

# Genetic Algorithm: A Tool for Multicast QoS Optimization in MANETs



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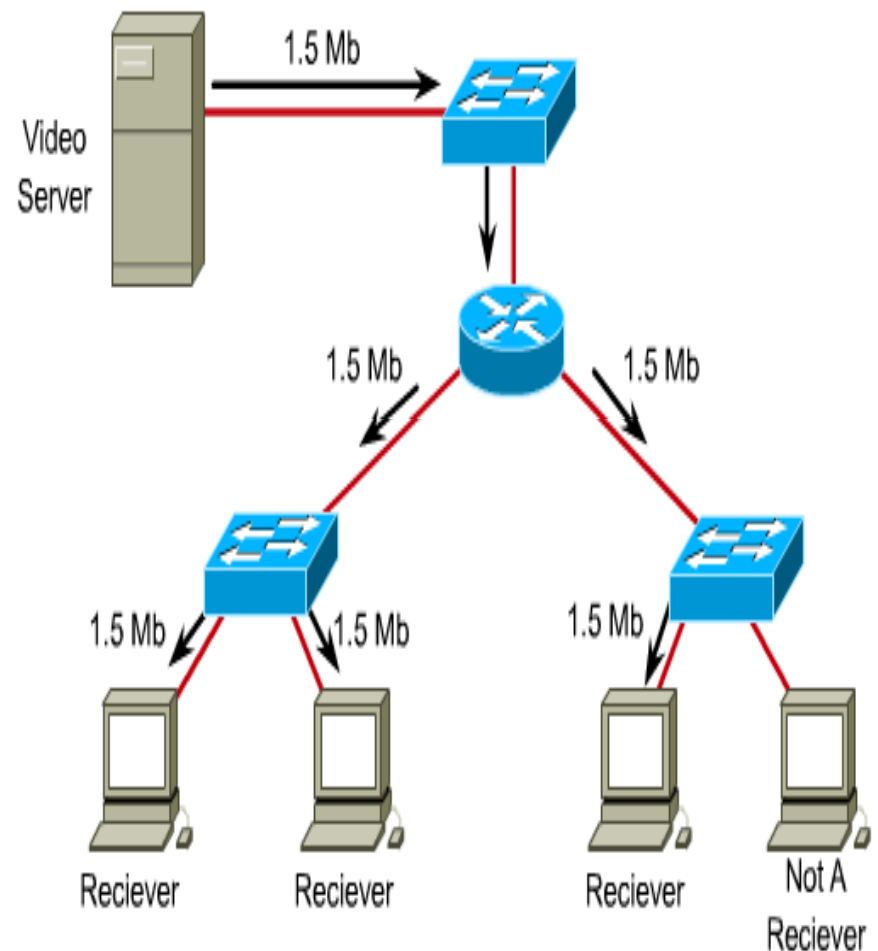
# Outline



- **Introduction**
  - Multicast Routing
  - Genetic Algorithm
  - QoS in Mobile Ad Hoc Networks
- **Proposed Algorithm**
  - GA-based multicast routing algorithm
- **Performance Simulation**

# Background

- Significant increase for the need of multicast services
  - Real-time stock quotes, network games, video streaming
- Multicast routing efficient than other types of routing
  - Sender sends a single copy of data to a special address group which can represent multiple nodes.
  - Saves bandwidth consumption and host processing by forcing the network to replicate packets only when necessary.



# Genetic Algorithm



- **What are Genetic Algorithms?**
  - Inspired by Darwin's *Origin of Species*. And developed by John Holland in the 1970's.
  - Following survival of fittest occurring in nature.
  - Problem modelled as processes in natural evolution and evolutionary genetics.
  - Analogy between terminologies in GA and genetics
- **Why use them?**
  - Useful in solving multiple (conflicting) constraints that are computationally intensive or intractable (NP-Complete)
  - Search from multiple search points in the solution space.
  - Problems tend to have multiple “ridges” in their solution space—GA does not get stuck in local traps.
  - Optimal/approximate solution as opposed to exact solution.

# Nature and GA...



***Nature***

***Genetic algorithm***

**Chromosome**



**String**

**Gene**



**Character**

**Locus**



**String position**

**Genotype**



**Population**

**Phenotype**



**Decoded structure**

# QoS Issues in MANETs

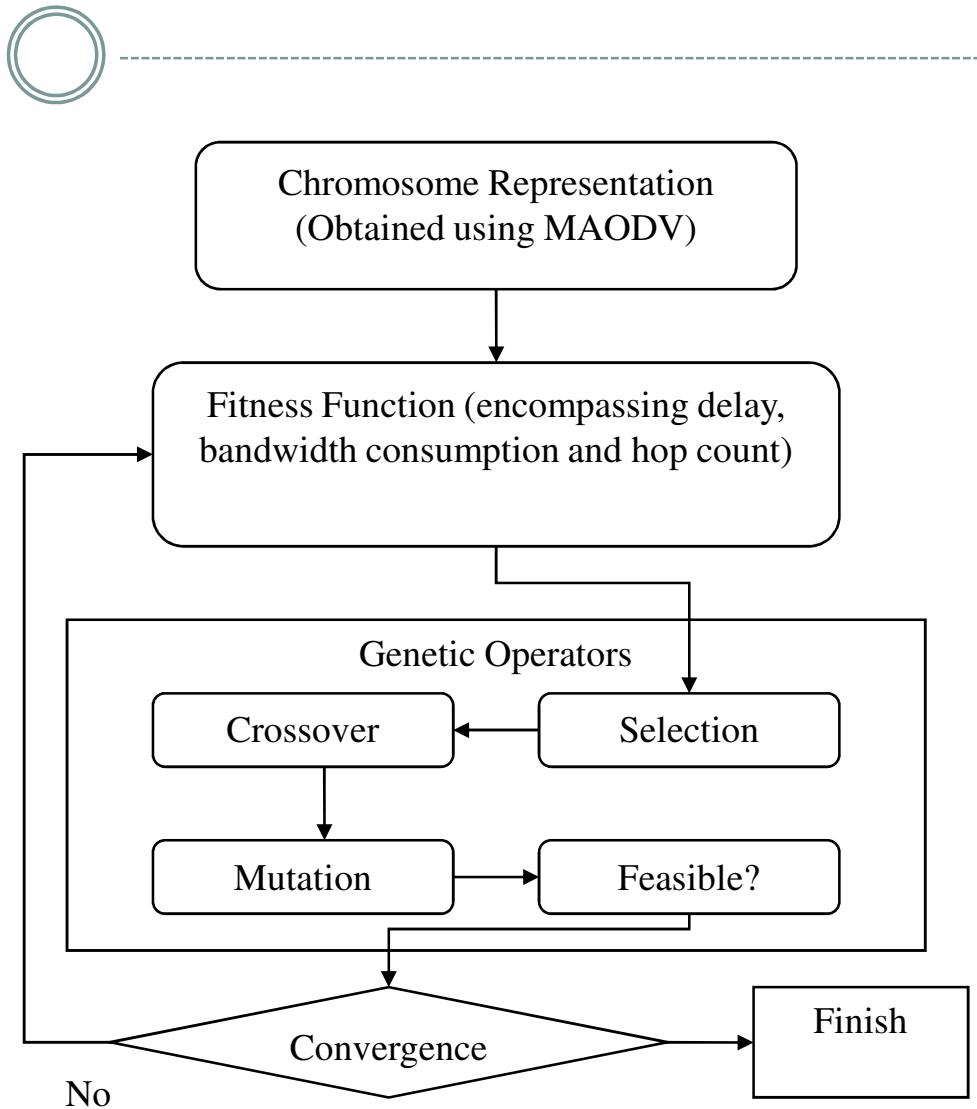


- QoS involves providing consistent and predictable data delivery to both real-time and non-real time services.
- MANETs, unlike cellular networks have no fixed infrastructure. The sender of data act as both as transmitter and receiver.
- Frequently used in emergency and temporary scenarios (e.g. disaster area, military operations)
- Due to dynamic nature of MANETs, QoS provisioning is challenging.
- Existing multicast protocols provide paths based on shortest path, and not able to meet QoS criteria imposed by multimedia applications.

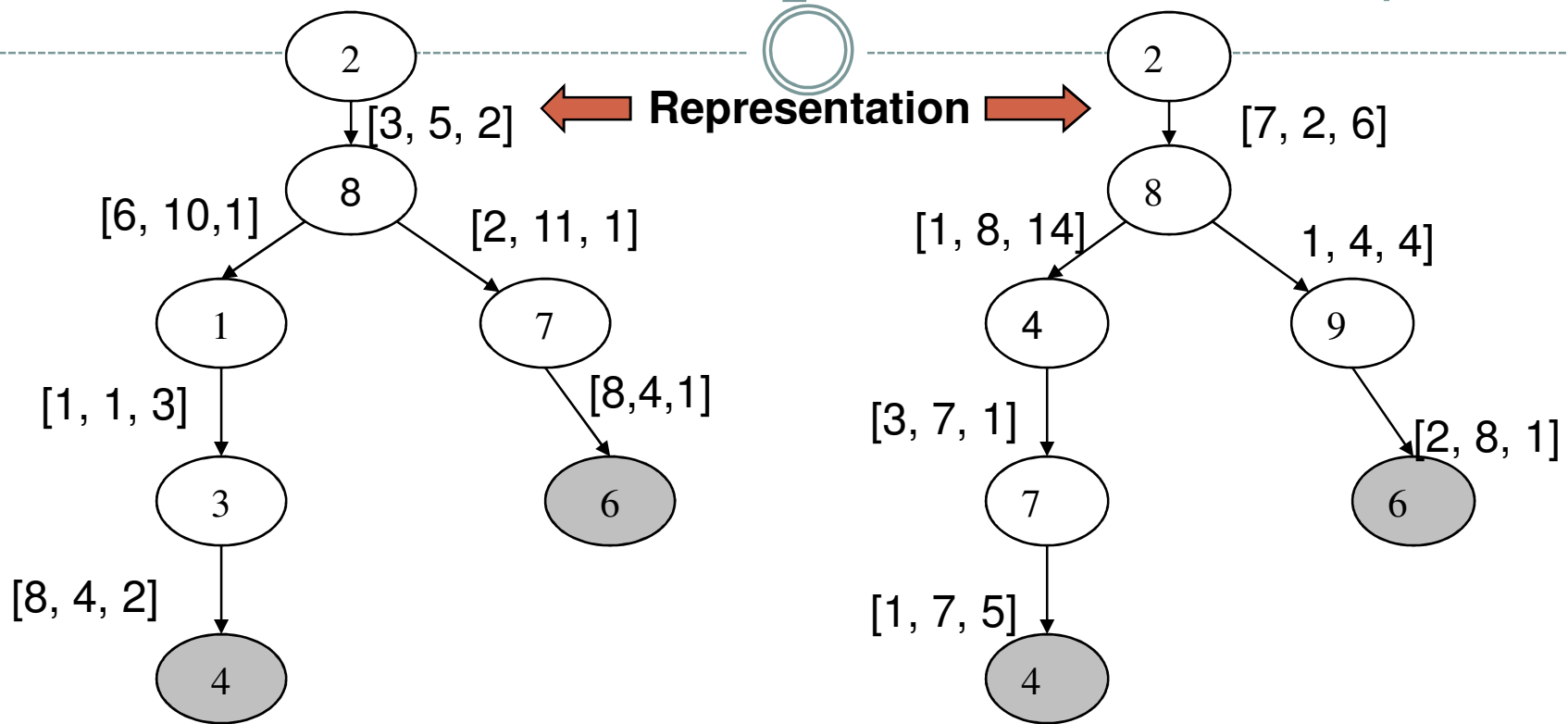
# Proposed Algorithm (1/6)

- **Objective:**

- Reach multicast destination within given delay, hop count & bandwidth.
- Multicast tree: find an optimal tree that satisfies these constraints
- How to represent a tree topology so that GA can be applied?



# Chromosome Representation (2/6)



- Two different trees representing same multicast topology with source node, 2 and destinations 4 and 6
- [3, 5, 2] = [Cost, Bandwidth, Delay]
- Tree1 Score (2->4) = [18, 20, 8]
- Tree2 Score (2->4) = [12, 24, 26]

# Fitness Function (3/6)



- After multicast topology representation, a score that shows the “quality” of chromosome should be evaluated.
  - “quality” score depends on the encoded (i.e. QoS) values
  - Equation that calculates is called fitness function => fitness score
  - Our goal: find the lowest cost tree => cheapest possible route to multicast destinations.
  - $\text{Fitness} = 1/(\text{Cost} + \text{Bandwidth} + \text{Delay})$ 
    - ✦ Lower this value the more efficient the route
- Fitness should reflect the objective of the problem and the chromosome the nature of the solution.

# Obtaining New Paths (4/6)

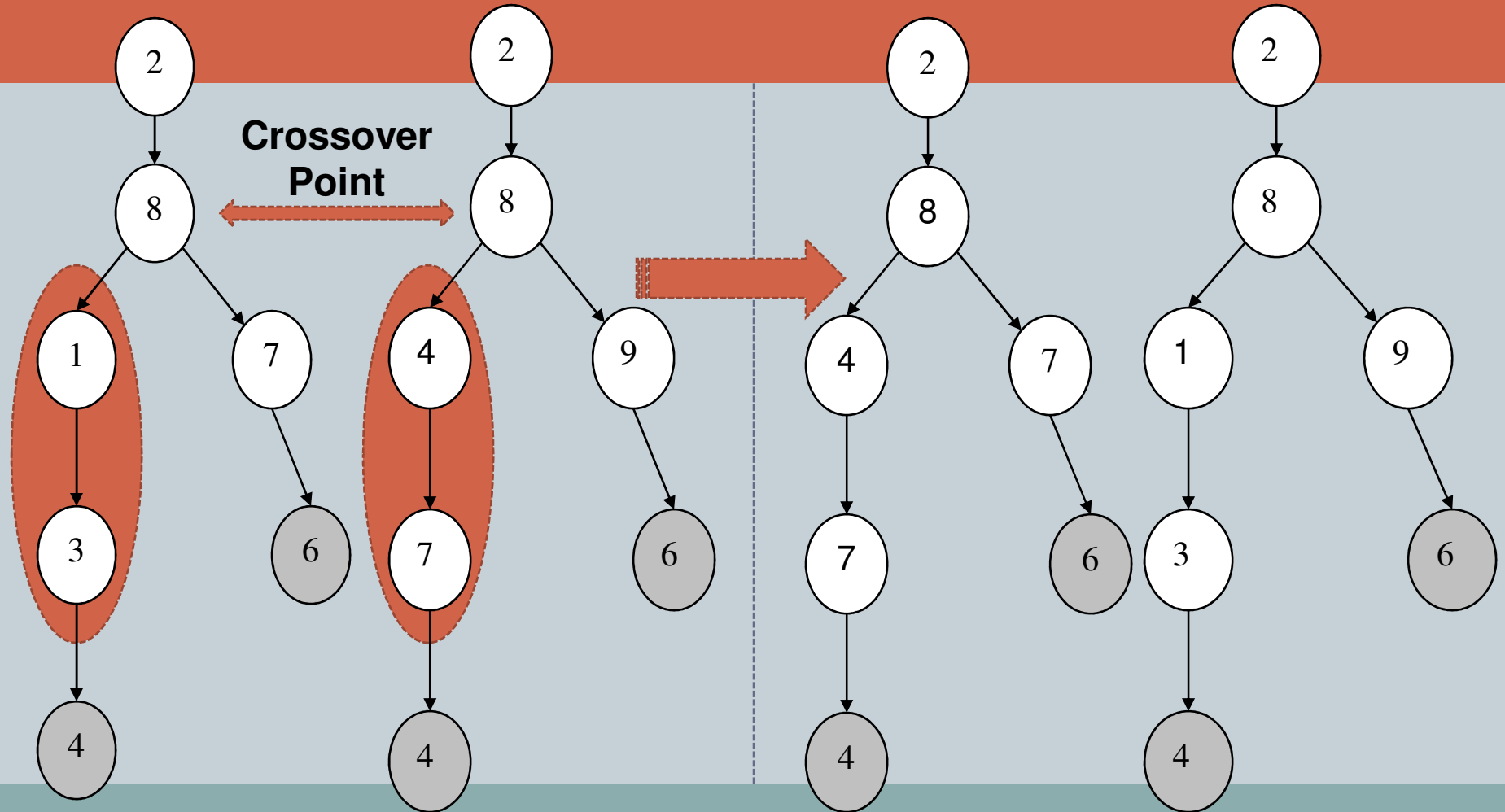


- **Given many trees, how are they selected?**
  - Various selection methods (to be parents): Tournament, roulette wheel selection
  - Approach used: based on the fitness score, chromosomes are ranked and then selected.
- **How does GA find new path?**
  - Via crossover and mutation (akin to reproduction in Nature)
    - ✦ Idea is to introduce new “genetic material” (nodes) in the chromosomes, and thus new paths
  - Fitness values are again calculated to check if they are optimal (or stop after N number of *generations*)

# Crossover (5/6)

[Bandwidth, Delay] = [24, 19]

[Bandwidth, Delay] = [20, 15]



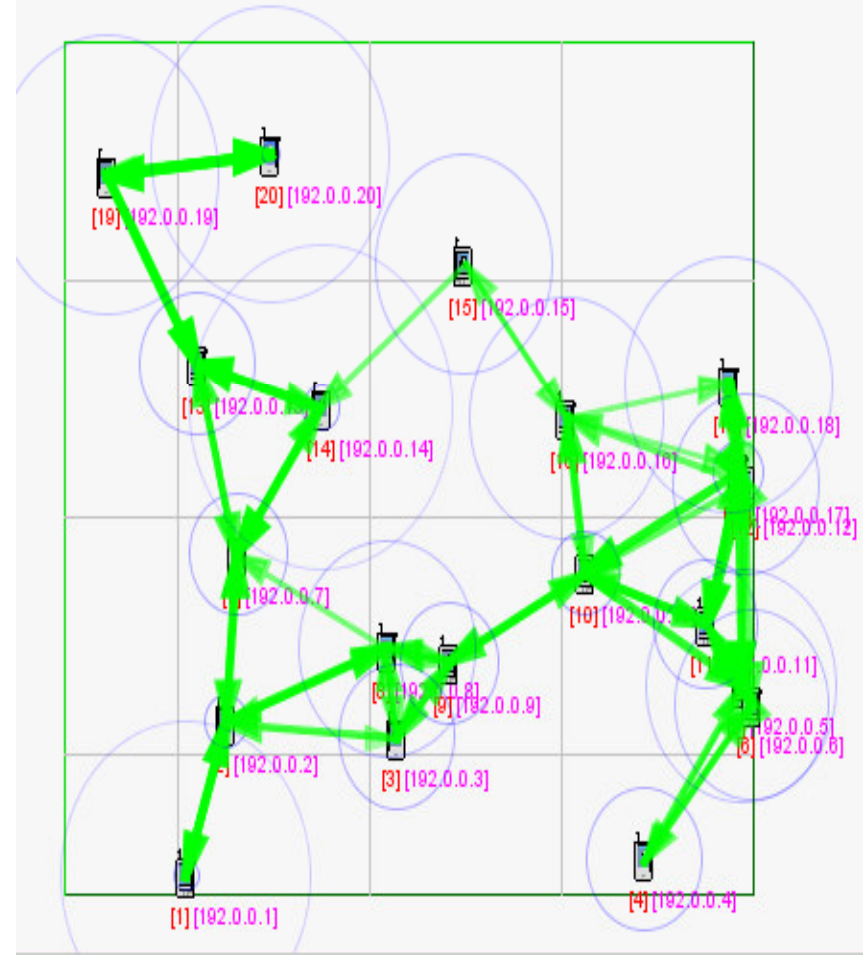
# Mutation (6/6)



- Mutation introduces randomness and creates a small diversion near the parent
  - So that we are searching in the same place.
  - Ordered lists: introduce new nodes (generate a subtree). Check if there are duplicate nodes in the tree.
  - Binary representation: flip the bits.
- Crossover & mutation ensure that the quality of solution improves, and this ensures diversity among chromosomes
  - A means to move throughout the search area (traditional approximation lack this ability)

# Performance Simulation & Results

- By varying different random seed value we obtain multiple trees for the same source and destinations using tree-based multicast routing protocol.
  - Encode tree into a chromosome
- The number of nodes vary from 20 to 180 with random waypoint mobility in a flat topology of 1000m x 1000m. The simulation runs for 200 – 900 seconds
- Tree obtained after GA compared against optimization using traditional techniques (LP)



# Conclusion



- Useful in emergency search & rescue: need for audio visual situational awareness
  - Genetic based routing can be used to optimize QoS on real-time basis
- An innovative way to look at optimisation problems
  - Enables to identify potential tree that are difficult to obtain via other algorithms.
  - Easier to implement