1,5)*xNew(i,5)+
A(1,6)*xNew(i,6)+A(1,7)*xNew(i,7)+A(1,8)*xNew(i,8)+
A(1,9)*xNew(i,9)+A(1,10)*xNew(i,10)+
A(1,11)*xNew(i,11)+A(1,12)*xNew(i,12)+
A(1,13)*xNew(i,13)+A(1,14)*xNew(i,14)+
A(1,15)*xNew(i,15)+A(1,16)*xNew(i,16)+
A(1,17)*xNew(i,17)+A(1,18)*xNew(i,18)+
A(1,19)*xNew(i,19)+A(1,20)*xNew(i,20)+
A(1,21)*xNew(i,21)+A(1,22)*xNew(i,22)+
A(1,23)*xNew(i,23)+A(1,24)*xNew(i,24)+
B(1,1)*xNew(i,25)+B(1,2)*xNew(i,26)+
B(1,3)*xNew(i,27)+B(1,4)*xNew(i,28)+
B(1,5)*xNew(i,29)+B(1,6)*xNew(i,30)+
B(1,7)*xNew(i,31)+B(1,8)*xNew(i,32)+
B(1,9)*xNew(i,33)+B(1,10)*xNew(i,34)
+B(1,11)*xNew(i,35)+B(1,12)*xNew(i,36)+
B(1,13)*xNew(i,37)+B(1,14)*xNew(i,38)+
B(1,15)*xNew(i,39)+B(1,16)*xNew(i,40)+
B(1,17)*xNew(i,41)+B(1,18)*xNew(i,42)+
B(1,19)*xNew(i,43)+B(1,20)*xNew(i,44)+
B(1,21)*xNew(i,45)+B(1,22)*xNew(i,46)+
B(1,23)*xNew(i,47)+B(1,24)*xNew(i,48)+
B(1,25)*xNew(i,49)+B(1,26)*xNew(i,50)+
B(1,27)*xNew(i,51)+B(1,28)*xNew(i,52)+
B(1,29)*xNew(i,53)+B(1,30)*xNew(i,54)+
B(1,31)*xNew(i,55)+B(1,32)*xNew(i,56)+
B(1,33)*xNew(i,57)+B(1,34)*xNew(i,58)+
B(1,35)*xNew(i,59)+B(1,36)*xNew(i,60)+
C(1,1)*xNew(i,61)+C(1,2)*xNew(i,62)+
C(1,3)*xNew(i,63)+C(1,4)*xNew(i,64)+
Tj4New(i), Tj5New(i), Tj6New(i)];
      TKNew(i,:) =  [Tk1New(i), Tk2New(i), Tk3New(i),
Tk4New(i), Tk5New(i), Tk6New(i)];
end
C(1,13)*xNew(i,73)+C(1,14)*xNew(i,74)+
C(1,15)*xNew(i,75)+C(1,16)*xNew(i,76)+
C(1,17)*xNew(i,77)+C(1,18)*xNew(i,78)+
C(1,19)*xNew(i,79)+C(1,20)*xNew(i,80)+
C(1,21)*xNew(i,81)+C(1,22)*xNew(i,82)+
C(1,23)*xNew(i,83)+C(1,24)*xNew(i,84)+
TJNew(i,1)*Fj(1,1)+TJNew(i,2)*Fj(1,2)+
TJNew(i,3)*Fj(1,3)+TJNew(i,4)*Fj(1,4)+
TJNew(i,5)*Fj(1,5)+TJNew(i,6)*Fj(1,6)+
TKNew(i,1)*Fk(1,1)+TKNew(i,2)*Fk(1,2)+
TKNew(i,3)*Fk(1,3)+TKNew(i,4)*Fk(1,4)+
TKNew(i,5)*Fk(1,5)+TKNew(i,6)*Fk(1,6);
 end
  % Reinsert offspring into population
  ObjVNew = ObjVSel';
  InitPop = InitPopNew;
    [ShowV  ShowP]= min(ObjVNew);
   %SHOWMINX = chromNew(ShowP,:);
  Best(gen+1) = min(ObjVNew);
  subplot(3,1,1)
  plot(Best,'m:p');xlabel('generation'); ylabel('f(x)');
  text(0.5,0.95,['Best = ',
num2str(Best(gen+1))],'Units','normalized');
    drawnow;
  gen = gen+1;
  SHOWMINX(gen,:) = chromNew(ShowP,:);
  ShowValueX(gen) = ShowV;
   meanChrom(gen) = sum(ObjVSel)/Pop;
   SD(gen) = std(ObjVSel);
   xd=1:MaxGen;
end
 subplot(3,1,3)
   errorbar(xd,meanChrom,SD)
   subplot(3,1,2)
   good = Best(1) ;
```

```
C(1,5)*xNew(i,65)+C(1,6)*xNew(i,66)+
C(1,7)*xNew(i,67)+C(1,8)*xNew(i,68)+
C(1,9)*xNew(i,69)+C(1,10)*xNew(i,70)+
C(1,11)*xNew(i,71)+C(1,12)*xNew(i,72)+
        good=good;
    end
    plot(i,good);xlabel('generation'); ylabel('f(x)');
    drawnow;
    hold on
    nn(i)= good;
  end
  plot((1:MaxGen),nn,'g:d')
  text(0.5,0.95,['Best = ',
num2str(good)],'Units','normalized');
  [q,w]=sort(ShowValueX);
  SHOWMINX(w(1,1),:)
  time = etime(clock,t0)
   MinTotal   =   min(Best);
  MinTotal
  % End of GA
```

```
for i = 1:MaxGen
   if Best(i)<good
      good = Best(i);
   else
```

APPENDIX B

The best result for small problem in the experiments

APPENDIX B

The best result for small problem in the experiments

The experiment 1 – Small problem.

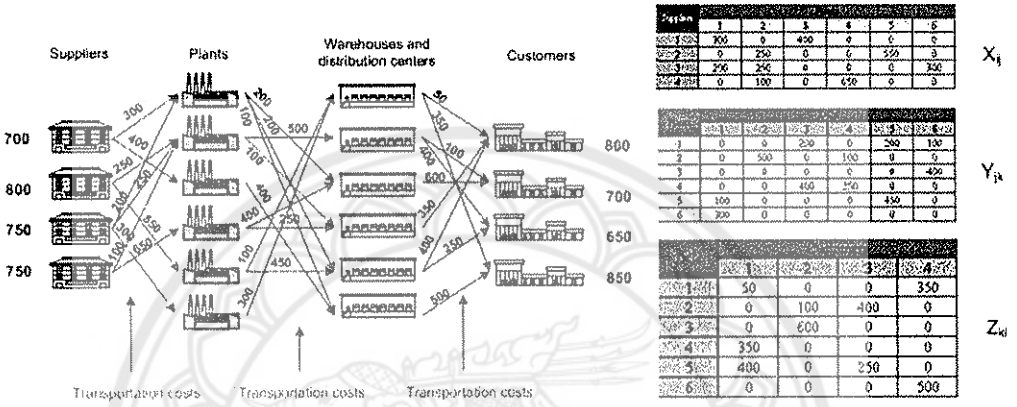

Figure 29 The best results of logistics chain networks with minimum total transportation cost by LP at 25750 Baht.

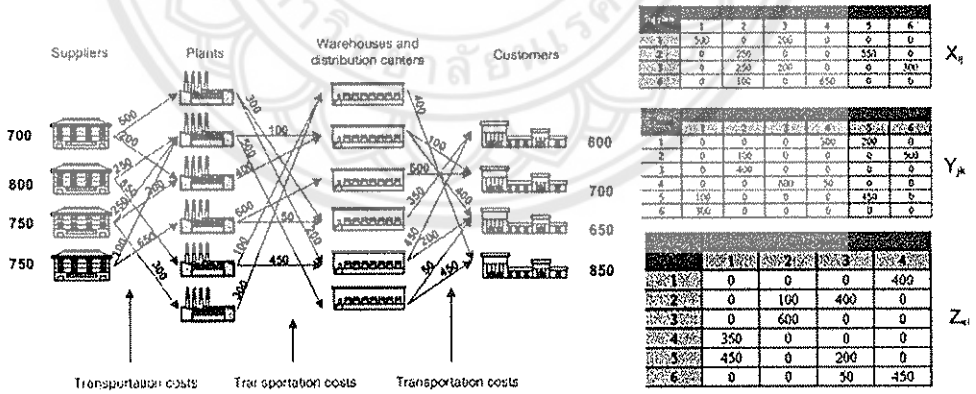

Figure 30 The best results of logistics chain networks with minimum total transportation cost by GA at 25750 Baht.

The experiment 2– Small problem.

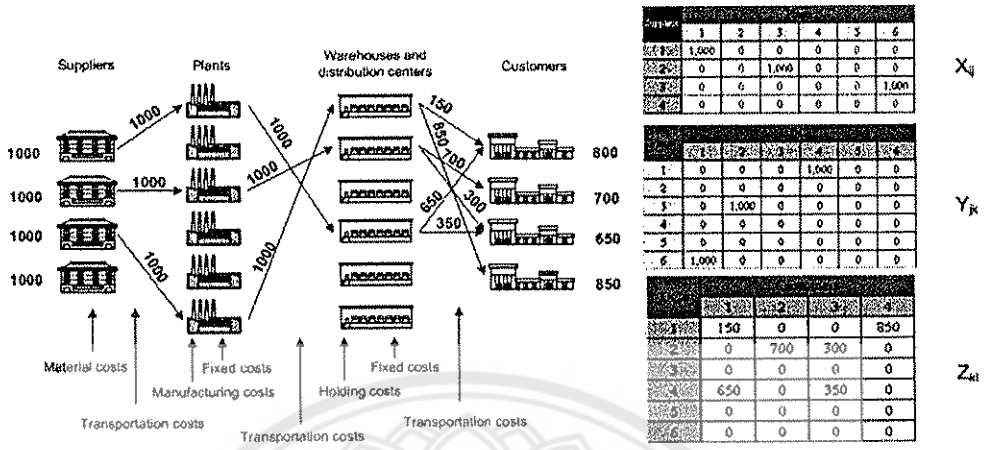

Figure 31 The best results of logistics chain networks with minimum total cost by LP at 87500 Baht.

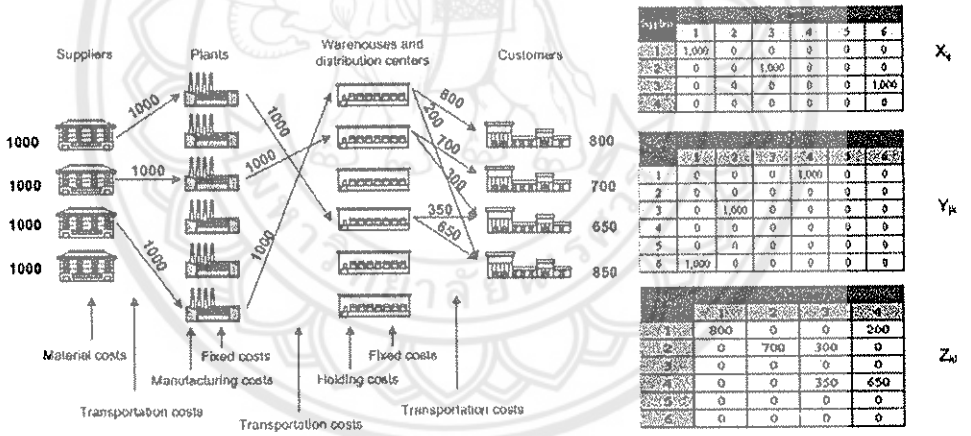

Figure 32 The best results of logistics chain networks with minimum total cost by GA at 88150 Baht.

The experiment 2– Medium problem.

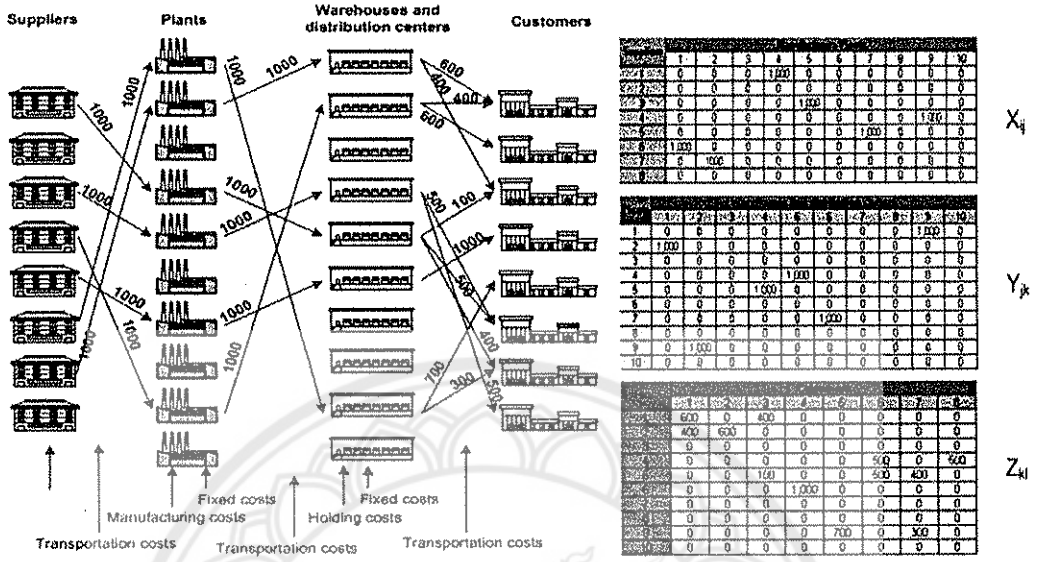

Figure 33 The best results of logistics chain networks with minimum total cost by LP at 187800 Baht.

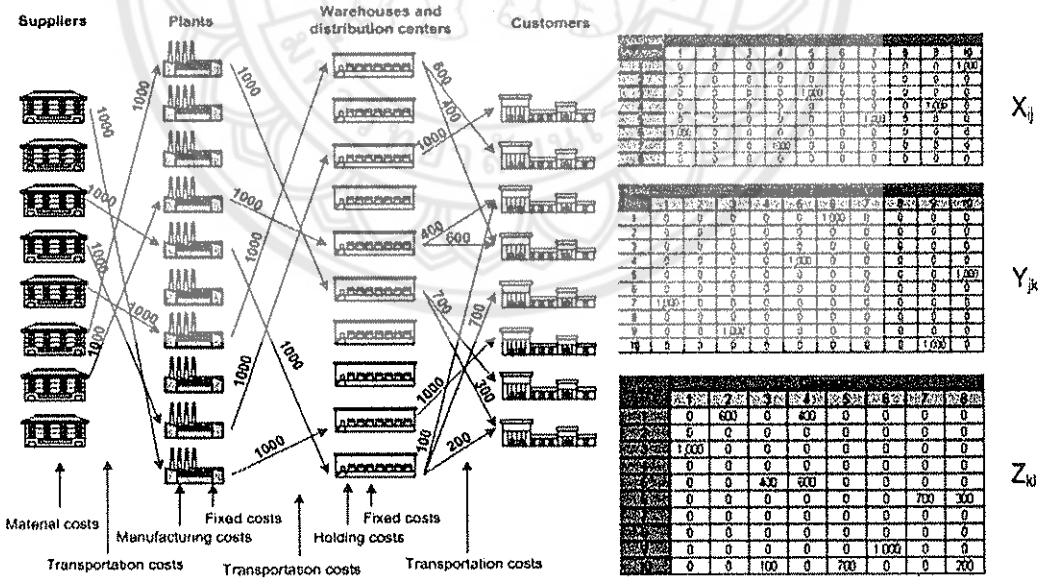

Figure 34 The best results of logistics chain networks with minimum total cost by GA at 199600 Baht.

The experiment 2– Large problem.

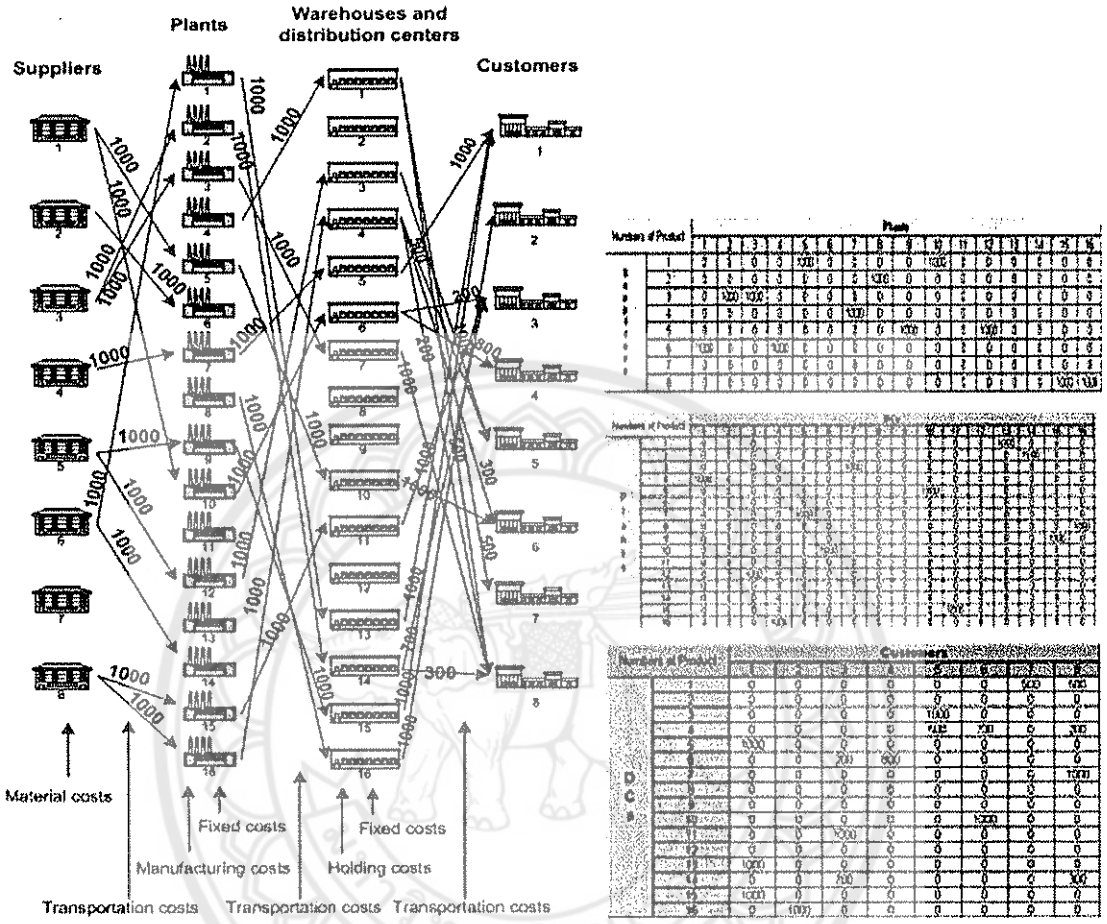

Figure 35 The best results of logistics chain networks with minimum total cost by GA at 674300 Baht.