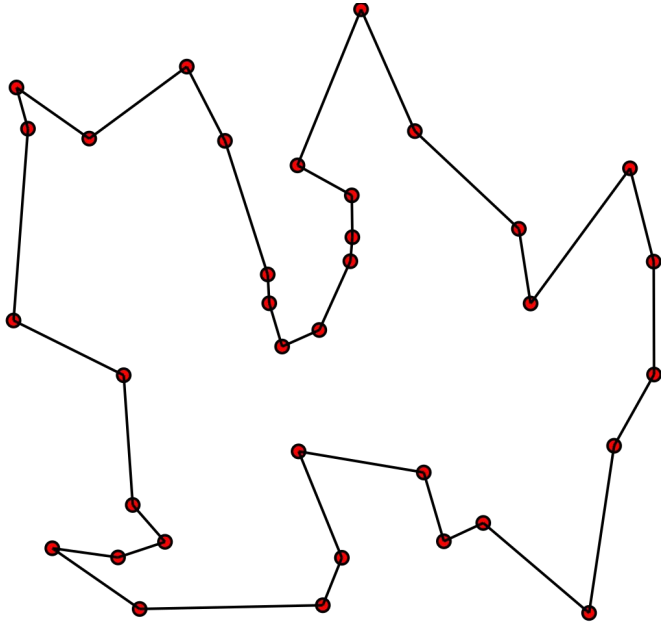
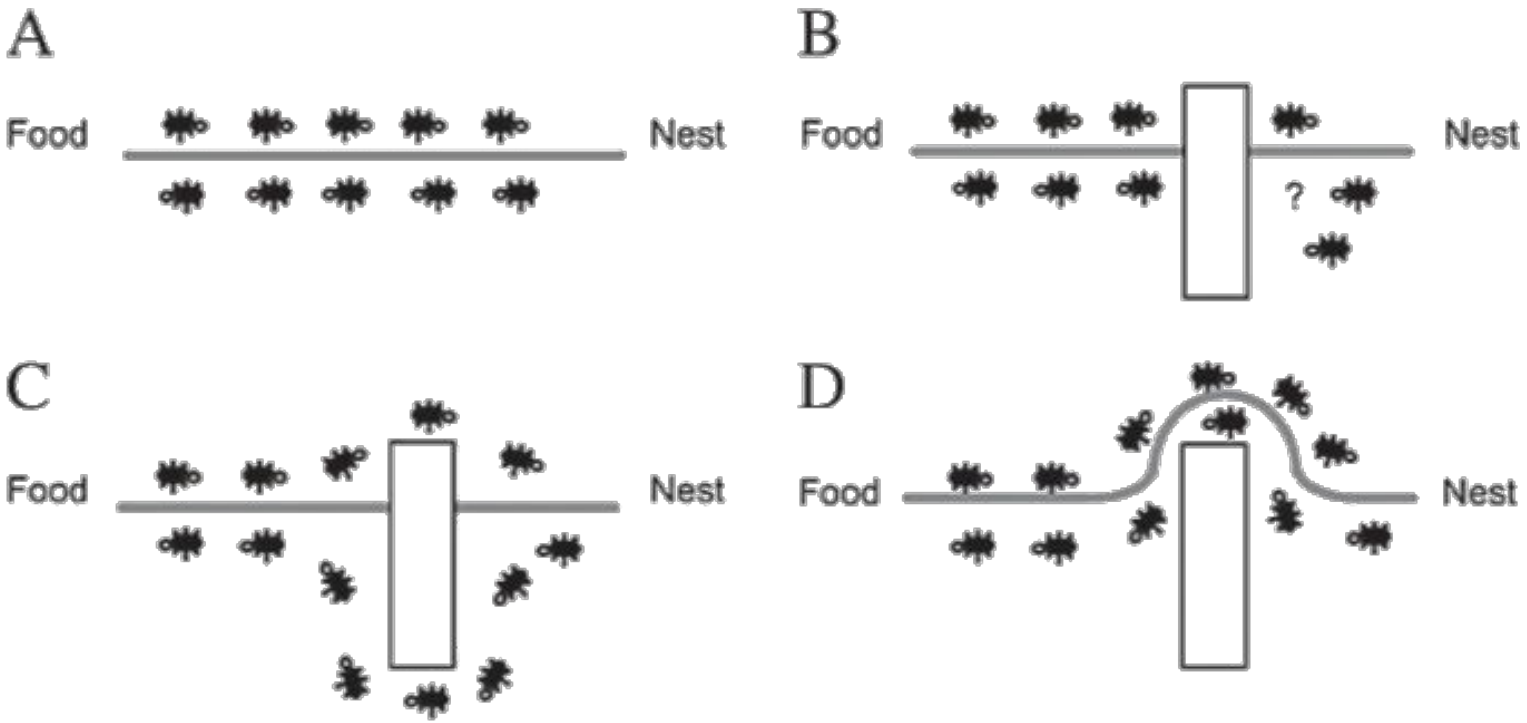
# Optimization Algorithms for Traveling Salesman Problem: A Comparison of Basic Ant System and Ant Colony Optimization-Genetic Algorithm Hybrid

Michael Webber, Andy Stoneman, and Alex Clark

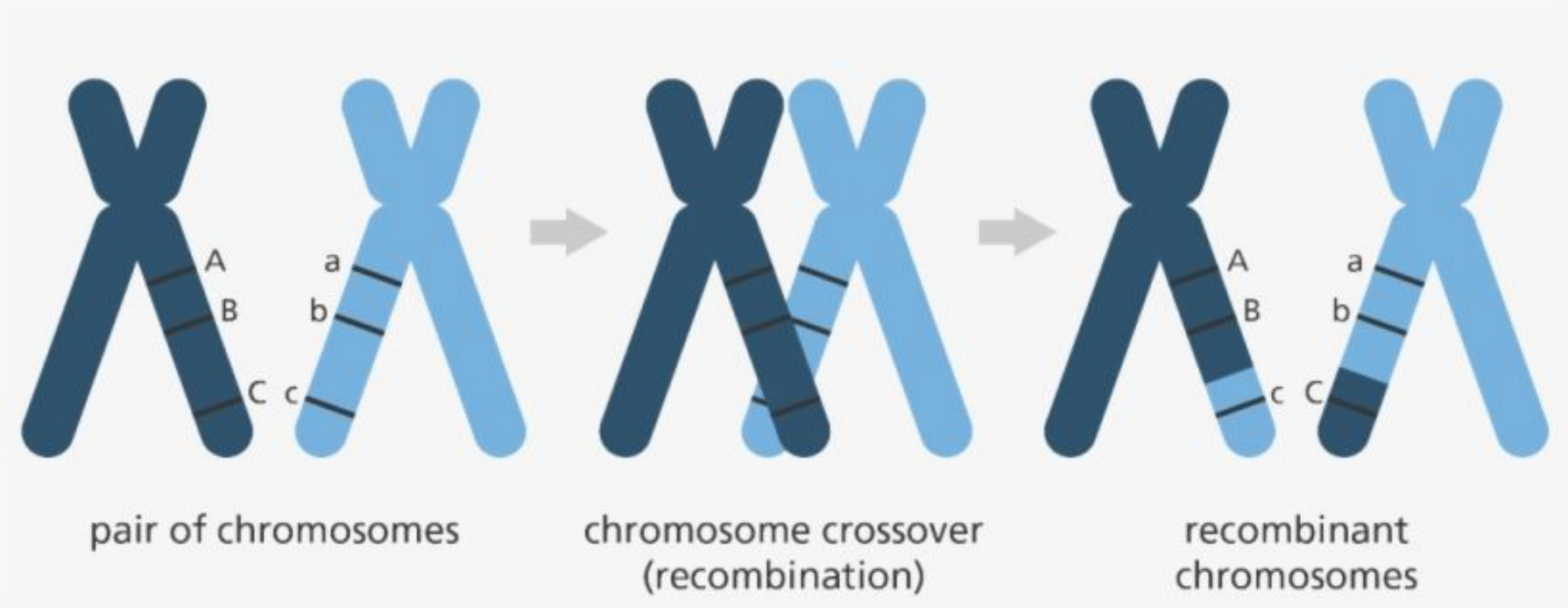
# Traveling Salesman Problem



# Ant Colony Optimization



# Genetic Algorithm



# Combining ACO and GA

# Ant Colony Optimization-Genetic Algorithm Hybrid

- ACO portion is just Basic Ant System
- Candidate solution for GA = single ant's constructed tour
- Genetic Algorithm modified:
  - Tournament Selection–Use top eight
  - Recombination–Order Crossover and Partially Mapped Crossover
  - No mutation–Made things worse
  - Replace bottom eight in initial population

# Modified Tournament Selection

```
/**
 * Runs the genetic algorithm portion of the hybrid. Picks half the number of ants using tournament selection
 * and then calls specified crossover operator.
 */
private void gaUpdate() {
    //tournament selection
    Ant[] parentAnts = new Ant[NUM_ANTS];
    Random randomSelect = new Random();

    for (int i = 0; i < 8; i++) {
        //pick two random candidates from the initial population
        Ant candidateOne = antCollection[randomSelect.nextInt(NUM_ANTS)];
        Ant candidateTwo = antCollection[randomSelect.nextInt(NUM_ANTS)];

        //check which one has a higher fitness and add it to the new empty array
        if (candidateOne.getCurDistance() > candidateTwo.getCurDistance()) {
            parentAnts[i] = candidateOne;
        } else {
            parentAnts[i] = candidateTwo;
        }
    }

    //recombination/crossover
    if (crossoverType == "OX") {
        orderCrossover(parentAnts);
    } else if (crossoverType == "PMX") {
        partiallyMappedCrossover(parentAnts);
    }
}
```

# Ordered Crossover

$P_1 = (8\ 3\ 4 \mid 1\ 2\ 7 \mid 5\ 6)$

$P_2 = (5\ 4\ 2 \mid 8\ 1\ 6 \mid 3\ 7)$

$C_1 = (x\ x\ x \mid 1\ 2\ 7 \mid x\ x)$

$C_2 = (x\ x\ x \mid 8\ 1\ 6 \mid x\ x)$

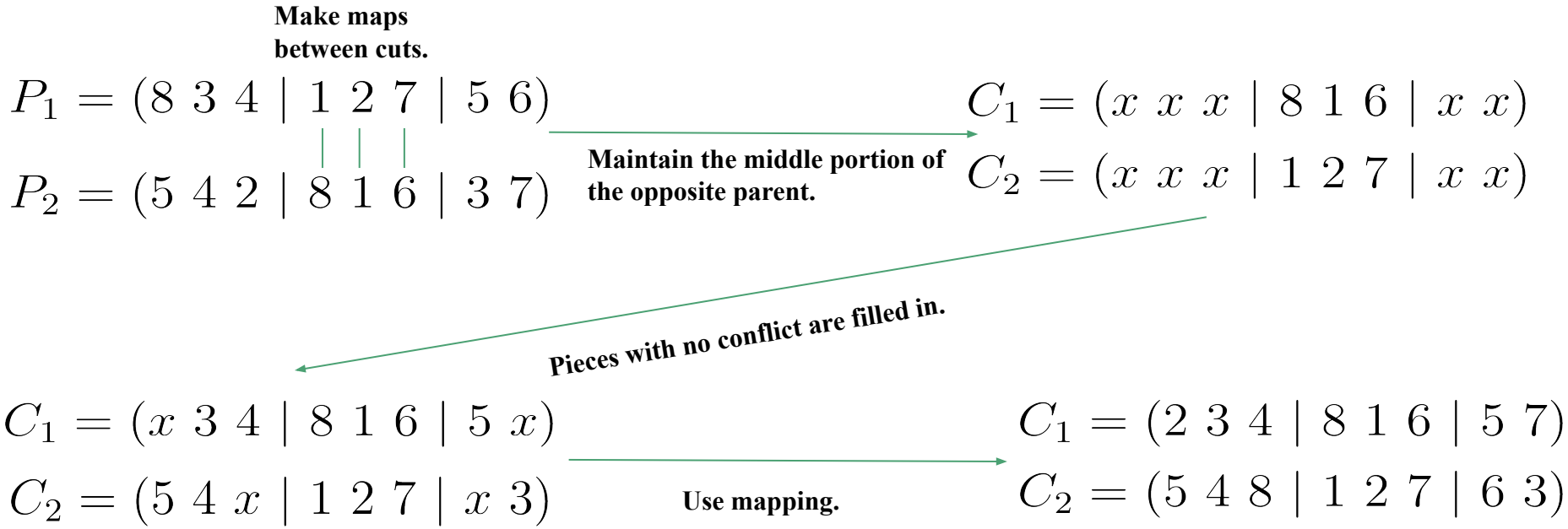
**Keep portion of the corresponding parent.**

**Insert ordering of the opposite parent's values after the cutoff and remove the values that are already in the child.**

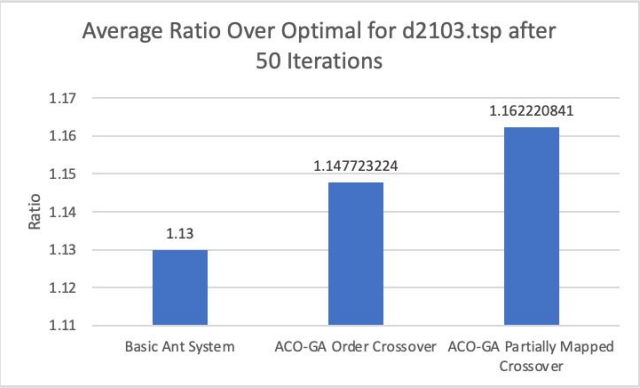
$C_1 = (4\ 8\ 6 \mid 1\ 2\ 7 \mid 3\ 5)$

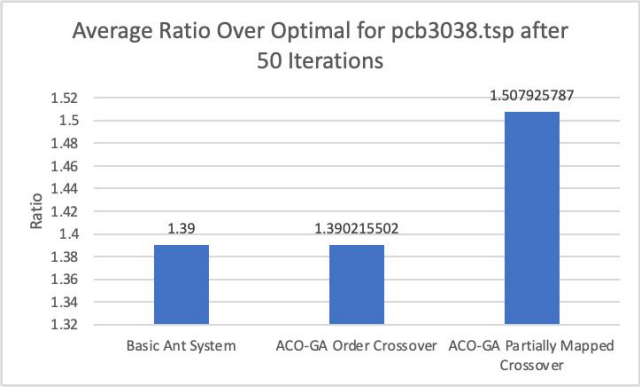
$C_2 = (4\ 2\ 7 \mid 8\ 1\ 6 \mid 5\ 3)$

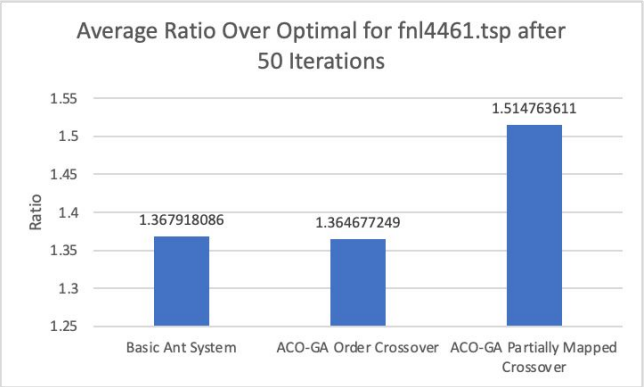
# Partially Mapped Crossover

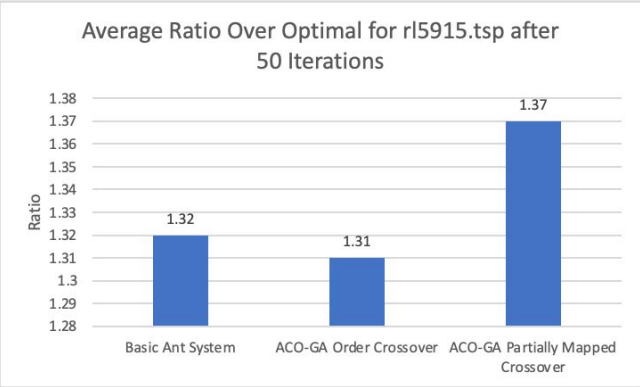


# Experiment 1: Fitness after 50 Iterations

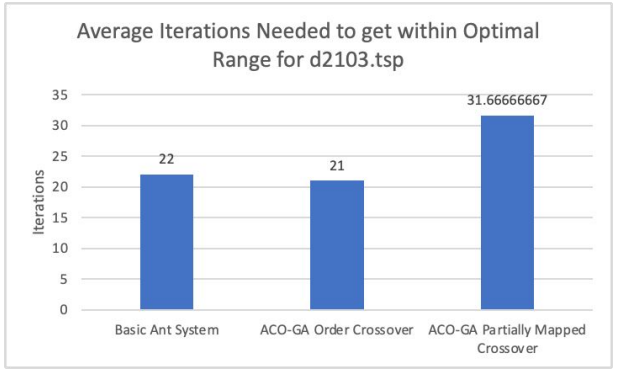


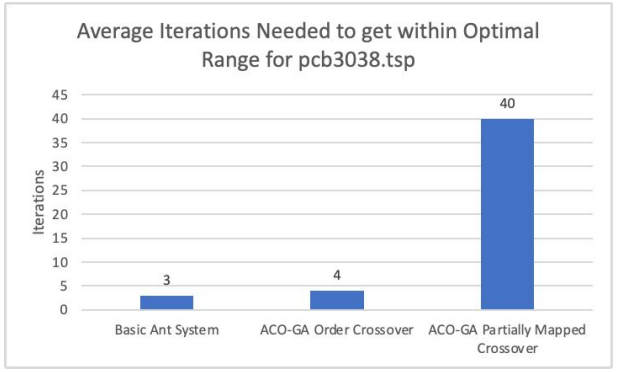



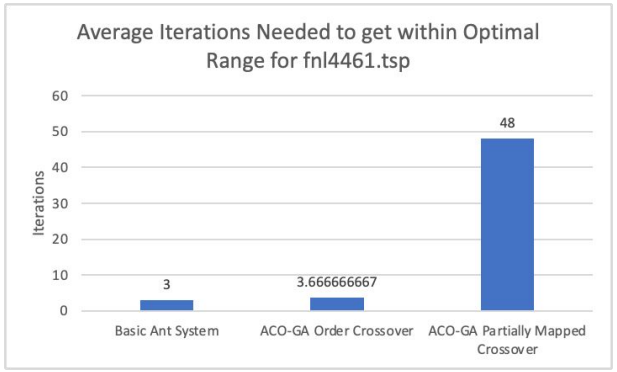



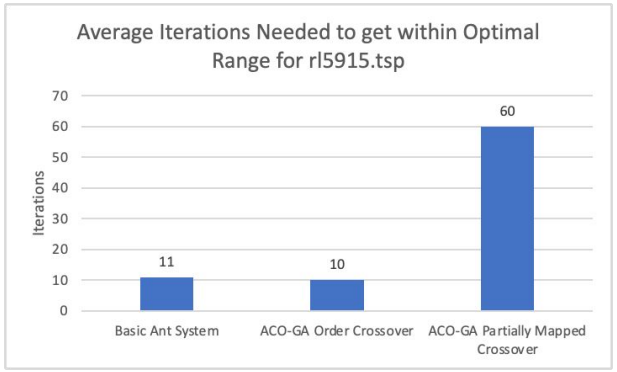



# Experiment 2: Iterations to Optimal Range



# Further Work

- Implementation of more selection types–vary number of selected ants or increase number of ants total
- Try new mutation implementations that could possibly return better results
- Test on more files–particularly larger files to see if trends continue

# Conclusion