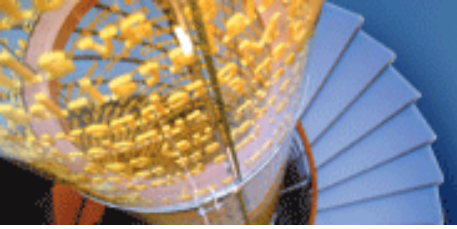


HALMSTAD UNIVERSITY

# A Merged Scheme of Two Evolutionary Algorithms for Spectrum Management in Mobile Ad Hoc Network (MANET)

**Mahboobeh Pasrapoor**

**and**

**Urban Bilstrup**

Halmstad University

Sweden

# Outline

- Motivation
- Problem Definition
- Background
- Population-based algorithms:
- ACO
- ICA
- Conclusion
- Future Work

# Motivation

**Two Main Requirements for Next Generation Tactical Network:**

- **A stable, network topology is essential to improve the networks' performance.**
- **An efficient channel assignment scheme is essential to maximize the spectrum efficiency.**

# Problem Definition

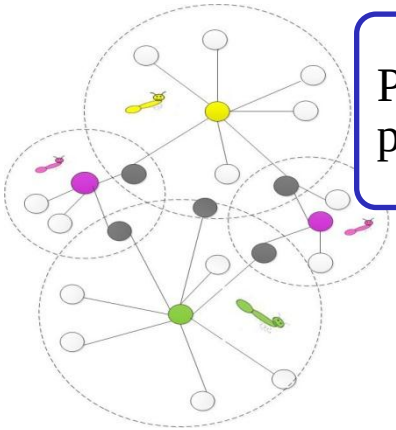
- Spectral efficiency is a fundamental problem in Next Generation Tactical Networks.
- Population-based algorithms can be applied to optimize the spectral efficiency and cluster formation
- The convergence characteristics and time complexity of the population-based algorithms for these problems are important factors.
- Assumptions:
  - There is a global knowledge about the available channels and the mobile nodes; thus the suggested algorithms are centralized algorithms.
  - During the cluster formation and channel assignment procedure, there is no change in the network topology

# Clustering with Ant Colony Optimization

The problem is represented as a graph and each potential solution is a complete path of graph.

To construct the solution, a probabilistic transition rule is used by each ant. The probabilistic transition rule is dependent upon two parameters: pheromone intensity and heuristic function.

Heuristic function is a problem dependent function to indicate the desirability of the node.



Pheromone intensity shows the desirability of path from the perspective of nodes.

Cost function is defined on the basis of the objective function

# Cluster Formation with ACO

The completed path is a sequence of nodes which are selected as the cluster heads and satisfy the constraints.

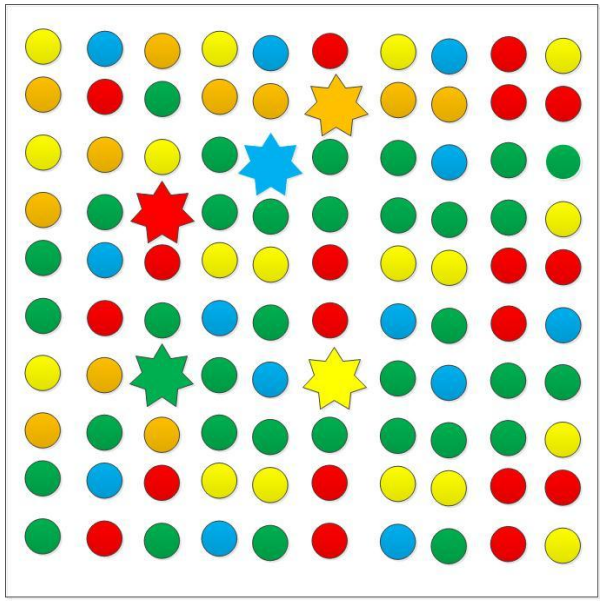
Ants construct the solution by incrementally choosing one node as a cluster head.

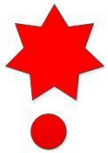
ACO_MDS selects the cluster heads in order to reduce the number of clusters, minimizing dominating set,

ACO_MSR forms a clustered topology finding a minimum dominating set while maximizing channel spatial reuse.

ACO_MSSR seeks a stable minimum dominating set that minimizes the potential inter-cluster interference.

# Imperialist Competitive Algorithm (ICA)





Imperialist

Country

The potential solutions are represented as countries.

Empires are formed and countries are classified as colonies and imperialists.

Evolutionary operators: assimilation, revolution and exchange are applied on resource part of each country.

# Grouping ICA (GICA)

Each country is divided into two parts: **Province and Resource**

Evolutionary operators: assimilation, revolution and exchange are applied on resource part of each country.

The element of province part is assigned according o the available elements of resource part .

$$\underbrace{f_2 f_3 f_1 f_3 f_1 f_2 f_1 f_1}_{Province(Clusterhead)} : \underbrace{f_3 f_1 f_2}_{Resourc(FrequecyChannel)}$$

# Channel Allocation – Single Objective Function

$$F_{SOF}(x) = \left(\left|\mathbf{x}_R\right| - f_l\right) + \sum_{k=1}^{\left|\mathbf{x}_R\right|} g(\mathbf{x}_R, f_k))$$

$$\underbrace{f_2 f_3 f_1 f_3 f_1 f_2 f_1 f_1}_{\text{Province}(Clusterhead)} : \underbrace{f_3 f_1 f_2}_{\text{Resourc}(FrequecyChannel)}$$

$$f_l = 3$$

$$F_{SOF}(x) = (3-3) + (4+2+2) = 8$$

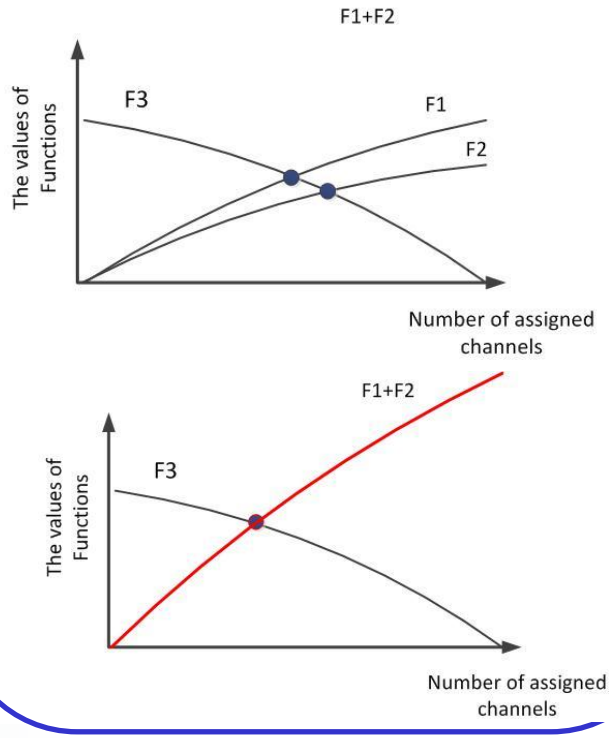
# Channel Allocation – Multi Objective Function

$$F_{MOF} = \exp(-abs(\sum_{k=1}^{3} w_k F_k))$$

$$\mathbf{F}_3(x) = \sum_{i=1}^{|x_P|} \frac{\mathbf{P}_i}{|x_P|} \times \hat{I}(x_{P(i)})$$

$$F_1(x) = \frac{(|\mathbf{x}_R| - f_l) + \sum_{k=1}^{|x_R|} g(|\mathbf{x}_R|, f_k))}{(|\mathbf{x}_P| \times f_u) + (|\mathbf{x}_R| - f_l)}$$

$$\mathbf{F}_2(\mathbf{x}) = \frac{\sum_{i=1}^{|x_P|} |I\, f \rightarrow i|}{|\mathbf{x}_P|^2}$$



# ACO_MDS – Multi Objective Function

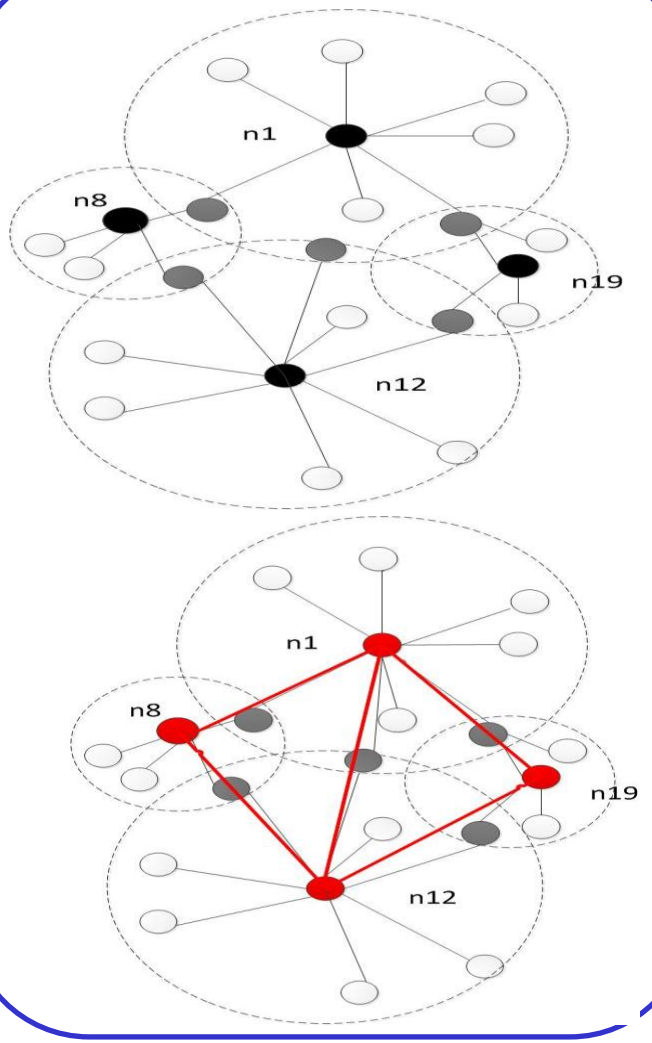
$$F_{ACO\_MSD}(\mathbf{x}^k) = \frac{\left|\mathbf{x}^k\right|}{(\left|V'\right| + n_{cc})}$$

$$\mathbf{x}^k = [n_1, n_8, n_{12}, n_{19}]$$

$$\left|V'\right| = 21$$

$$n_{cc} = 4$$

$$F_{ACO\_MSD}(\mathbf{x}^k) = \frac{4}{25}$$



# ACO_MSR and ACO_MSSR – Multi Objective Function

$$F_{ACO\_MSR}(\mathbf{x}^k) = w_1 F_1(\mathbf{x}^k) + w_2 F_2(\mathbf{x}^k)$$

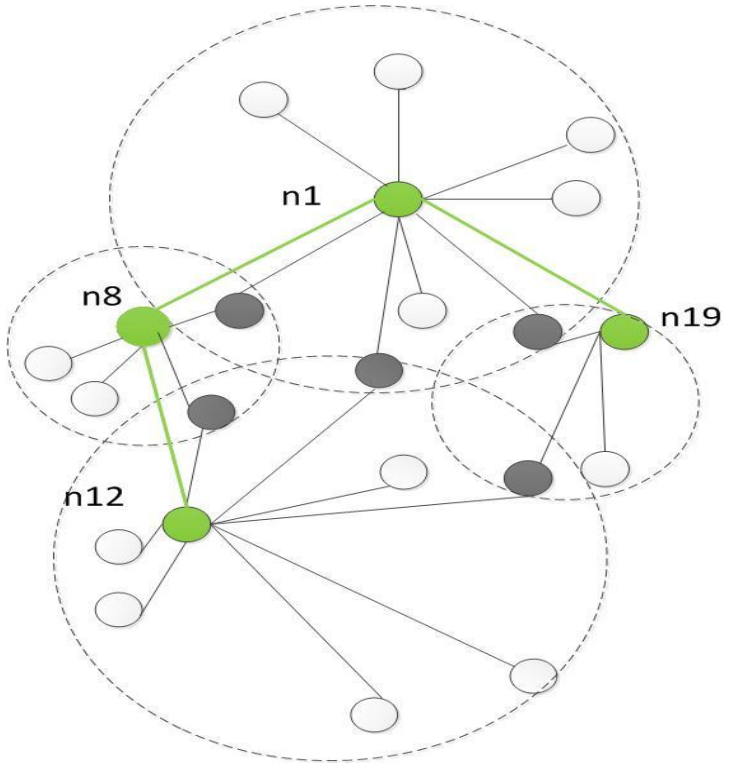
$$F_1(\mathbf{x}^k) = \left(1 / \left|\mathbf{x}^k\right|^2\right) \times \sum_{i=1}^{\left|\mathbf{x}^k\right|} \left| I_{CH_i} \right|$$

$$CH_1 = n_1$$

$$I_{CH_1} = \{n_8, n_{19}\}$$

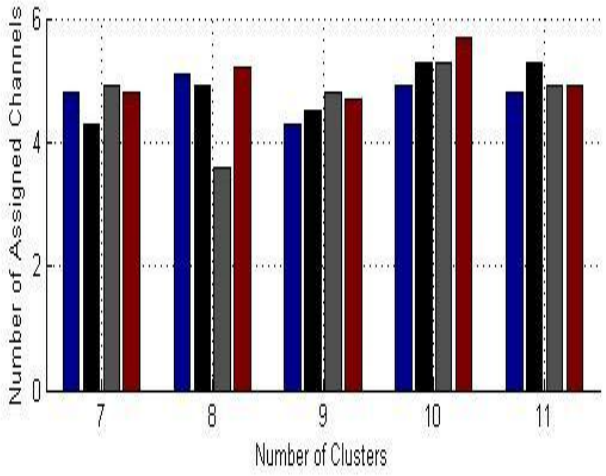
$$F_2(\mathbf{x}^k) = \left|\mathbf{x}^k\right| / \left|V'\right|$$

$$F_2(\mathbf{x}^k) = 4/21$$

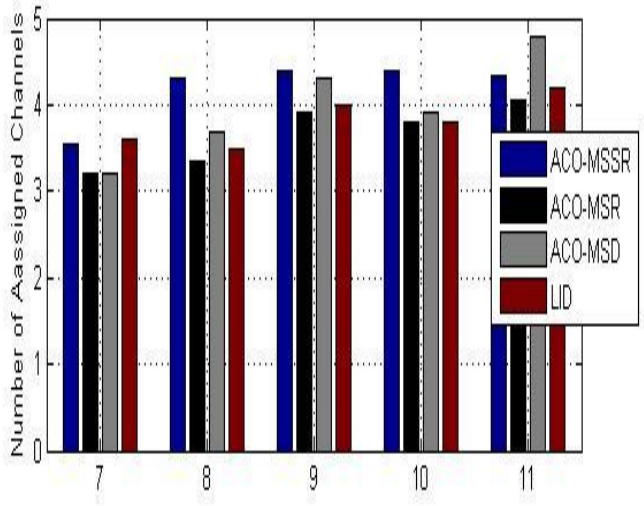


# Merging of ACO and ICA for Resource Management

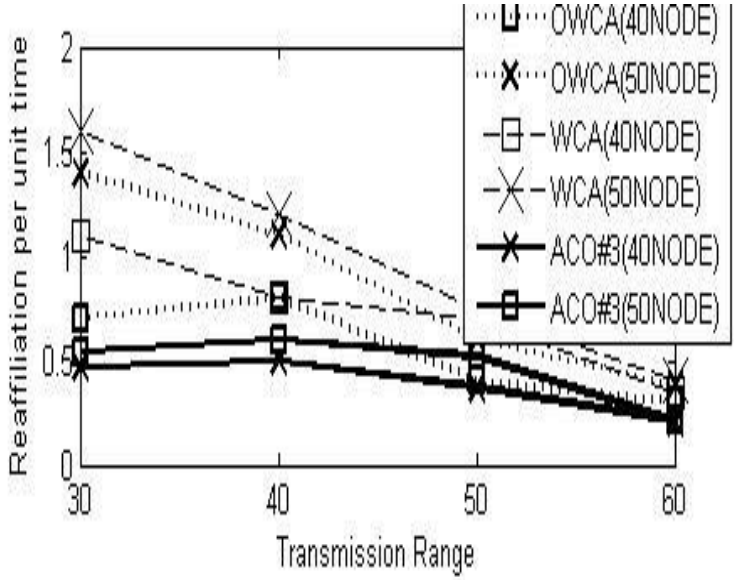
The number of assigned channels to different clustering algorithms

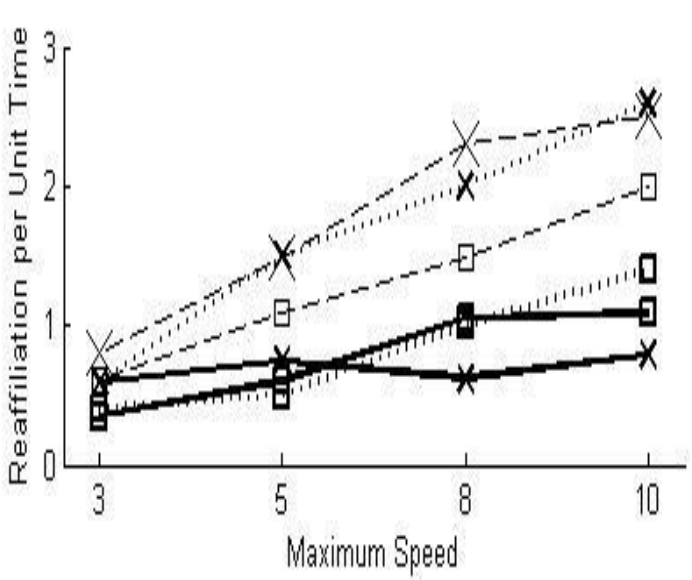



The average inter-cluster interference



# Comparison of stability



# Conclusion

The characteristics of the merged methods for spectrum management are:

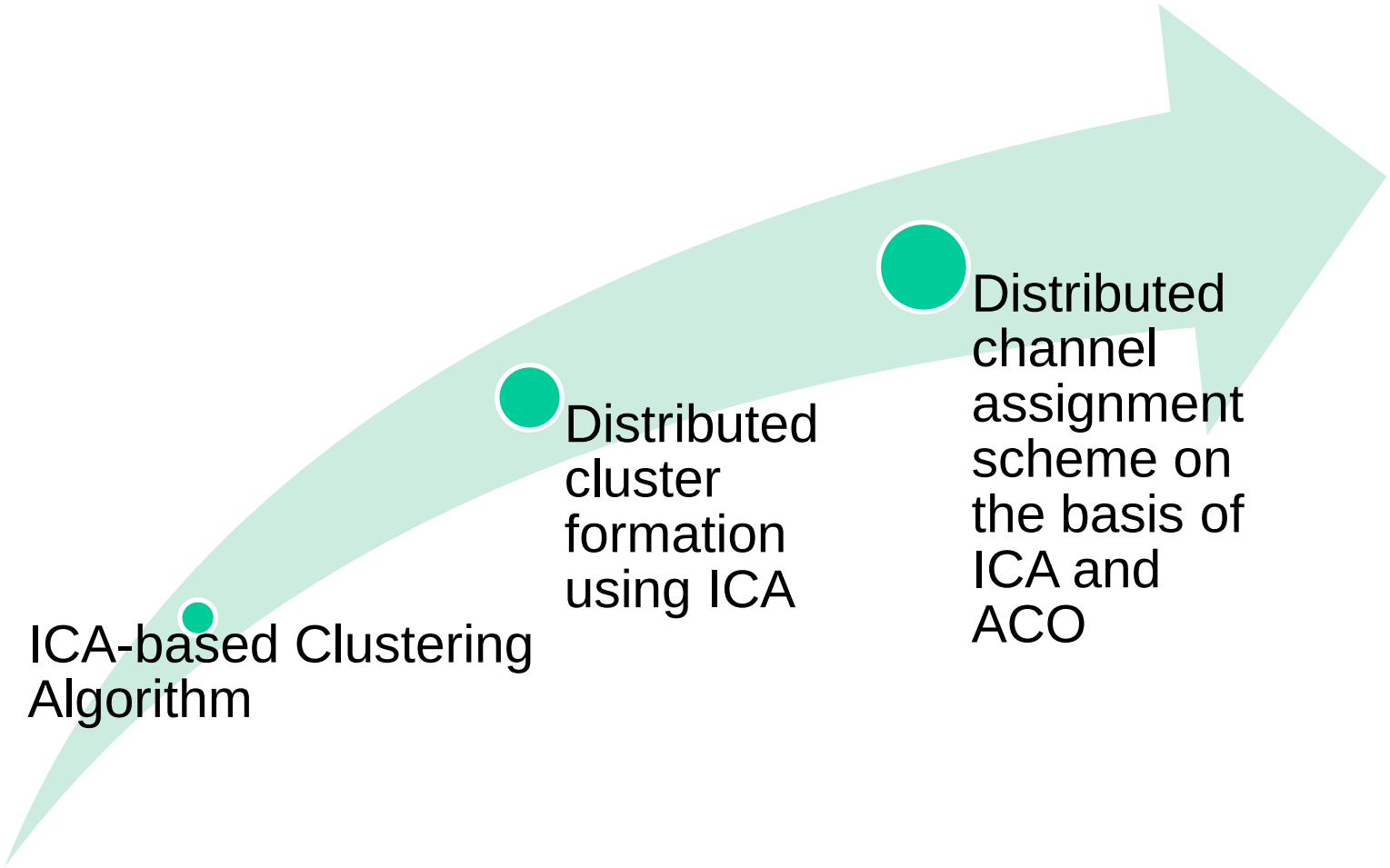
- Improvement of spectrum efficiency
- Minimizing the average level of inter-cluster interference inside the network.
- Different multi-objective functions are investigated to solve the underlying multi-objective optimization problems of spectrum management.

# Conclusion

The features of ACO-based clustering algorithm are:

- ACO_MDS: reduce the number of clusters, minimizing dominating set.
- ACO_MSR and ACO_MSSR: are scalable and stable clustered network structure, also contribute in forming interference aware clusters.

# Future Work


ICA-based Clustering Algorithm
Distributed cluster formation using ICA
Distributed channel assignment scheme on the basis of ICA and ACO

*Questions ?*

*Thank You!*