Optimizing the Surge Arresters Location for Improving Lightning Induced Voltage Performance of Distribution Network

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UNIVERSIDAD NACIONAL DE COLOMBIA

PhD Thesis
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Presentation Outline

1. *Introduction*

2. *Modelling Lightning Induced Voltage*

3. *Improving Lightning performance*

4. *Optimizing Tool*

5. *Conclusions and Future Work*

Introduction - Motivation

➢ *Power quality has become one of the main area of interest around the world for mains, utilities, industries and consumers.*

➢ *Lightning causes around 50% of the network electromagnetic disturbances (short interruptions and voltage sags)*


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Introduction - Motivation

➢ *Millions of USD for losses caused by lightning in distribution network*

➢ *Is important to look forward techniques for reducing lightning impact on distribution networks.*

➢ *Shielding wire groundings, surge arresters and enhacement of Line BIL are a very useful technique*

Lightning Induced Voltage Modelling

By means of accurate calculation of lightning-induced overvoltages on real distribution networks
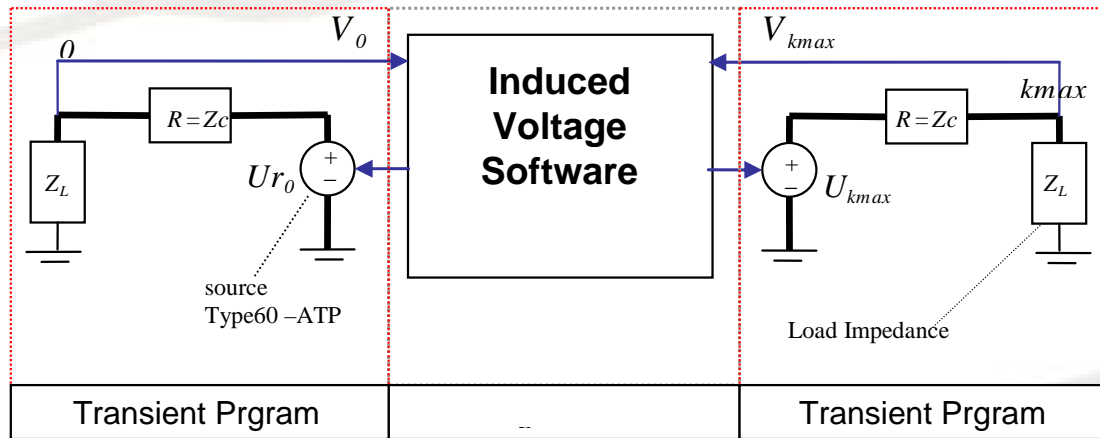
⬇
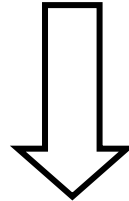
Optimized design of distribution networks against external overvoltages

⬇
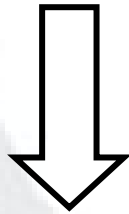
Correct definition of number and location of protective devices (shielding wire groundings and surge arresters)

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Link with Transient Analysis Software

- LIOV-EMTP/MATLAB (Methodology A)
EMTP96 – using **TACS** on a **DLL** and **MATLAB** – using **S-function**

- YALUK-ATP (Methodology A)
ATP – Using **Foreign Models** on a **DLL**

- LIV-ATP (Methodology B)
**ATP** programmed in **MODELS**

Diminishing Number of Failures

➤ *Surge Arrester (SA) helps to Diminish the fault rate due to induced Voltages*

➤ *The best solution for a straight line is locate a SA Every Pole*

Diminishing Number of Failures

➢ *Which is the best SA location?*

   o *If the number of SA is fixed and limited?*

   o *If it is used a Complex distribution Network with non-homogeneous pole distribution?*

Measurement Point

B
C
A
S/E

0   3   6km
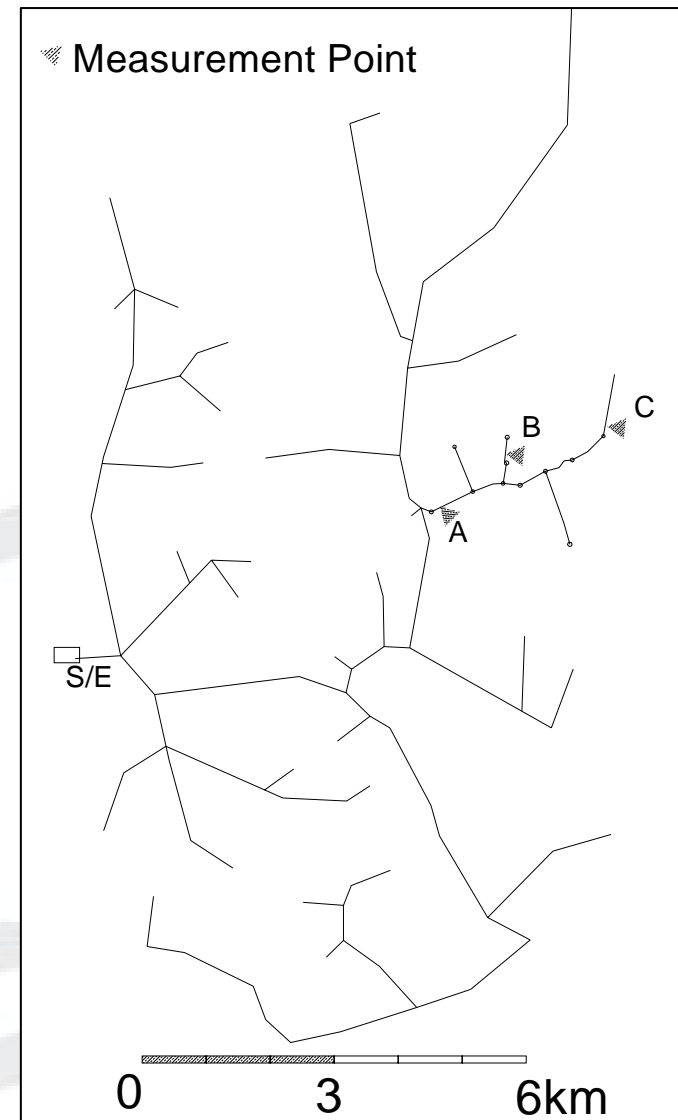
Software Tool – Structure

➢ *It was developed a Optimizig Software Tool for SA location.*

➢ *Object function is diminish number of failures for a fixed number of SA*

➢ *Based on Genetic Algorithm (GA) Technique*

➢ *Each 'individual' (possible solution) is characterized with an unique SA location*

➢ *For each individual it should be calculated the lightning-induced voltage performance of the line.*

➢ *It is used a certain number of strokes for this task*

What is Genetic Algorithm?
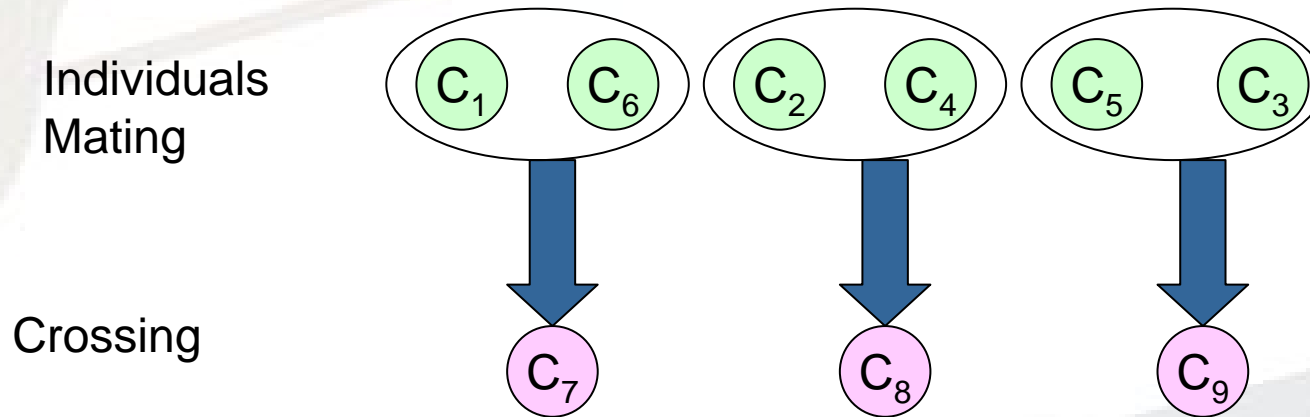
Initial individual
generation

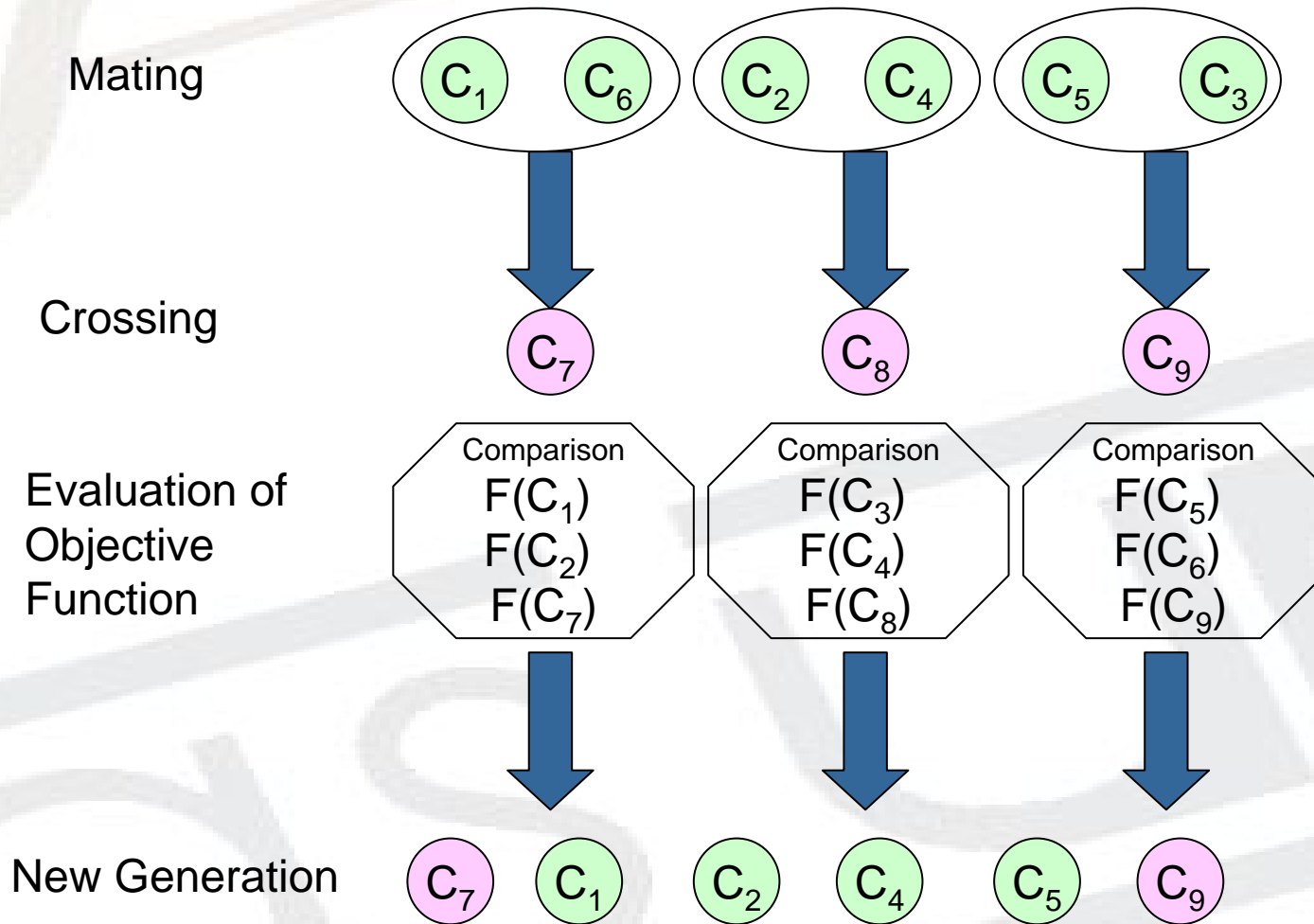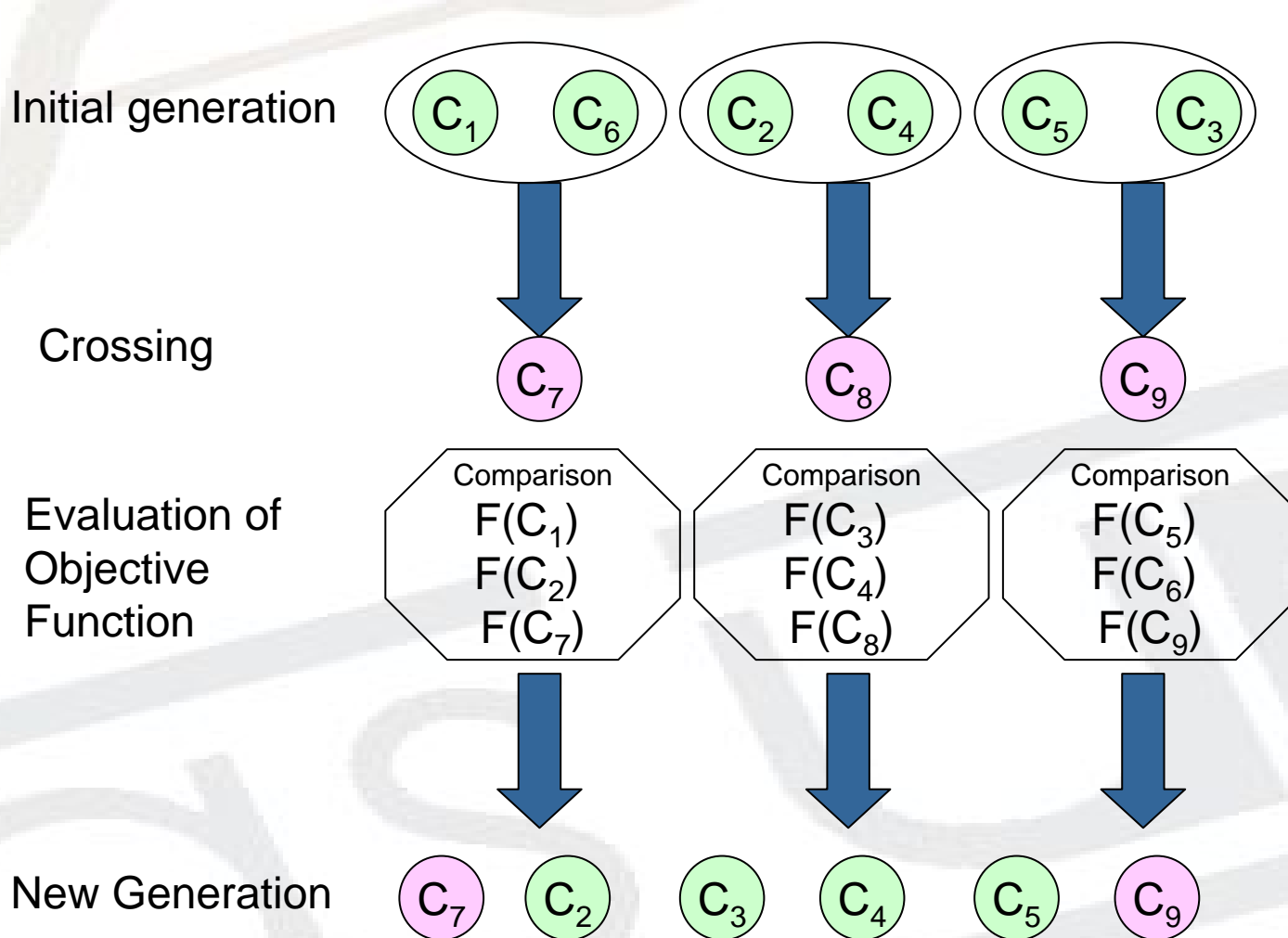C_1 C_2 C_3 C_4 C_5 C_6

What is Genetic Algorithm?

Individuals
Mating

C_1 C_6 C_2 C_4 C_5 C_3

Crossing

C_7 C_8 C_9

What is Genetic Algorithm?

Mating

C_1 C_6 C_2 C_4 C_5 C_3

Crossing

C_7 C_8 C_9

Evaluation of Objective Function

Comparison
$F(C_1)$
$F(C_2)$
$F(C_7)$

Comparison
$F(C_3)$
$F(C_4)$
$F(C_8)$

Comparison
$F(C_5)$
$F(C_6)$
$F(C_9)$

New Generation

C_7 C_1 C_2 C_4 C_5 C_9

What is Genetic Algorithm?

Initial generation: C_1 C_6 | C_2 C_4 | C_5 C_3

Crossing: C_7 | C_8 | C_9

Evaluation of Objective Function:

Comparison: $F(C_1)$ $F(C_2)$ $F(C_7)$ | Comparison: $F(C_3)$ $F(C_4)$ $F(C_8)$ | Comparison: $F(C_5)$ $F(C_6)$ $F(C_9)$

New Generation: C_7 C_2 | C_3 C_4 | C_5 C_9

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Genetic Algorithm Scheme


```
Random generation of
first individuals
              |
              v
Population  ──Chromosomes Population──>  Modifying Data cases ──> Execution YALUK-ATP
              |                                                          |
              v                                                          v
Assigning   <──Fitness Values──  Reading Data  <──  Output Files
Probability
              |
              v
Selecting 'parents'
              |
              v
Crossover and  ──Chromosomes new individuals──> Modifying Data cases ──> Execution YALUK-ATP
Mutation                                                                       |
              |                                                                v
              v
Comparison between  <──Fitness Values──  Reading Data  <──  Output Files
'parents' and 'sons'
```

Evaluating Objective Function

Evaluating Objective Function
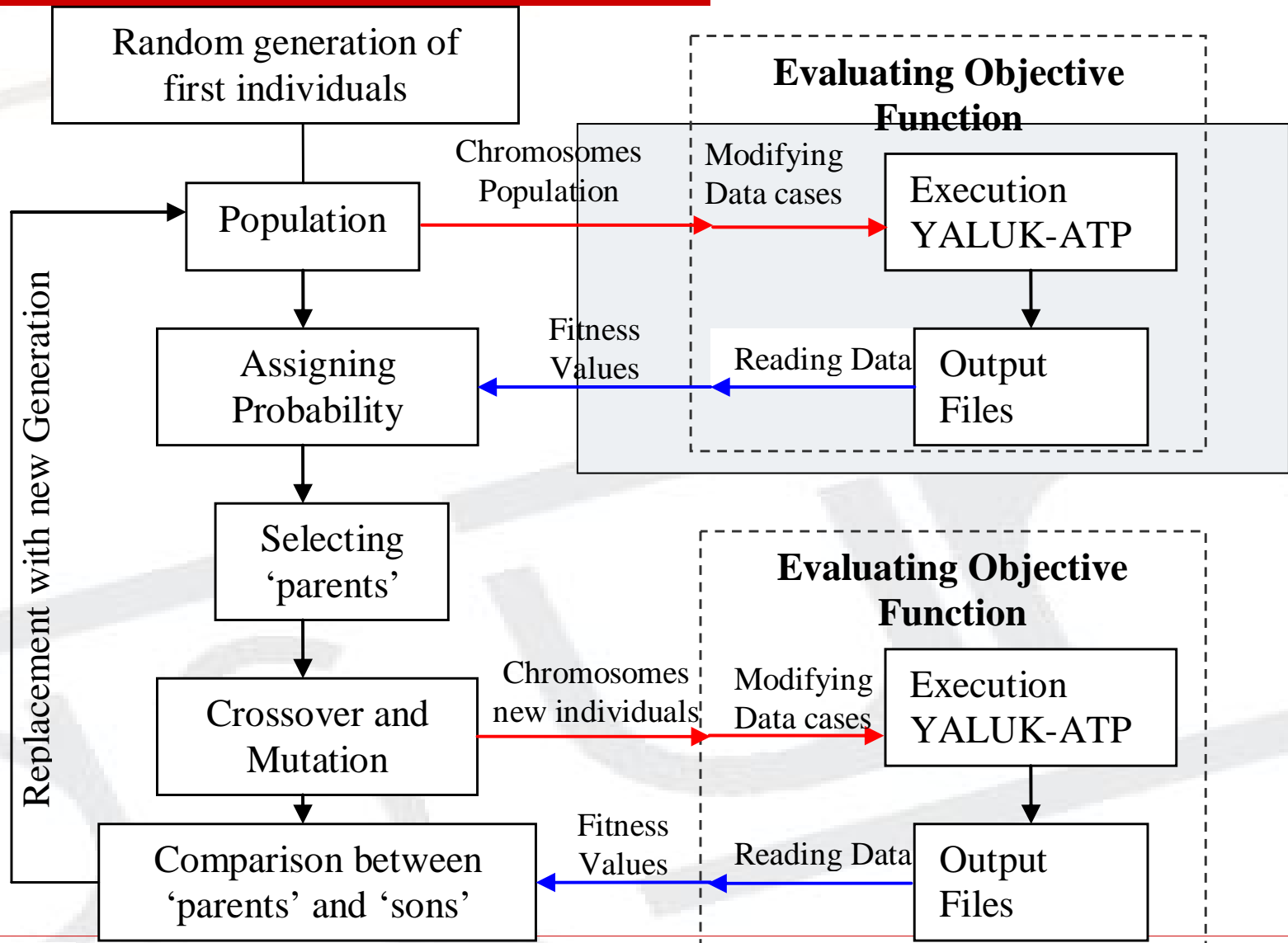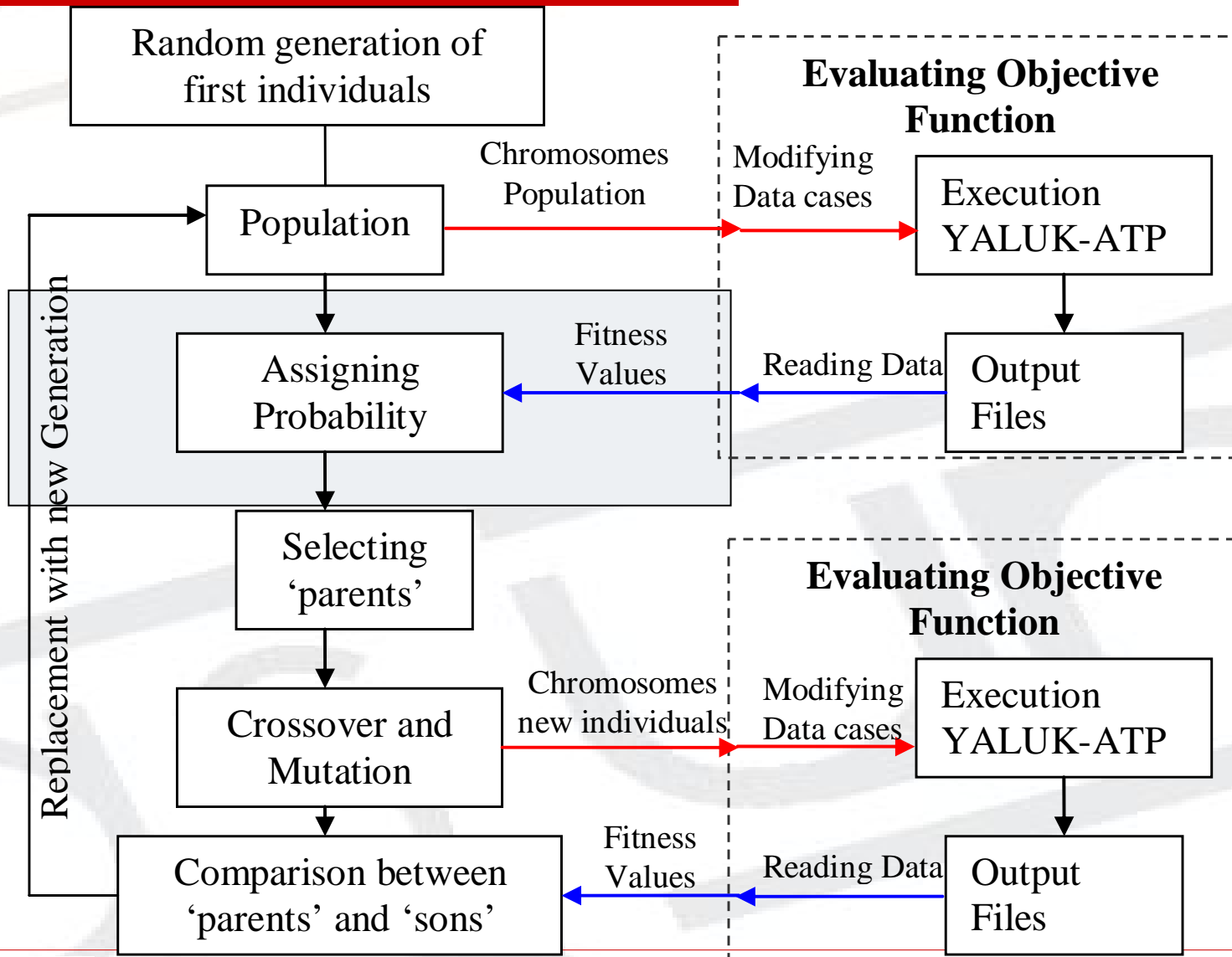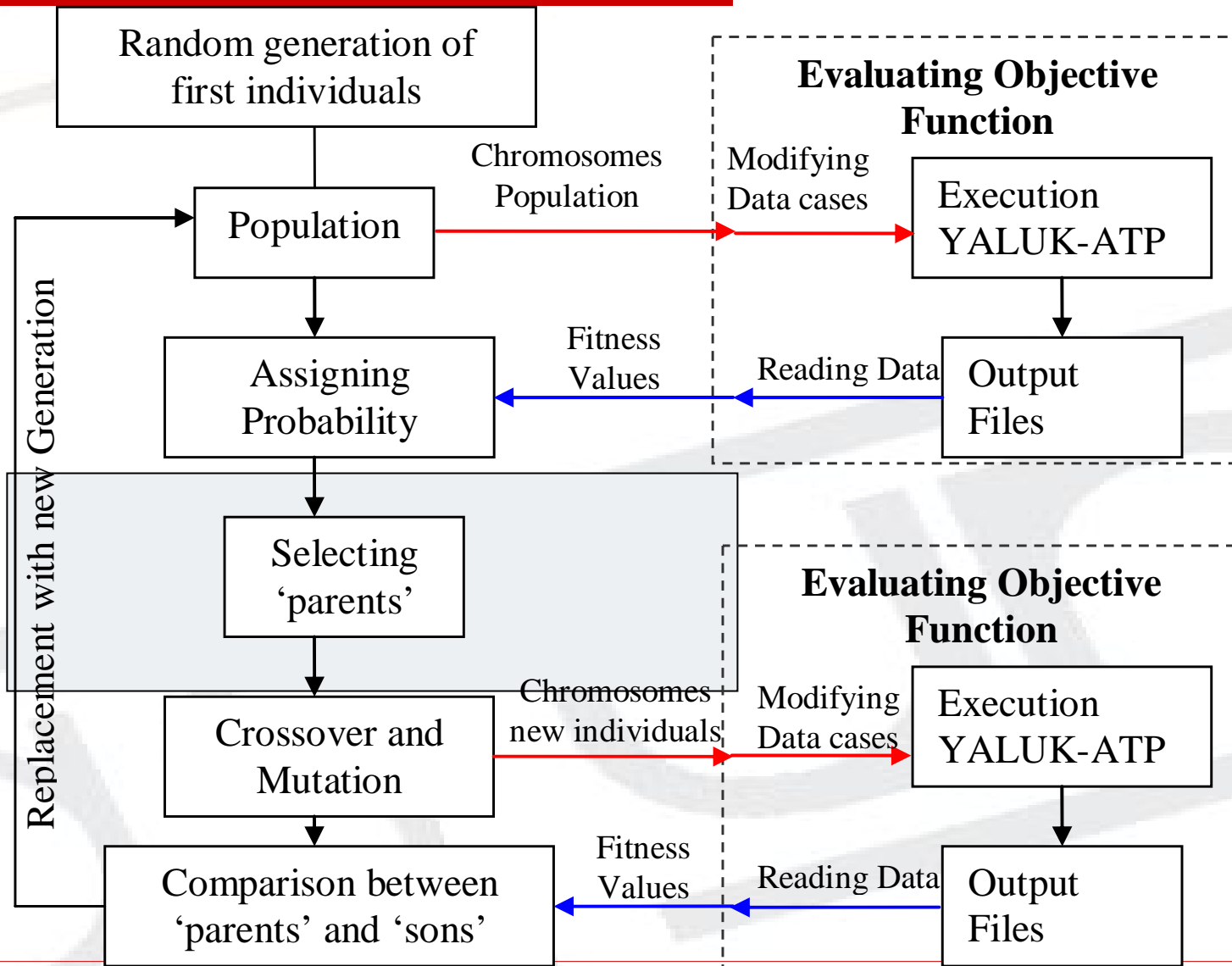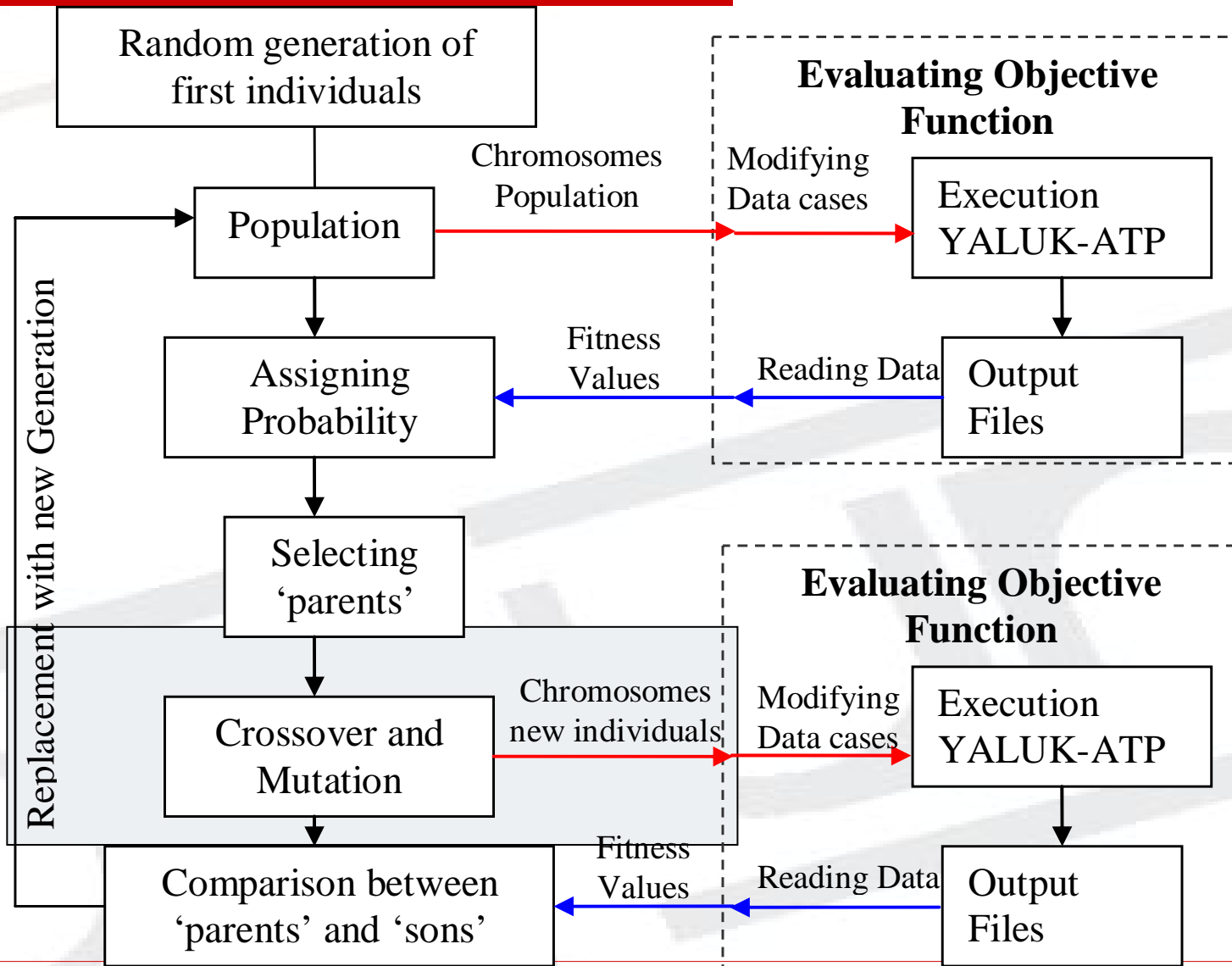
Replacement with new Generation

Genetic Algorithm Scheme
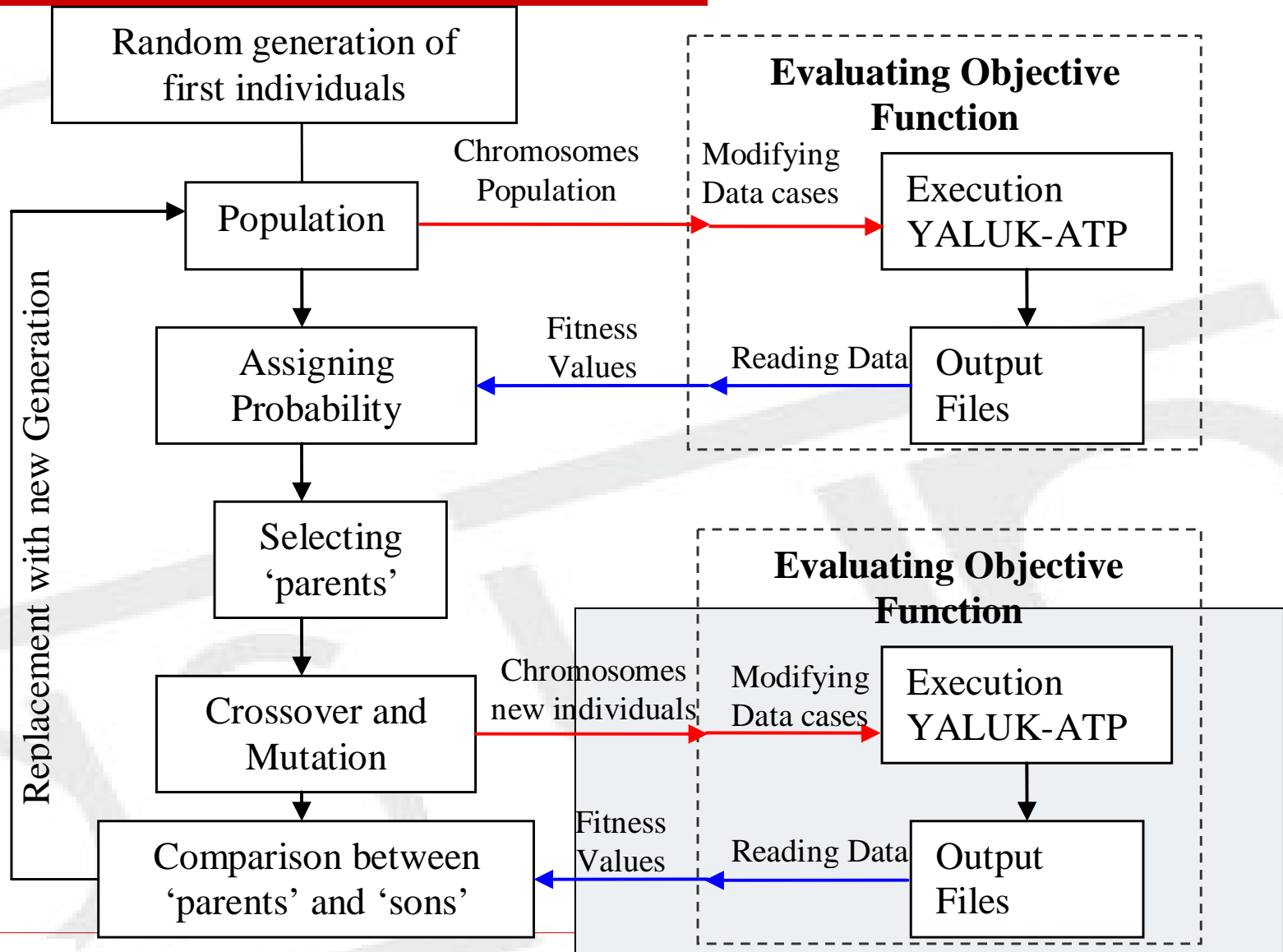
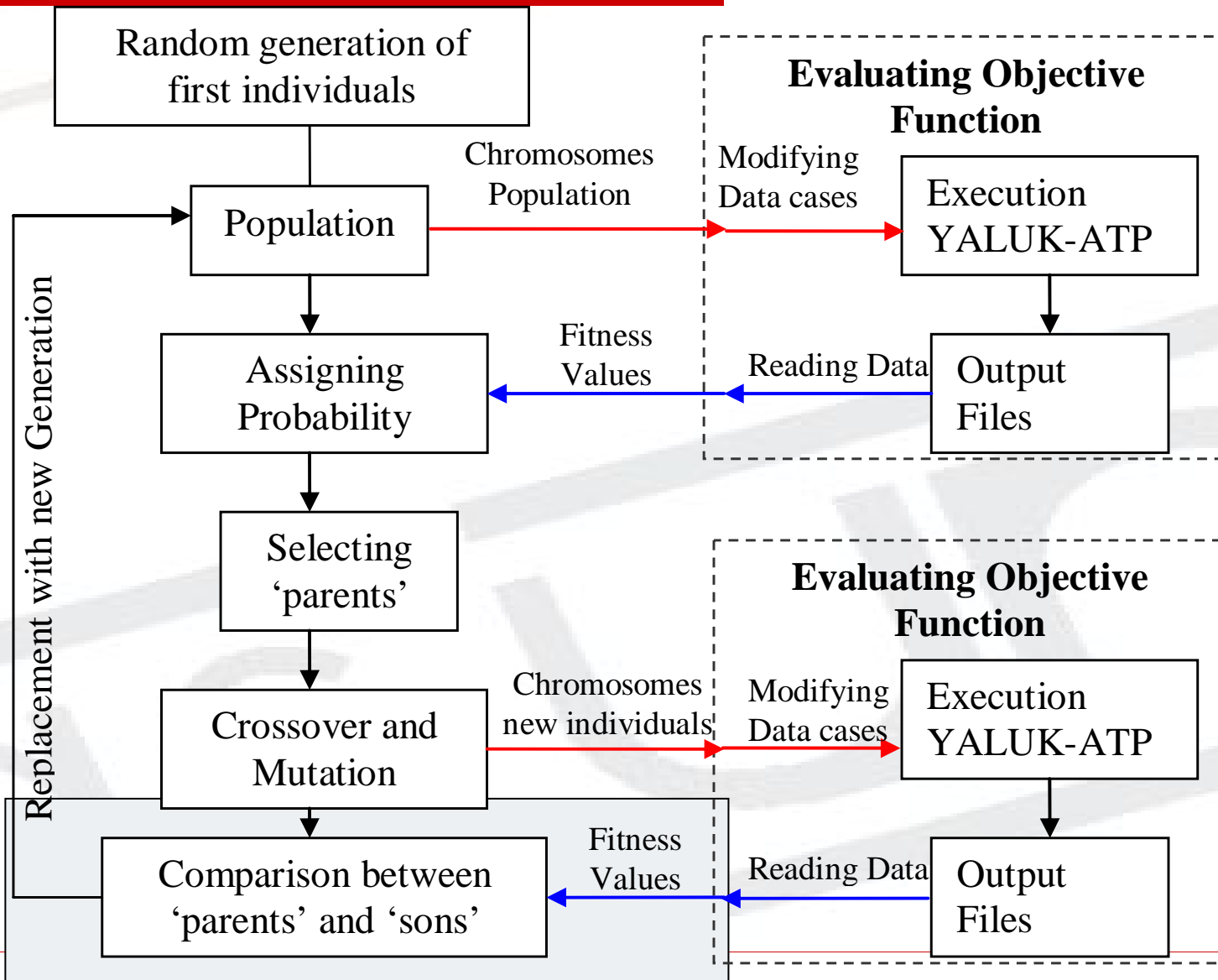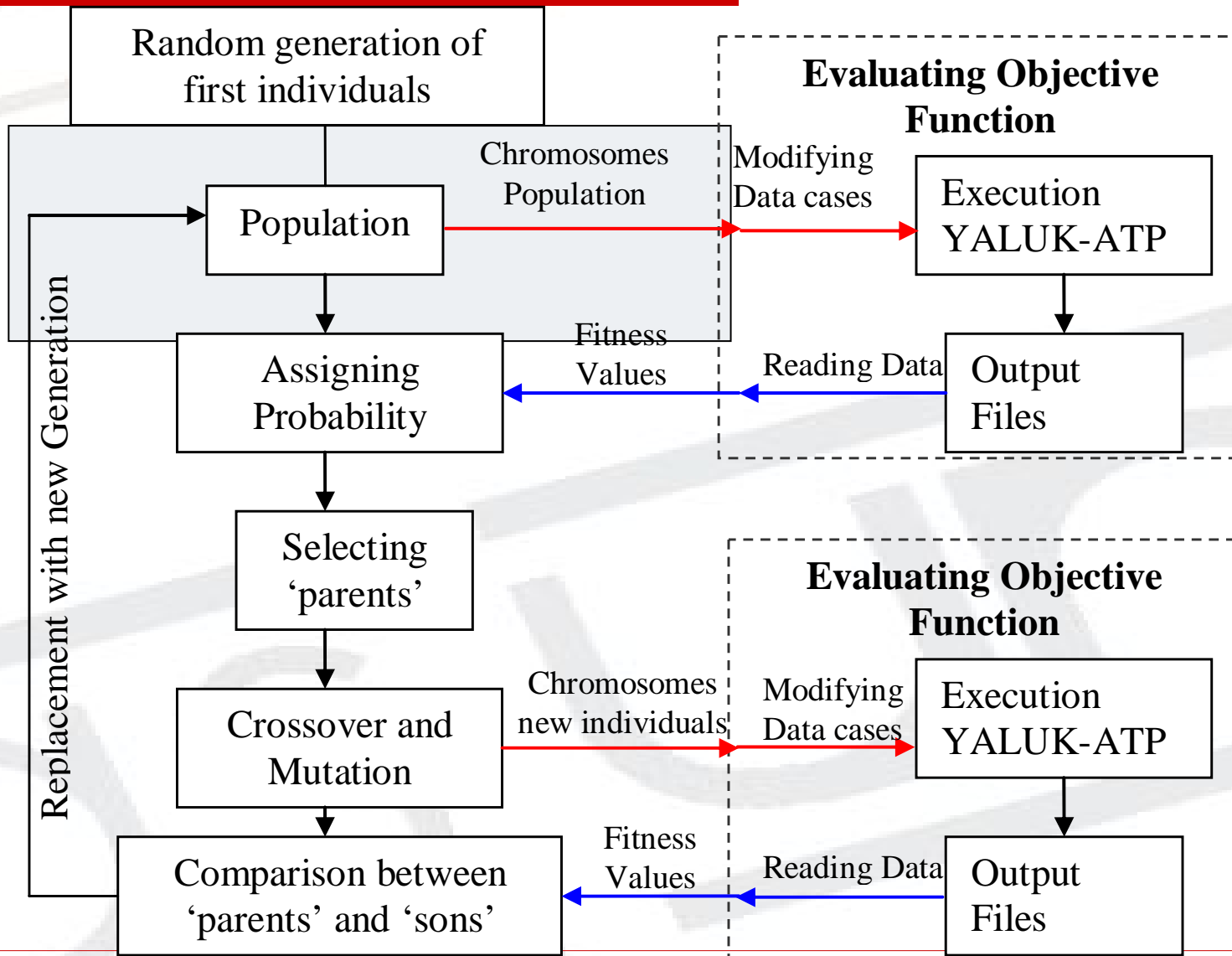# *Genetic Algorithm Scheme*

Genetic Algorithm Scheme

Genetic Algorithm Scheme

Genetic Algorithm Scheme

Genetic Algorithm Scheme

Genetic Algorithm Scheme

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Genetic Algorithm Scheme

Random generation of first individuals

Population

Assigning Probability

Selecting 'parents'

Crossover and Mutation

Comparison between 'parents' and 'sons'

Replacement with new Generation

Evaluating Objective Function

Chromosomes Population → Modifying Data cases → Execution YALUK-ATP

Fitness Values ← Reading Data ← Output Files

Evaluating Objective Function

Chromosomes new individuals → Modifying Data cases → Execution YALUK-ATP

Fitness Values ← Reading Data ← Output Files

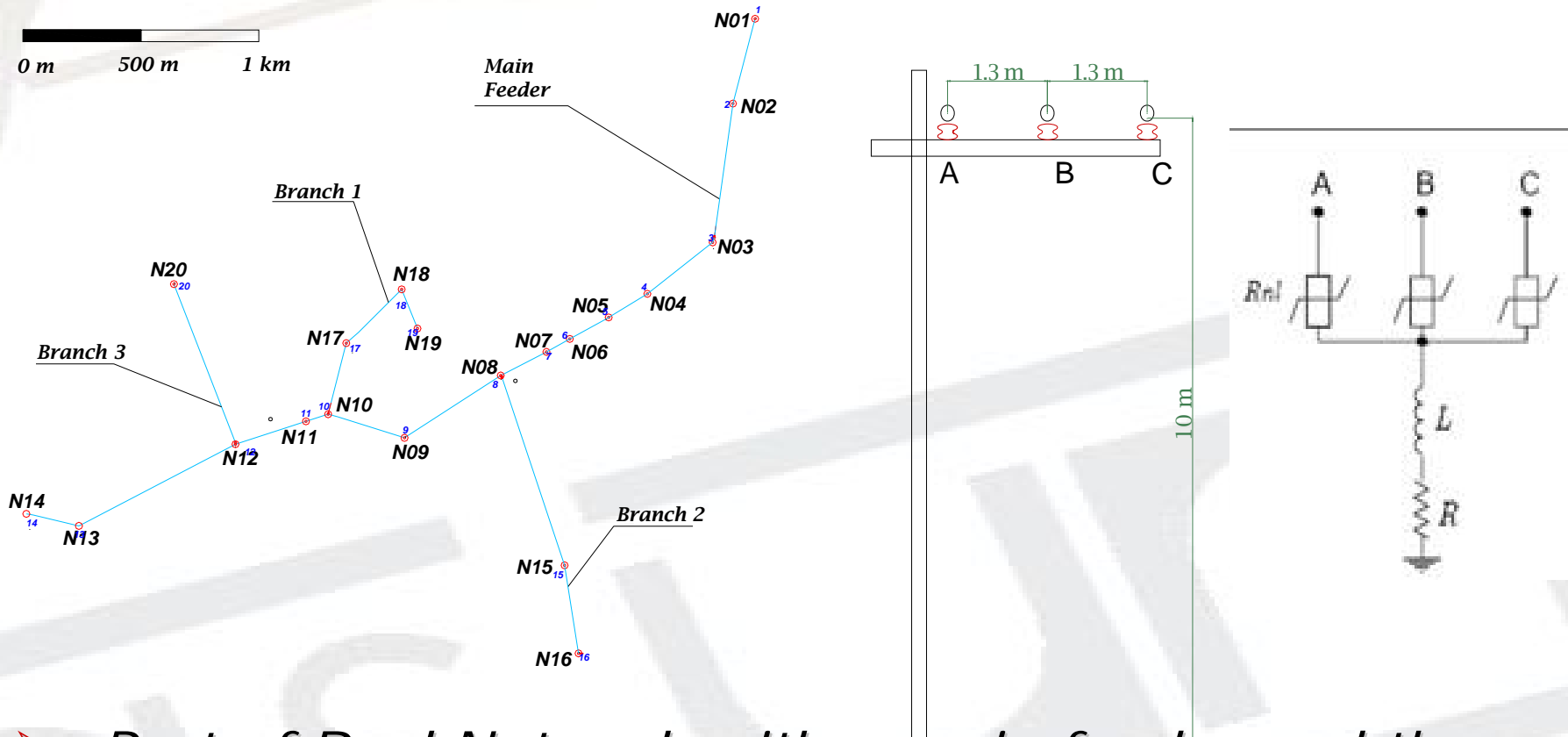UNIVERSIDAD NACIONAL DE COLOMBIA

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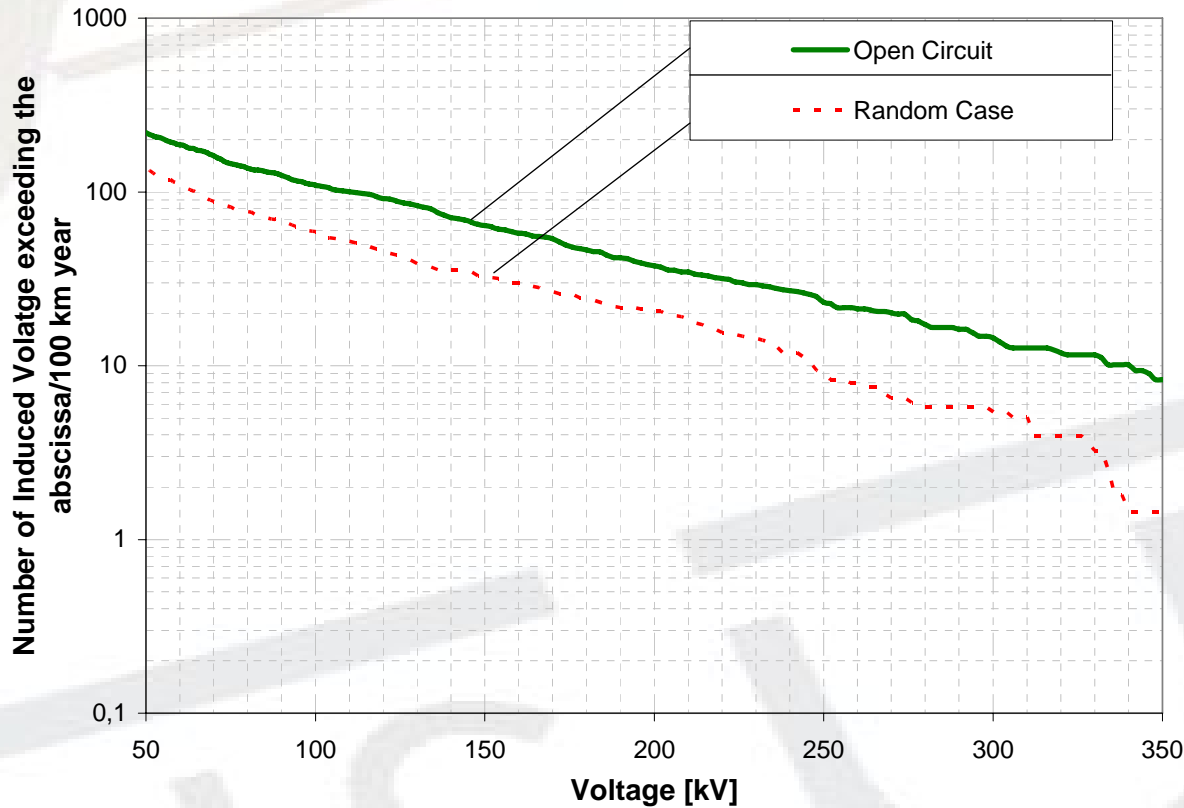# *Genetic Algorithm Scheme*

Example of Genetic Algorithm Tool

➢ *20 Nodes Network (three phase)*

➢ *Location of 4 three phase Surge Arresters*

➢ *4845 possible SA locations*

➢ *Lightning performance calculated with*

  o *40   Strokes*

  o *100 Strokes*

➢ *It is chosen a base case with a SA located randomly*

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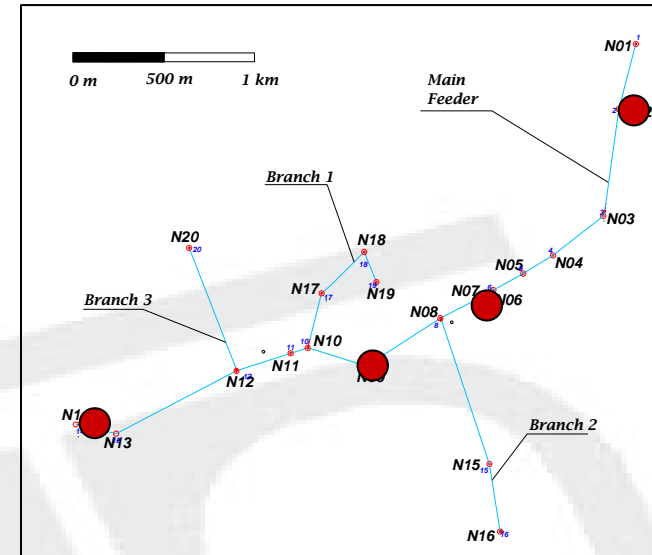Tampa June 25th 2007**

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Effect of Power System Components

➢ *Part of Real Network with a main feeder and three branches with different length.*
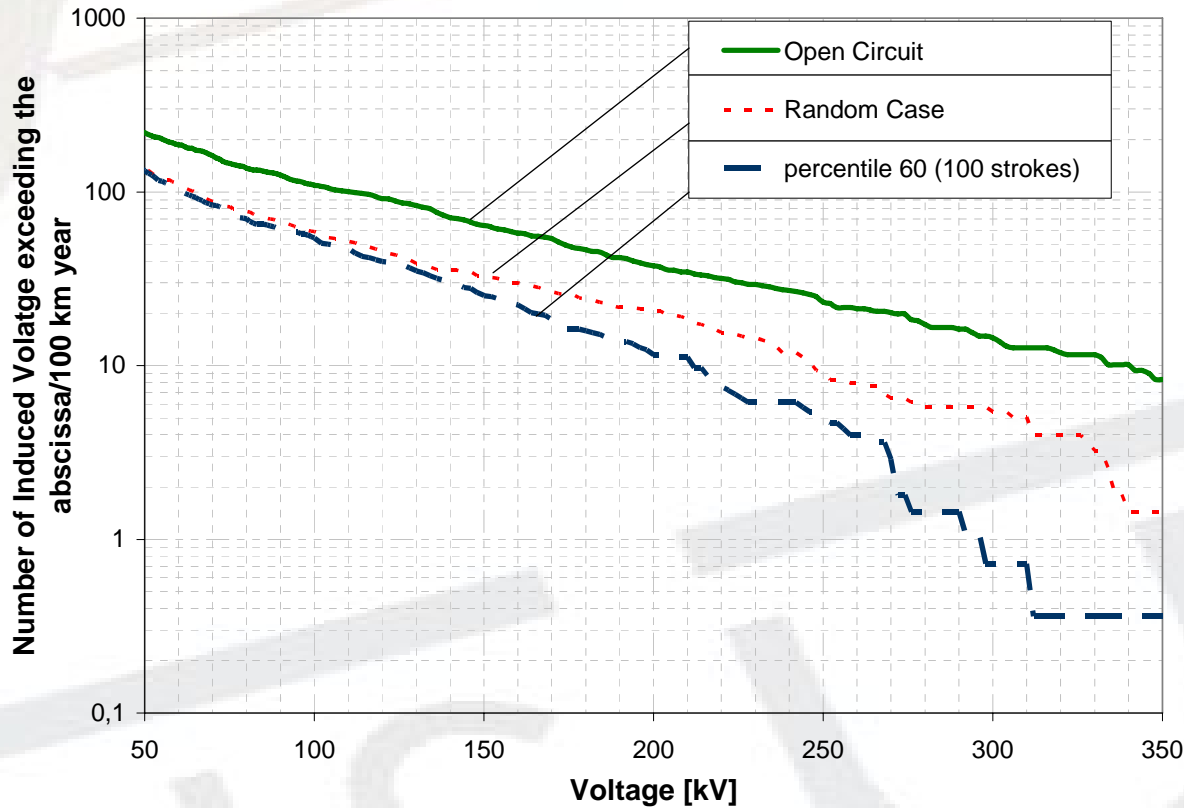
➢ *Total length 7km aprox.*

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Engineering Application

SA – Location - Random
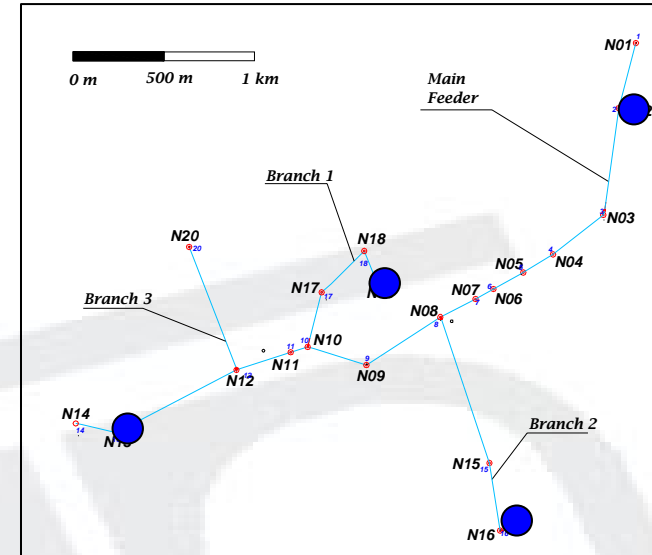
- Random case diminish the number of outages for 200kV from 35 to 20

Engineering Application

- Random case diminish the number of outages for 200kV from 35 to 20

- Running Genetic Algorithm Tool the number of failures for 200kV is 10

Conclusions

➤ *Here is described a new methodology based on genetic algorithms intended to find an optimal solution for the location of a set of surge arresters.*

➤ *This methodology could bring better results when a reasonably probability curve is possible to be obtained for each individual.*

➤ *Greater number of strokes should be used for each solution, implying that big efforts should be done in order to reduce induced voltage computation time.*

Conclusions

➢ *This tool allows to find a "good" solution but not always this is the best one.*

➢ *This proposed methodology contributes on the researching focused on the using of artificial intelligence techniques, such as, genetic algorithms for designing and planning the distribution network systems optimally.*

➢ *Further work should be done in incrasing the number of parameters to simulate meanwhile it is improve the computation time.*

THANK YOU

FOR YOUR ATTENTION