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Nature Inspired Business Algorithms

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Nature Inspired Business Algorithms

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Points to be Discussed

- Formal Definition
- Process Involve in Digital Business
- Domains of Digital Business
- Nature Inspired Algorithm
- Ant Colony Optimization
- Frog Inspired Algorithms
- Crocodile Predatory Strategy

Definition

- The term “Digital Business” is used in a context of digital transformation, disruptive technologies, business optimization and integration/ convergence.
- It’s also associated with digital marketing transformation and social business.
- It involves a new ways to connect, collaborate, conduct business and build bridges between people, it touches the core of all business functions and even the ways organizations are managed.
- Digital technologies have also challenged existing business models and continue to do so.

Various Domains of Digital Business

Cloud Computing

- Advanced System Architecture
- Adaptive Security Architecture
- Cyber Security and Digital risks
- Business process outsourcing
- Reengineering
- Mobile Computing

Information of Thing

- Mesh App and Service Architecture
- Information Management and Strategy

Data Engineering

- Data, information, content and knowledge
- Business Data Integration
- Big Data Analytics and management
- Customer Experience Management (CEM)

Algorithmic Business

- Advanced Machine Learning
- Autonomous Agents and Things
- Deep learning
- Nature Inspired Algorithms

Google Algorithm History

- Each year, Google changes its search algorithm around 500–600 times. While most of these changes are minor, Google occasionally rolls out a "major" algorithmic update (such as Google Panda and Google Penguin, Google Pigeon and Hummingbird) that affects search results in significant ways.
- For search marketers, knowing the dates of these Google updates can help explain changes in rankings and organic website traffic and ultimately improve search engine optimization. Below, is the list of the major algorithmic changes that have had the biggest impact on search.
- https://moz.com/google-algorithm-change
- http://www.itworldcanada.com/article/what-does-algorithmic-business-really-mean-anyway/384310

Neil Patel

http://neilpatel.com/blog/the-ultimate-google-algorithm-cheat-sheet/

Justification

Gartner has predicted that "Digital Business" will dominate the computing and business arena for the next 10 years rather than simply Data Mining or Business Intelligence.

One may go through the following web pages to have a first hand information

- http://www.gartner.com/smarterwithgartner/five-keys-to-understanding-algorithmic-business/
- http://www.gartner.com/smarterwithgartner/the-arrival-of-algorithmic-business/
- http://www.gartner.com/technology/research/algorithm-economy/
- http://memeburn.com/2015/09/the-future-of-business-algorithmic-and-platform-defined-gartner/

Process involved in Digital Business

- Business Process Understanding
- Technology Adaption and Digital Transformation
- Modeling the Random nature of Business Operations
- Modeling Ambiguity and Uncertainty in Business
- Developing Business Algorithms
- Social Side of Digital Business

Nature Inspired Algorithms

- In nature, various living beings like ant, fish, frogs, crocodiles, lions etc., follow various strategies while hunting the prey, whose size is comparatively big with respect to their size.

- Real world is full of complex problems which can not be solved optimally but near optimal solutions to the problem can be generated (some times).

- In today's complex business scenario, strategies inspired from nature can be applied for competitive advantages.

Nature Inspired Algorithms

- The nature optimizes the following in a seamless manner.

  - Explore
  - Exploit
  - Enjoy
  - Encounter

Nature Inspired Business Algorithms

- Fish School Search Algorithm
- Ant Colony Optimization
- Frog Inspired Algorithm
- Bee Colony Algorithm
- Particle Swarm Optimization
- Cuckoo Search Algorithm
- Cat Swarm Optimization
- Bat Intelligence Algorithm
- Bacteria Foraging Optimization
- Coral Reef Optimization
- Genetic algorithms
- Crocodile Predatory Strategy

ANT COLONY OPTIMIZATION (ACO)

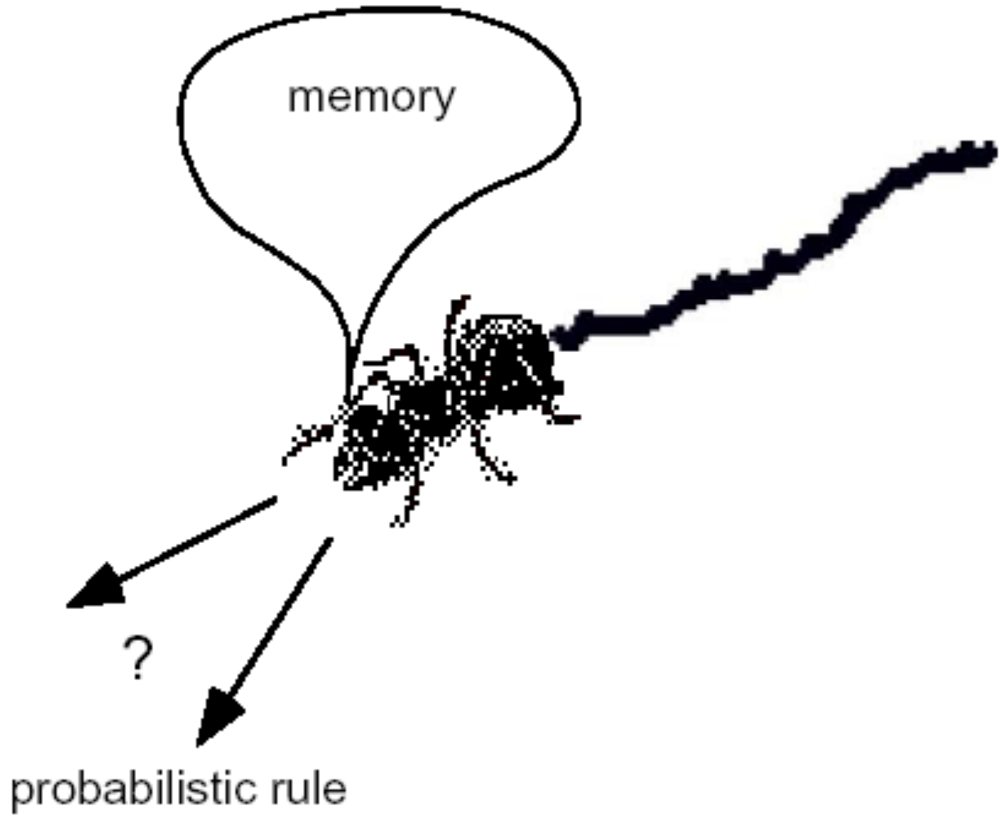
- ACO is a meta-heuristic population-based optimization technique inspired by biological systems.

- Proposed by Marco Dorigo, the research director for the Belgian Funds for Scientific Research and a co-director of IRIDIA, the artificial intelligence lab of the Université Libre de Bruxelles. in early 90s in his PhD dissertation.

- Uses multi-agent approach for solving difficult combinatorial optimization problems, based on: How ants are able to find shortest route between their nest and source of food?

- **Answer is Stigmergy:** a mechanism of indirect coordination between agents or actions

Choosing the path at each step



Natural behavior of ants

- Ants can explore vast areas without global view of the ground.
- Ants find the food and bring it back to the nest.
- Ants find shortest routes between food and nest and converge.

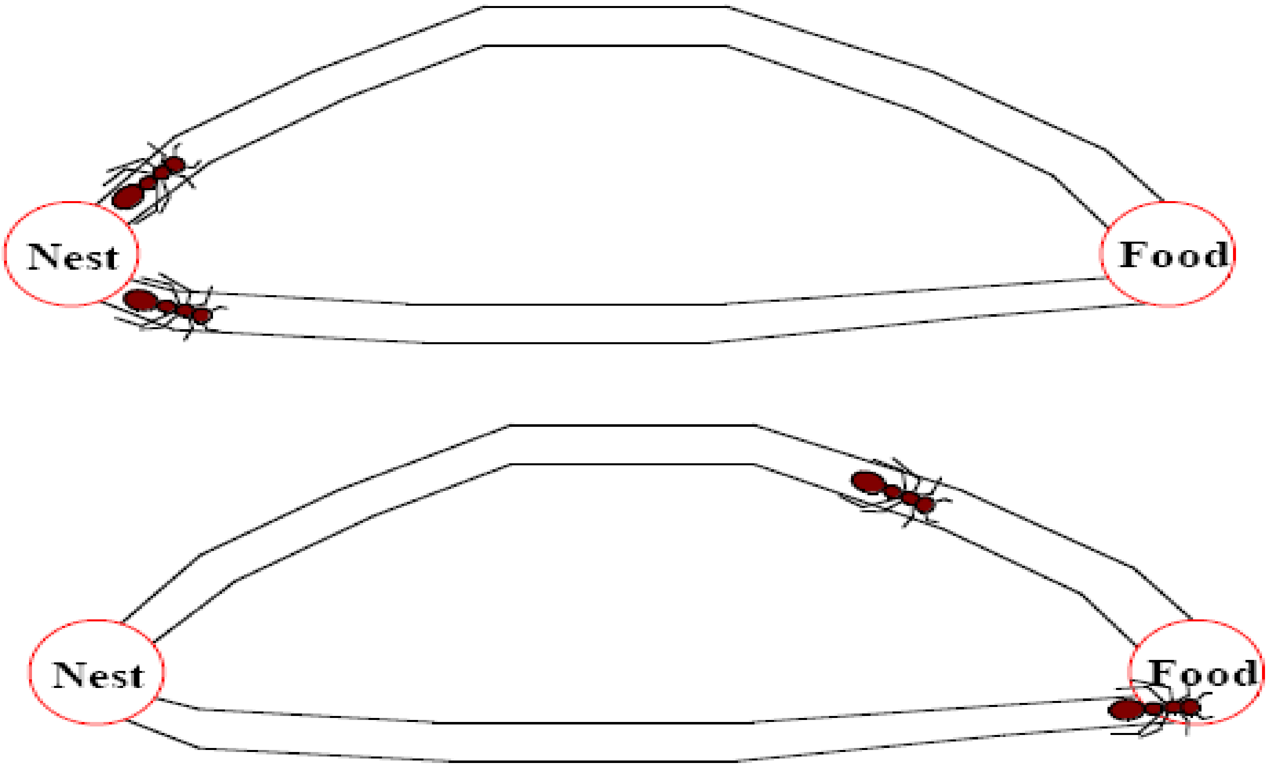
How can they manage such great tasks ?

Answer: They lay *pheromones* on ground that form a trail that attracts other ants.

Natural behavior of ants

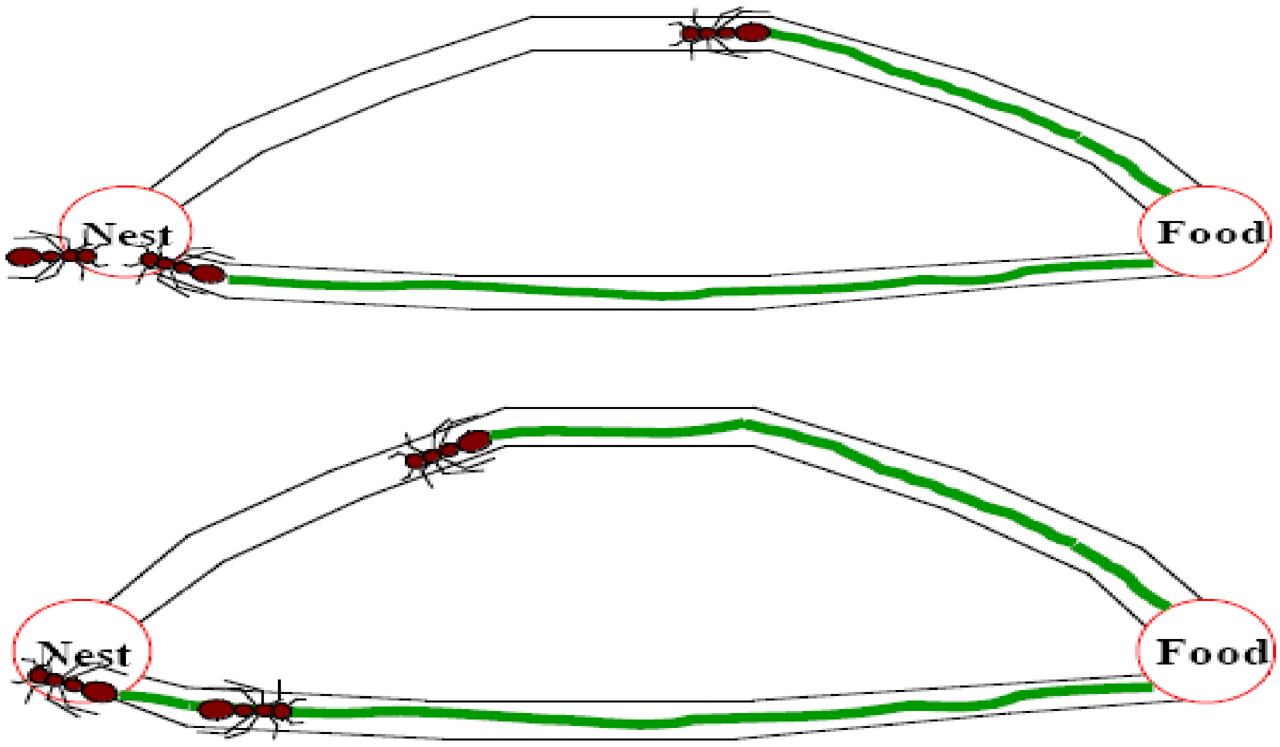
- If an ant decides to follow the pheromone trail with some probability, it itself lays more pheromone, thus reinforcing the trail.
- The more ants follow the trail, the stronger the pheromone, the more likely ants are to follow it.
- Pheromone builds up on shorter path faster since it does not have much time to decay, so ants start to follow it.
- Shorter paths serve as the way to food for most of the other ants.

Ant foraging: Co-operative search for food by pheromone trails



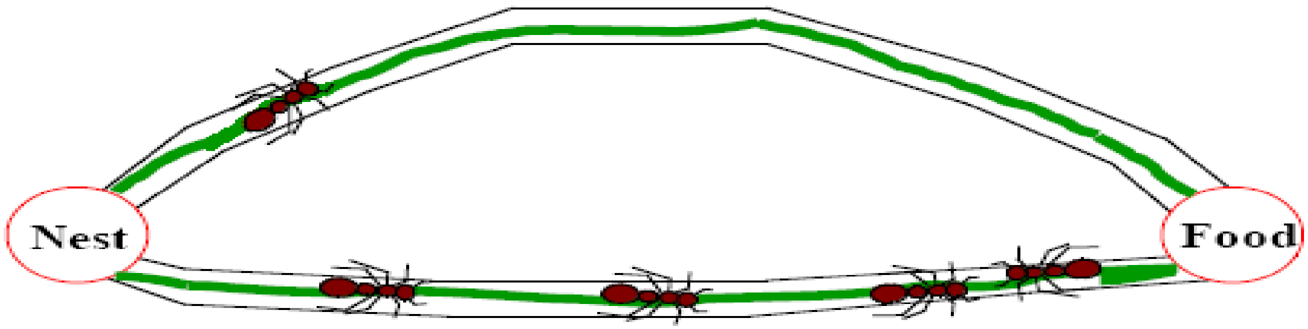
- Initially the pheromone deposits will be the same for the right and left directions.

Ant foraging – Co-operative search for food by pheromone trails

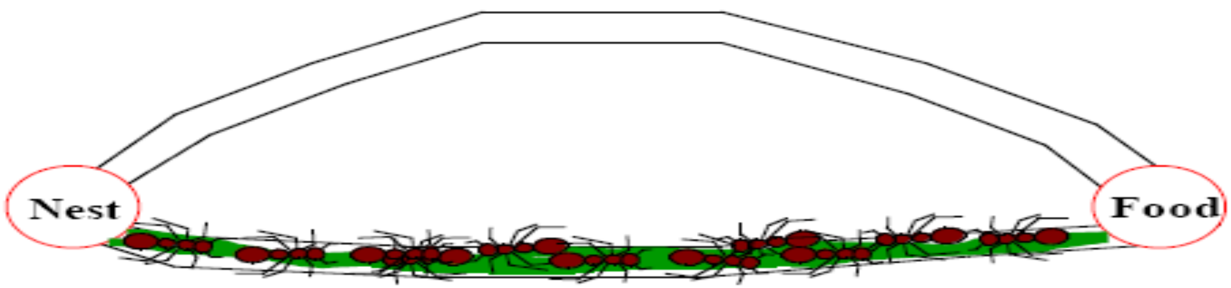


When the ants in the shorter direction find a food source, they carry the food and start returning back, following their pheromone trails, and still depositing more pheromone.

Ant foraging – Co-operative search for food by pheromone trails



New ants that later starts out from the nest to find food will also choose the shortest path.



Over time, this positive feedback (autocatalytic) process prompts all ants to choose the shorter path.

ACO algorithm

- Ant Colony Algorithms are typically use to solve minimum cost problems.
- The process starts by generating m random ants (solution).
- An ant k (k=1,2,⋯,m) represents a solution string, with a selected value for each variable.
- An ant is evaluated according to an objective function.
- Accordingly, pheromone concentration associated with each possible route (variable value) is changed in a way to reinforce good solutions.
- There are two working modes for the ants:
  - either forwards or backwards
- The ants memory allows them to retrace the path it has followed while searching for the destination node.
- Before moving backward on their memorized path, the ants leave pheromones on the arcs they traversed.

ACO algorithm

- Initialization:
  - Construct ant solutions
  - Define attractiveness τ, based on experience from previous solutions
  - Define specific visibility function, η, for a given problem (e.g. distance)

- Ant Walk:
  - Initialize ants and nodes (states)
  - Choose next edge probabilistically according to the attractiveness and visibility

ACO algorithm

- An ant will move from one node to other node with probability (pseudorandom proportional rule):

$$\text{Prob}(\textit{choose available edge e}) = \frac{\tau(\text{e}) * \eta(\text{e})}{\sum_{\text{available edges e'}} \tau(e') * \eta(\text{e'})}$$

where

τ(e) is the amount of pheromone on edge e

η(e) is the distance cost of edge e

- Each ant maintains a list of infeasible transitions for that iteration

ACO algorithm

- Update attractiveness of an edge according to the number of ants that pass through.
- Pheromone Update:

$$\tau(e') = \begin{cases} (1-\rho)*\tau(e), & \text{if edge is not traversed} \\ (1-\rho)*\tau(e) + \text{new pheromone}, & \text{if edge is traversed} \end{cases}$$

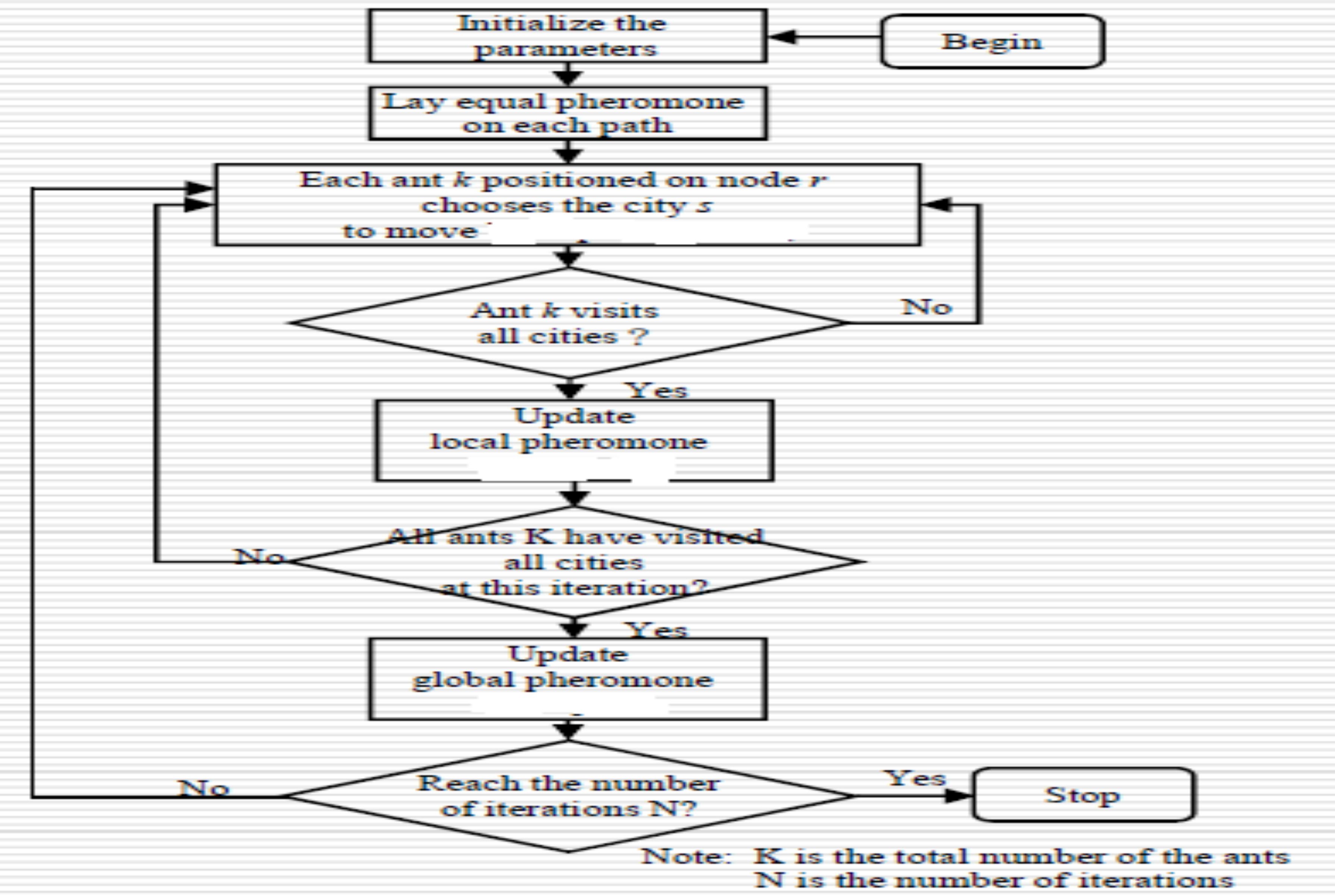
- Parameter $0 \leq \rho \leq 1$ is called evaporation rate.
- Pheromones = long-term memory of an ant colony
- "new pheromone" or **Δτ** usually contains the base attractiveness constant **Q** and a factor that you want to optimize (Q/ Length of tour).

Note: Rules are probabilistic, so mistakes can be made!

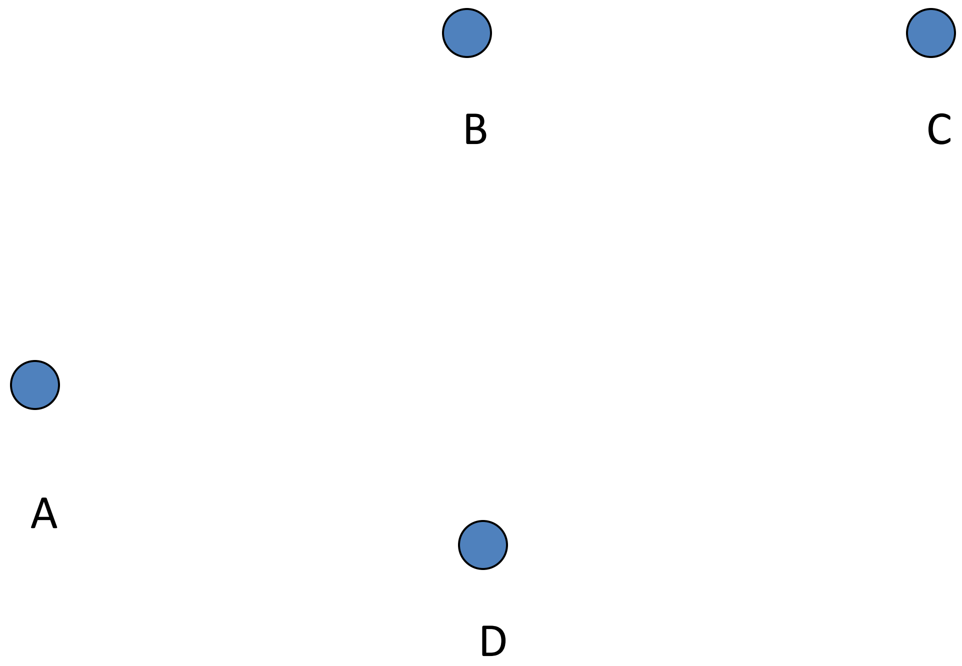
ACO Pseudo Code

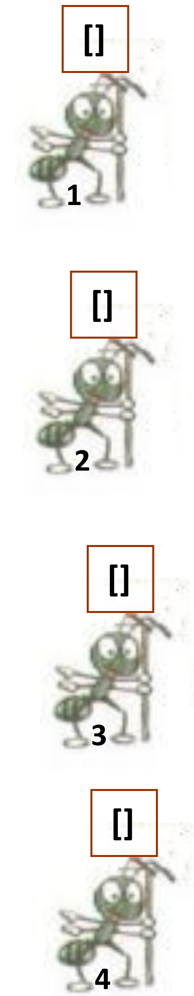
```
Initialize the base attractiveness, τ, and visibility, η, for each edge;
        for i < IterationMax do:
            for each ant do:
            Choose probabilistically (based on previous equation) the
               next state to move into;
                 Add that move to the tabu list for each Ant;
                  Repeat until each Ant completed a solution;
        end;
For each ant that completed a solution do:
     update attractiveness τ for each edge that the ant traversed;
   end;
    if (local best solution better than global solution)
     save local best solution as global solution;
        end;
    end;
```

Steps for Solving TSP Problem by ACO



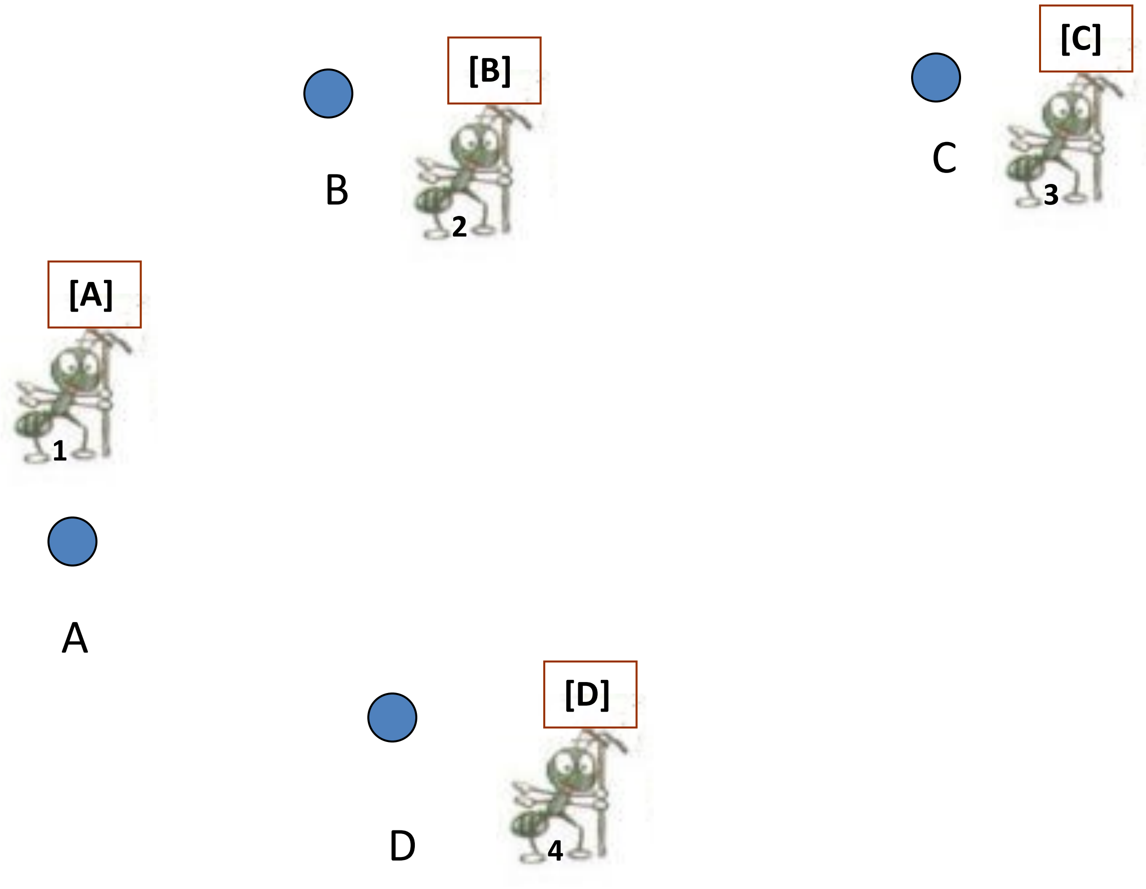
A simple TSP example





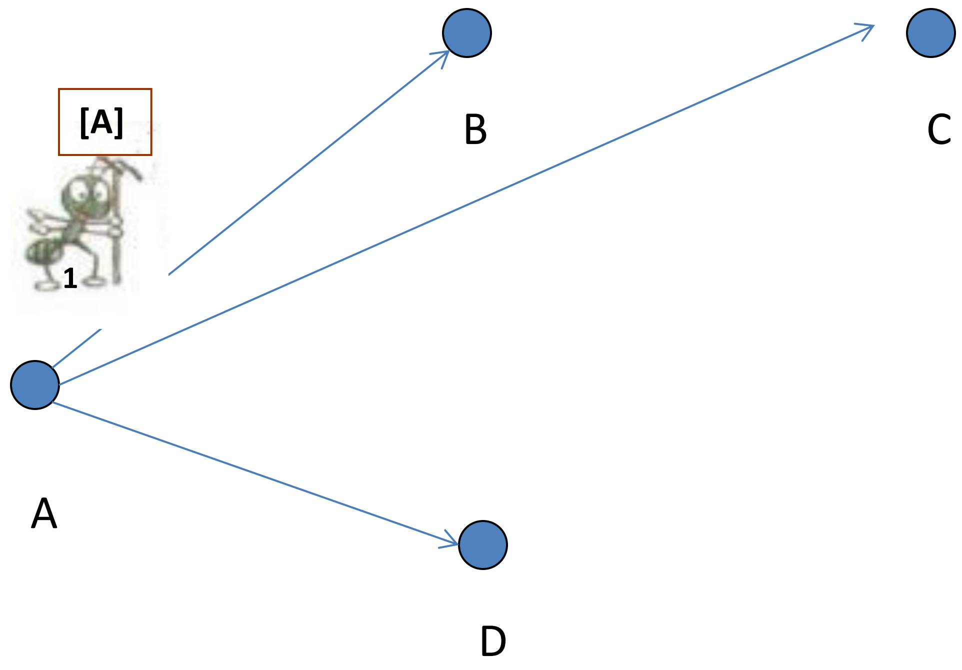
d_{AB} =8;d_{BC} = 4;d_{CD} =15;d_{DA} =6

Iteration 1



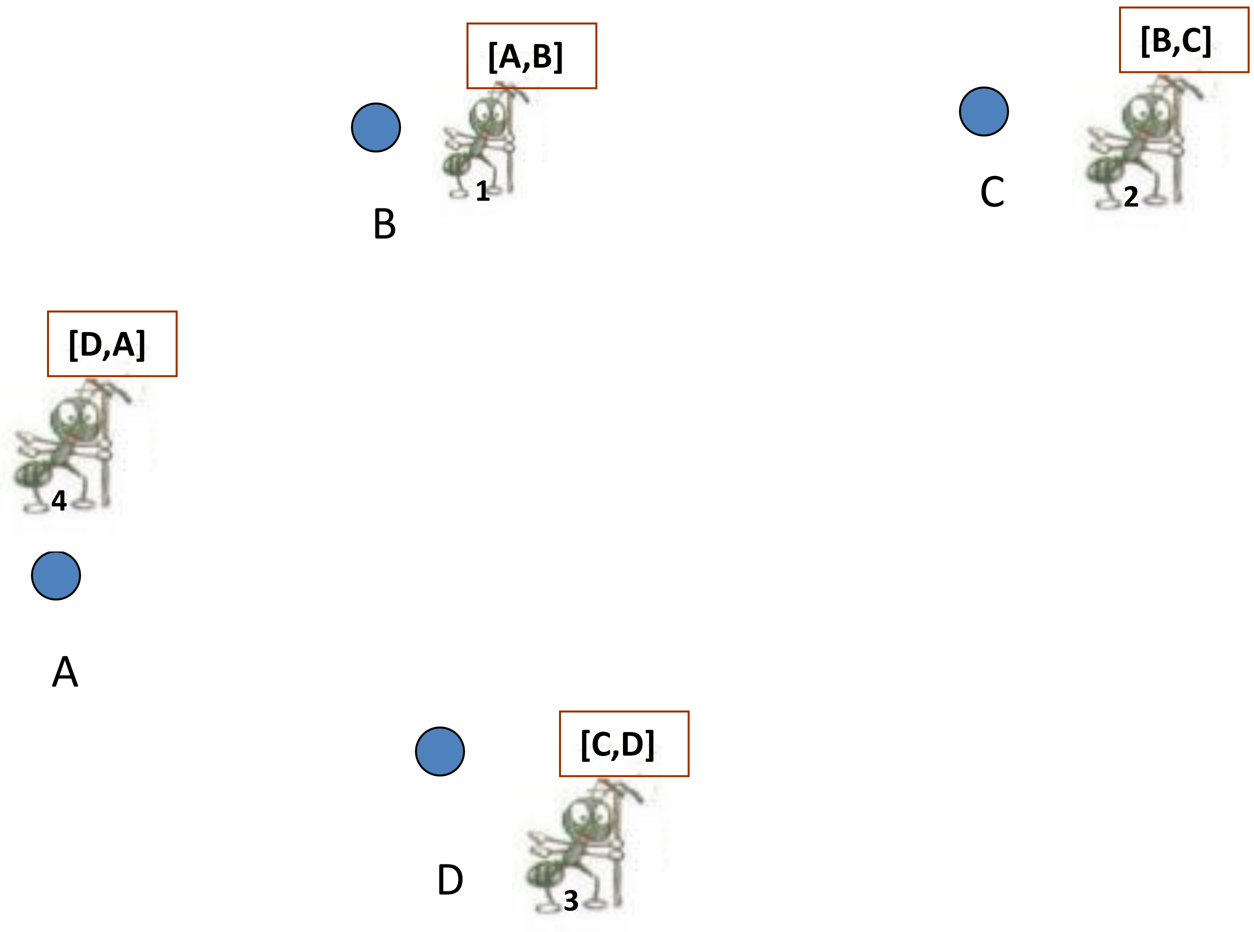
$d_{AB} = 8; d_{BC} = 4; d_{CD} = 15; d_{DA} = 6$

How to build next sub-solution?



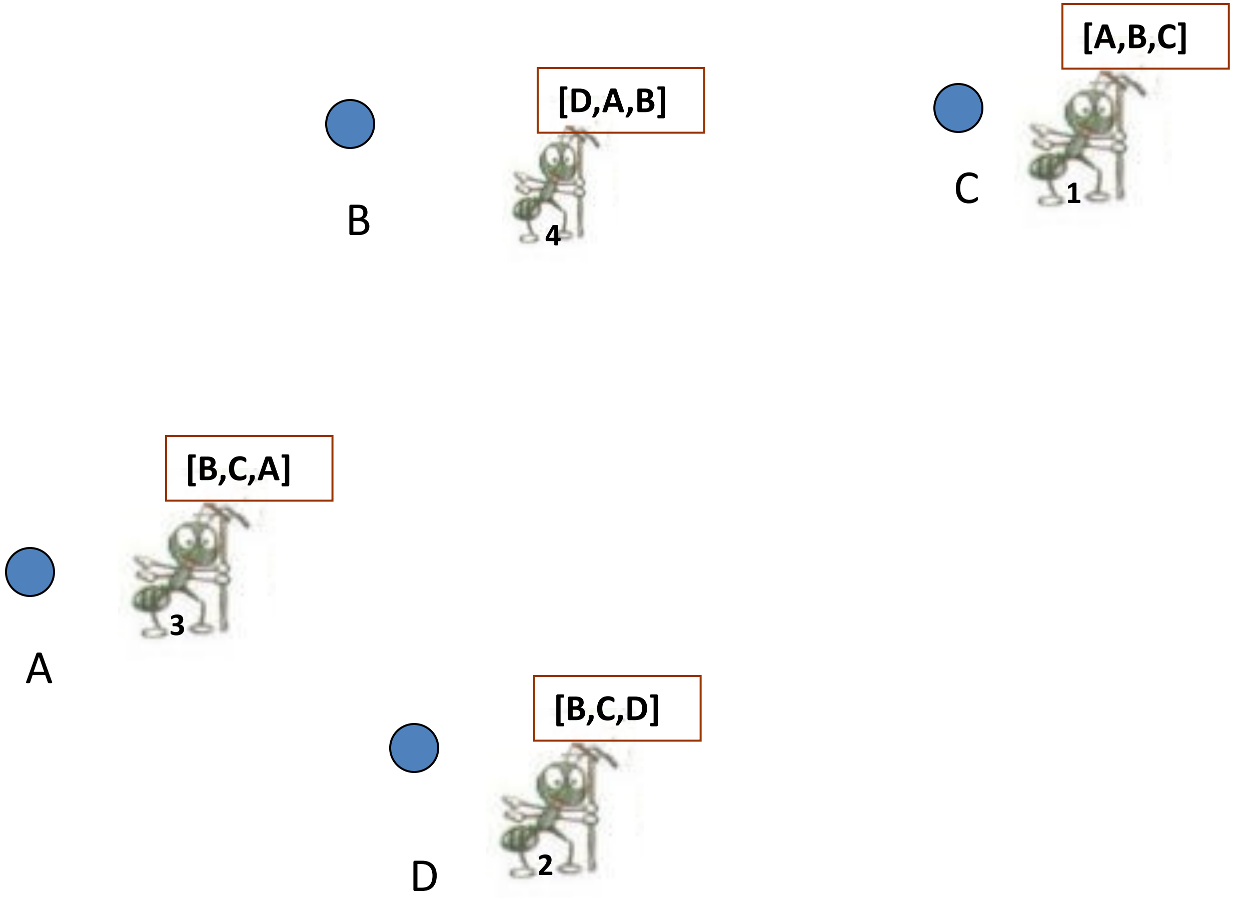
$d_{AB}=8; d_{BC}=4; d_{CD}=15; d_{DA}=6$

Iteration 2



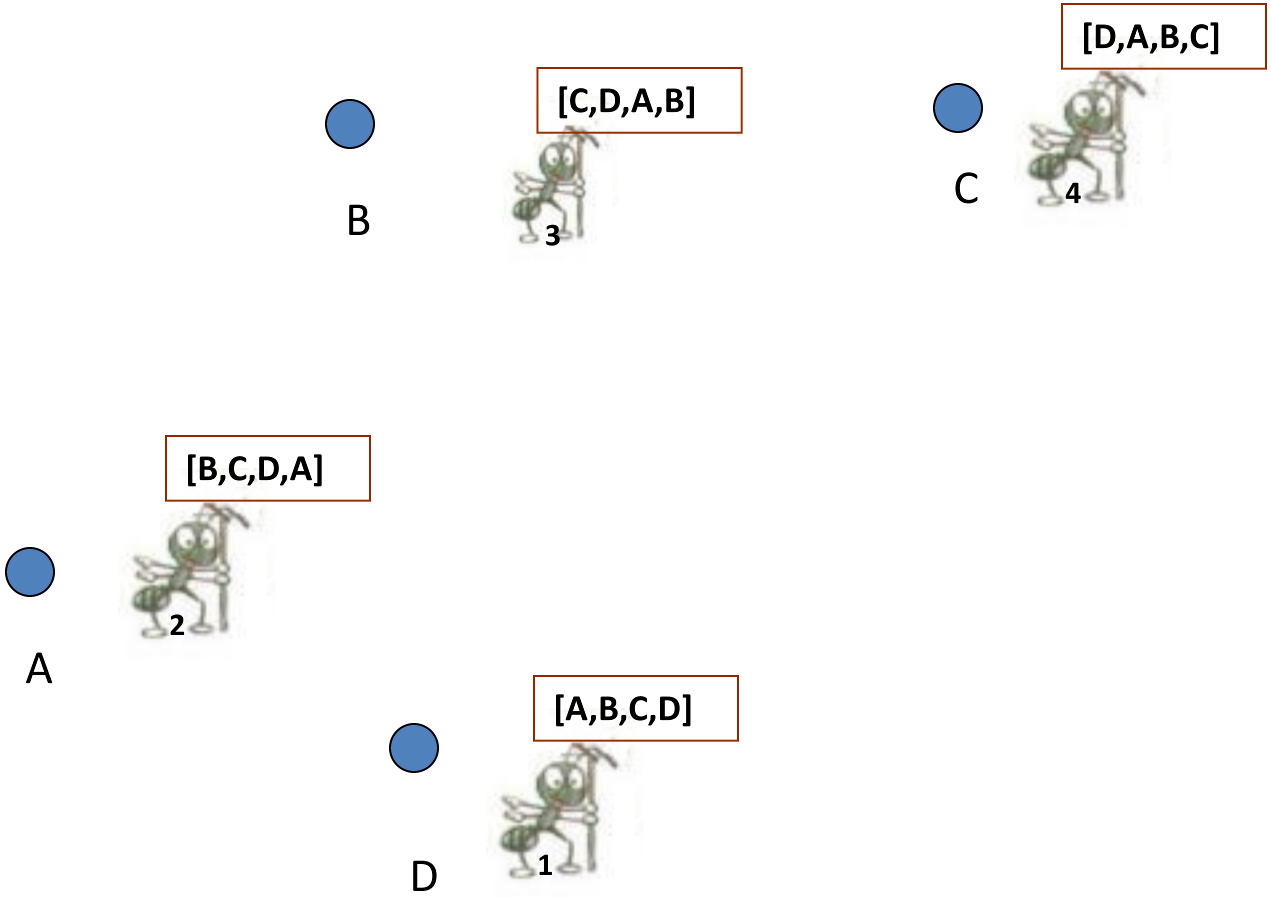
$d_{AB} = 8; d_{BC} = 4; d_{CD} = 15; d_{DA} = 6$

Iteration 3



$d_{AB} = 8; d_{BC} = 4; d_{CD} = 15; d_{DA} = 6$

Iteration 4



$$d_{AB} = 8; d_{BC} = 4; d_{CD} = 15; d_{DA} = 6$$

Path and Pheromone Evaluation

[A,B,C,D

L_1 =27

[B,C,D,A]

L_2 =25

[C,D,A,B]

L_3 =29

[D,A,B,C]

L_4 =18 → **Best tour**

$d_{AB}=8; d_{BC}=4; d_{CD}=15; d_{DA}=6$

End of First Run

Save Best Tour (Sequence and length)

Evaporate Pheromone

New ants start

ACO Characteristics

- Exploit a positive feedback mechanism.
- Demonstrate a distributed computational architecture.
- Exploit a global data structure that changes dynamically as each ant transverses the route.
- Involves probabilistic transitions among states or rather between nodes.

Advantages

- Inherent parallelism
- Positive Feedback accounts for rapid discovery of good solutions
- Efficient for Traveling Salesman Problem and similar problems
- Can be used in dynamic applications (adapts to changes such as new distances, etc.)

Disadvantages

- Theoretical analysis is difficult
- Sequences of random decisions (not independent)
- Probability distribution changes by iteration
- Time to convergence uncertain (but convergence is guaranteed!

Applications

- Traveling Salesman Problem
- Quadratic Assignment Problem
- Network Model Problem
- Vehicle routing
- Graph coloring

Summary

- ACO is a recently proposed metaheuristic approach for solving hard combinatorial optimization problems(NP HARD Problems).
- Artificial ants implement a randomized construction heuristic which makes probabilistic decisions.
- The accumulated search experience is taken into account by the adaptation of the pheromone trail.
- ACO Shows great performance with the "ill-structured" problems like network routing.
- In ACO local search is extremely important to obtain good results.

Frog Inspired Algorithms

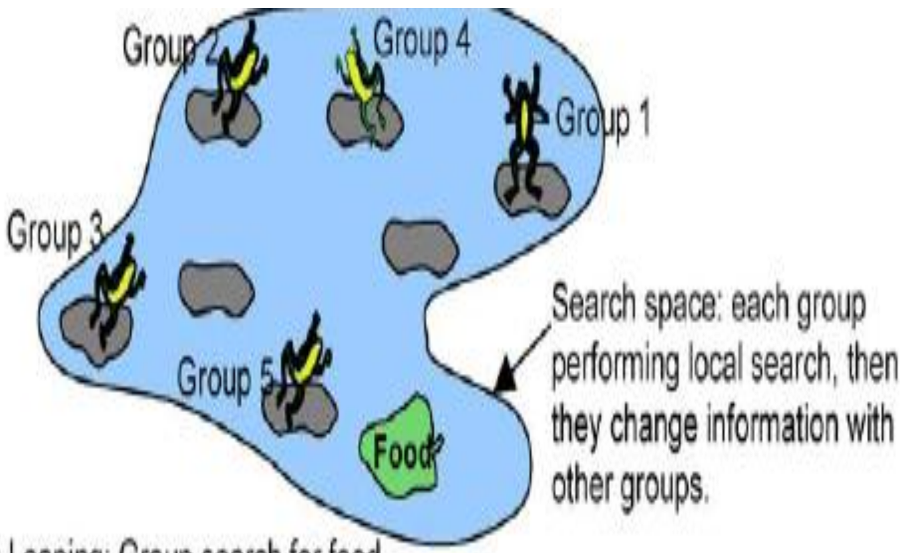
- Shuffled Frog Leaping Algorithm
- Frog Calling Algorithm

Shuffled Frog Leaping Algorithm

- Frog Inspired Algorithms are evolutionary meta-heuristic stochastic search methods that depends on social behavior of species i.e frog.
- Developed by **Muzaffar M Eusuff** and **Kevin E. Lansey** from **University of Arizona** in 2000.
- It is a population based meta-heuristic algorithm that seek for global optimal solution.

Meme: It is an idea, behavior or style that spreads from individual to individual within a culture or community.

Memeplex: Groups of memes that are found present in same individual.



Shuffled Frog Leaping: Group search for food

Shuffled Frog Leaping Algorithm

Steps:

1. An initial population of 'P' frogs is chosen randomly.
2. For S−dimensional problems, each individual frog 'i' is represented in S variables.

   $$Xi = (xi1, xi2, \ldots, xis).$$

3. Then, the frogs are sorted in descending order as per their fitness.
4. The entire population is divided into 'm' memeplexes each containing 'n' frogs i.e (P=m∗n).
5. First frog goes to 1^{st} memeplex, the 2^{nd} frog to 2^{nd} memeplex, and so on.

$$\text{Change in frog position } (D_i) = rand() \cdot (X_b - X_w) \quad (1)$$

$$\text{New position } X_w = \text{current position } X_w + D_i; \quad (D_{max} \geq D_i \geq -D_{max}) \quad (2)$$

Whereas,

Xb =best fitness

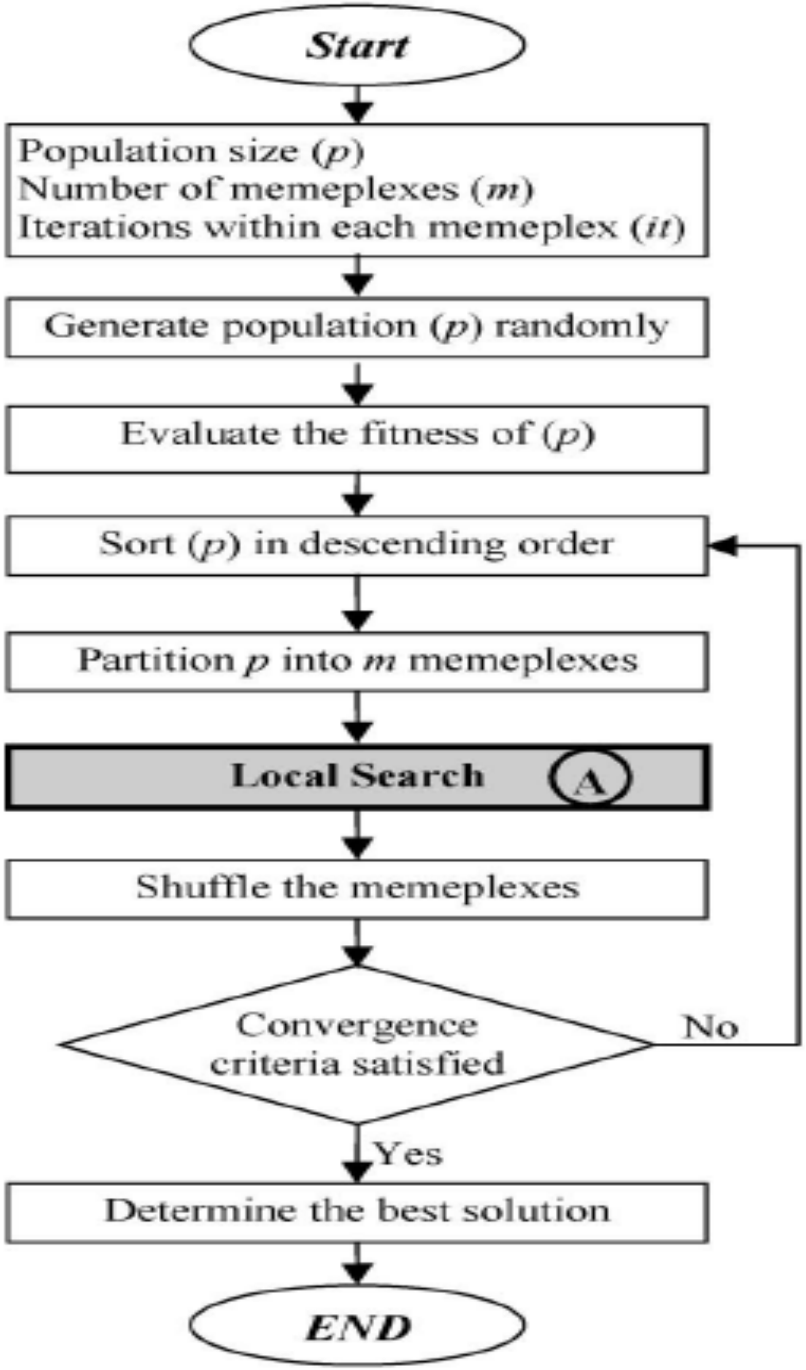
Xw = Worst fitness

Xg = global best fitness

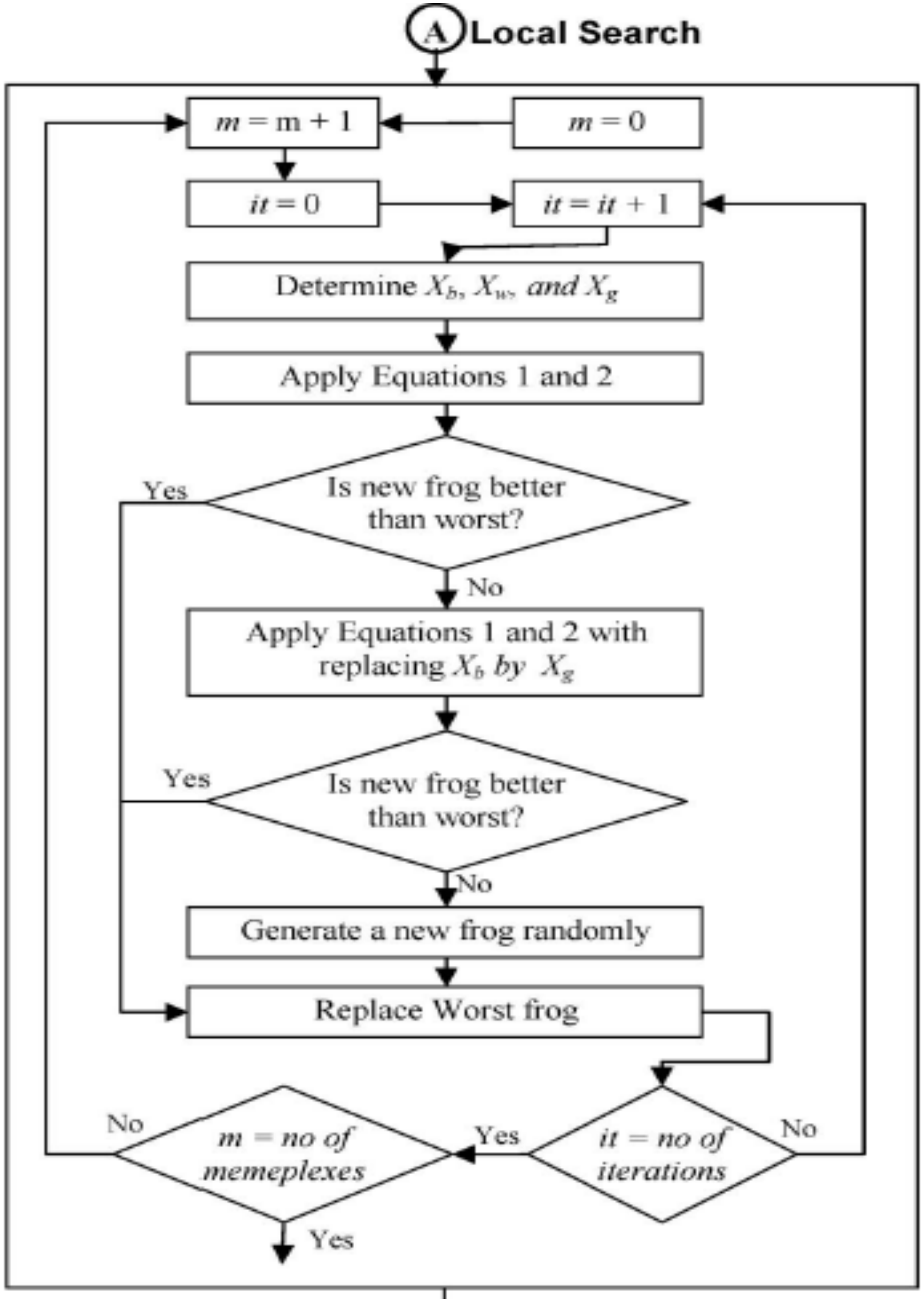
Rand() = random number b/w 0 & 1

Dmax = max. Allowed change in frog position.

Shuffled Frog Leaping Algorithm



Shuffled Frog Leaping Algorithm



Frog Calling Algorithm

Proposed by *Mutazono*, A., Sugano, M., Murata, M in 2012.
They proposed 3 factors for this algorithms:

Factor 1 : Territory

A frog would check, if there is any calling frog in its own territory/ range, then it will ensure whether the number is within acceptable range. Once it is done, then it will decide to produce calls.

Factor 2 : Number of Competing frogs

If the probability for the frog to win is high, then it will begin to call.

Factor 3 : Body Size

Once the weak calling frog detects its current condition, it will adopt sleep strategy to avoid competition.

Application: Demand and Supply Chain Management for Milk Union

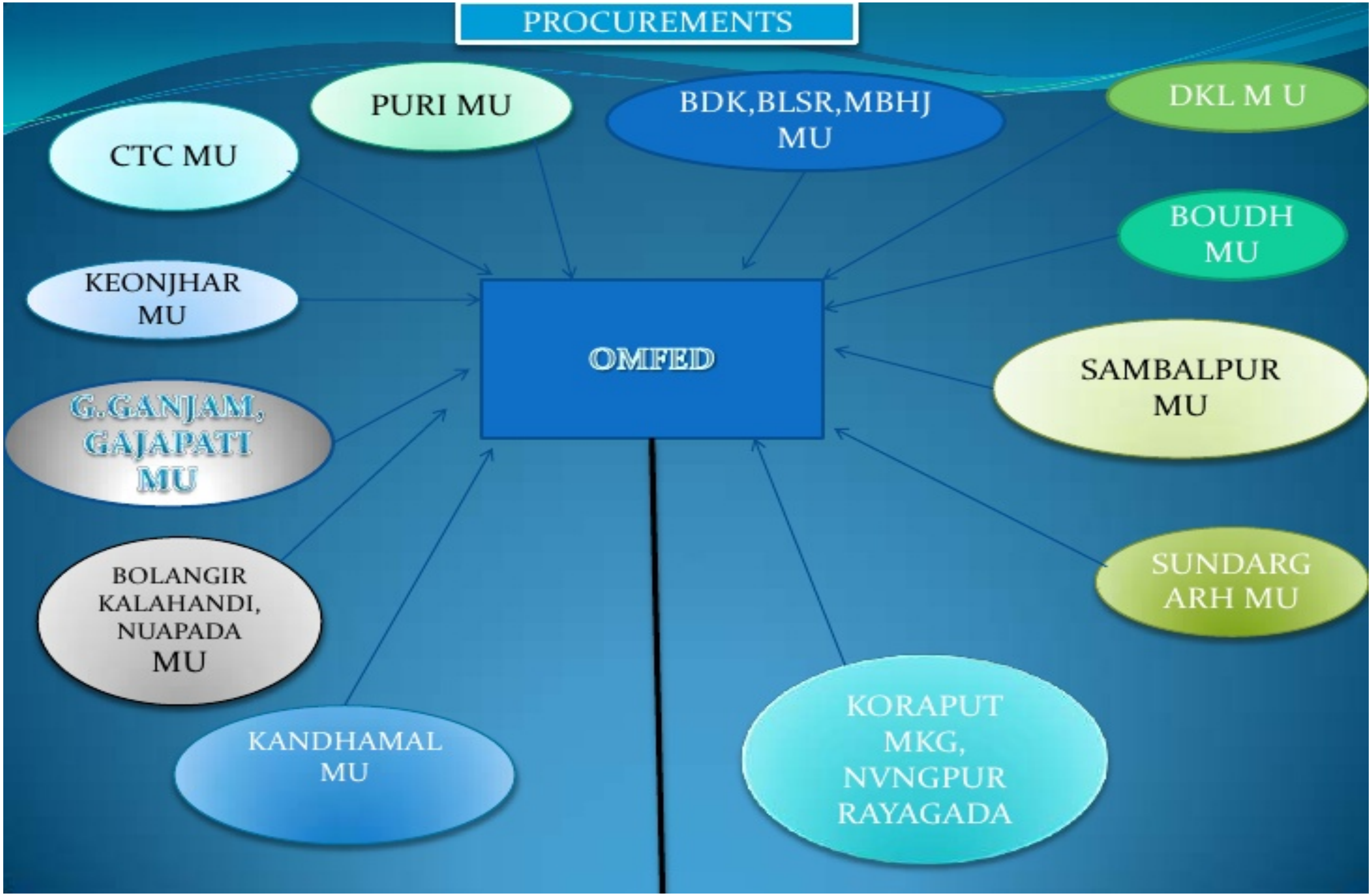
- Profit maximization in diary industry is a constraint-based complex problem. The following challenges make the supply chain of diary industry more complex:

1. Market price is determined by the government (unlike market driven)
2. Demand varies w.r.t the festivals/ marriage time i.e. handling uncertainty in market place.
3. Purchase price is also fixed by the government

Demand and Supply Chain Management for Milk Union

- Profit maximization in diary industry is a constraint-based complex problem.
- The following challenges make the supply chain of diary industry more complex:
- During festivals or marriage seasons demand for milk and milk products reach its peak.
- During peak demand times, deciding what other demands should be dropped is a challenge.
- Optimal distribution plan must be searched for, while considering peak demand regions, distribution networks to peak demand regions and various costs involved in the distribution process such as distribution network costs, cost of holding stocks and resources, and finally expiry date of both commodity and end-products.

OMFED Collection Network



Source: Suvadarshini, A. , & Roy, G. P. (2014). Supply Chain Management in OMFED-Creating Values through White Channels: A Case Study. *Journal of Business and Management Sciences*, *2*(3A), 33-40.

Profit Maximization in OMFED

In order to maximize profit the following must be considered:

1. Supply shortages during peak demands are needed to be visualized.
2. Capacity constraints are required to be understood.
3. Decisions must be taken from a profit perspective.
4. The decision making system must be capable of forecasting demand of milk during various seasons or events and plan processing and storage capacities to store milk.

- Profit in its simplest form can be defined as

(price – cost of Production & Transportation) x volume

Profit Maximization in OMFED

- Factors affecting profit maximization in diary industry:
- Nature of milk production and supply process i.e.,
- Market dynamics is also responsible for fluctuations in commodity pricing.
- Effective management of market dynamics i.e., ‘push’(steady supply) and ‘pull’(peak market demand)

Summary

- Simple method
- Less computation burden
- High-quality solution
- Stable convergence specifications
- Good optimization performance
- Better diversification ability compared to the standard SFL algorithm.

Applications

- Water Supply System
- Tunnel System
- Power Supply Distribution
- Shop Management
- Project Management (Civil Engineering)
- Robot Control
- Clustering
- Data Mining
- Image processing
- Circuit Design
- Travelling Salesman Problem
- Solving Knapsack Problem & many other algorithms

Particle Swarm intelligence

- Introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems.
- Based upon the study of collective behavior in decentralized and self-organized (biological) systems.
- Study of self-organizing process in natural and artificial swarm systems.
- Examples in nature : bird flocking, animal herding, bacterial growth, fish schooling etc.

Characteristics of Swarms

- Composed of many individuals
- Individuals are homogeneous
- No centralized control structure
- Local interaction based on simple rules
- Local interactions lead to "intelligent" global behavior
- Self-organized
- Constitutes a natural model particularly suited to distributed problem solving

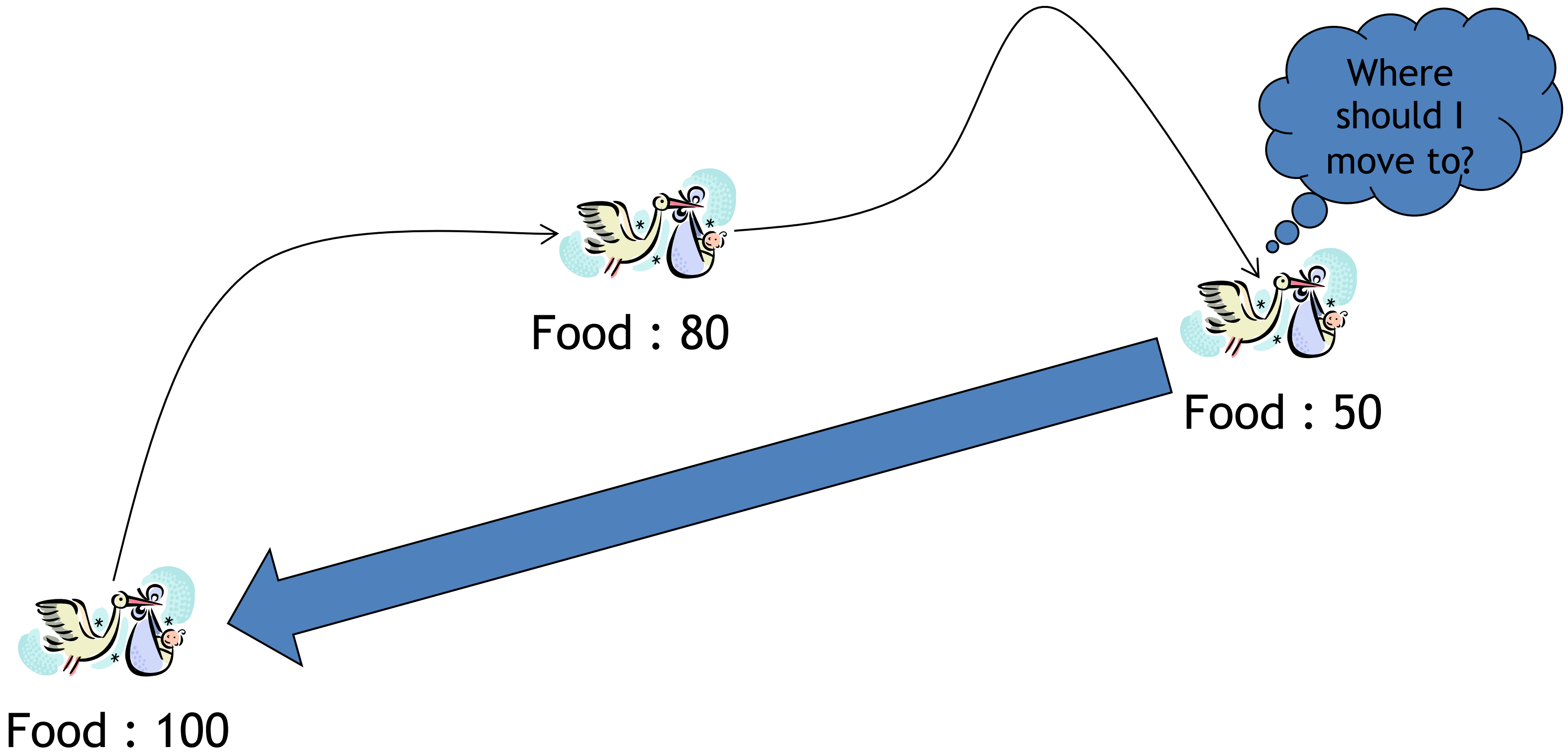
- Main objective: To model the simple behaviors of individuals, and their local interactions with the environment and neighboring individuals, to solve complex optimization problems.

Bird's Foraging Behavior

- Based on observation of bird flocks searching for food.
- Birds are driven by the goal of community survival rather than being focused on survival of the individuals.
- Indirect communication between birds enables them to converge to better food sources.
- Random probabilistic search enables them to find better, globally optimal, food sources as opposed to substandard, locally optimal, ones.

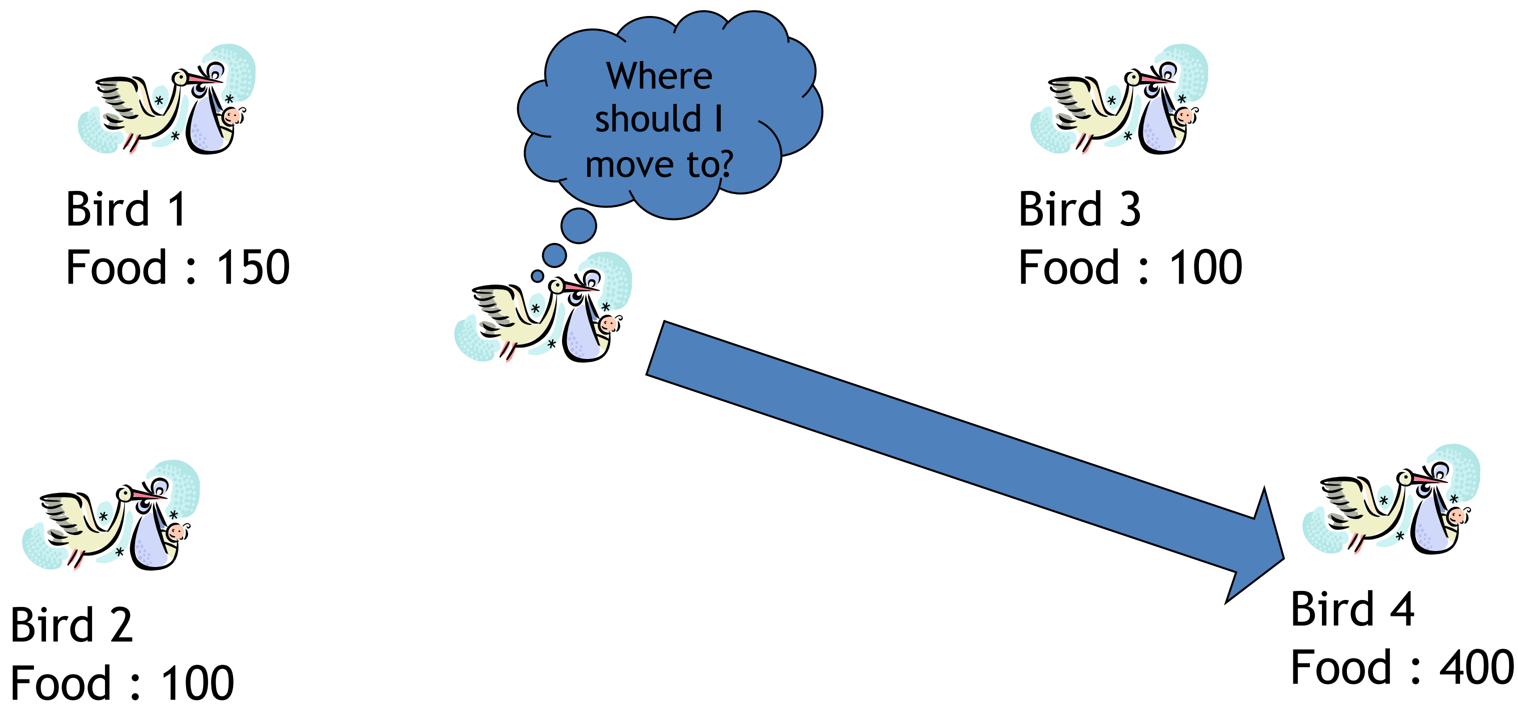
Particle Swarm Optimization Basic Idea: Cognitive Behavior

- An individual remembers its past knowledge



Particle Swarm Optimization ~ Basic Idea: Social Behavior

- An individual gains knowledge from other members in the swarm (population)



Particle Swarm Optimization

- Hypotheses (Initial solutions), are plotted in an n-dimensional space and were seeded with an initial velocity, and a communication channel between the particles.
- Each agent stores two positions in memory:
  - its personal best, which is the agent's closest position to the target since the beginning,
  - the local best, which is the closest position to the target that some agent in the neighborhood has made.
- Particles then move through the solution space, and are evaluated according to some fitness criterion after each time-step.
- Particles are accelerated towards particles with better fitness values.

Particle Swarm Optimization

(PSO) models two simple behaviors. Each individual moves toward its closest best neighbor, moves back to the state that the individual has experienced to be best for itself.

As a result, the collective behavior observed, due to each of these individuals converging into a state, is the best solution for all individuals.

$$\mathbf{x}_i = (x_{i,1}, x_{i,2}, \ldots, x_{i,n}) \in \Re^n$$

$$\mathbf{v}_i = (v_{i,1}, v_{i,2}, \ldots, v_{i,n}) \in \Re^n$$

- Swarm: a set of particles (S)
- Particle: a potential solution
    - Position:
    - Velocity:
- Each particle maintains
    - Individual best position (PBest)
- Swarm maintains its global best (GBest)

Particle Swarm Optimization Algorithm

For each particle
Initialize particle with feasible random number
END
Do
For each particle
Calculate the fitness value
If the fitness value is better than the best fitness value (**pbest**) in history
Set current value as the new **pbest**
End
Choose the particle with the best fitness value of all the particles as the **gbest**
For each particle
Calculate particle velocity according to velocity update equation
Update particle position according to position update equation
End
While maximum iterations or minimum error criteria is not attained

PSO Value Updation

- Original velocity update equation

$$\mathbf{v}_i(k+1) = \text{Inertia} + \text{cognitive influence} + \text{social influence}$$

$$\mathbf{v}_i(k+1) = \omega \times \mathbf{v}_i(k) + c_1 \times random_1() \times (PBest_i - \mathbf{x}_i(k)) + c_2 \times random_2() \times (GBest - \mathbf{x}_i(k))$$

  - w: constant
  - c_1,c_2: acceleration factor related to gbest
  - $random_1()$, $random_2()$: random variables between 0-1

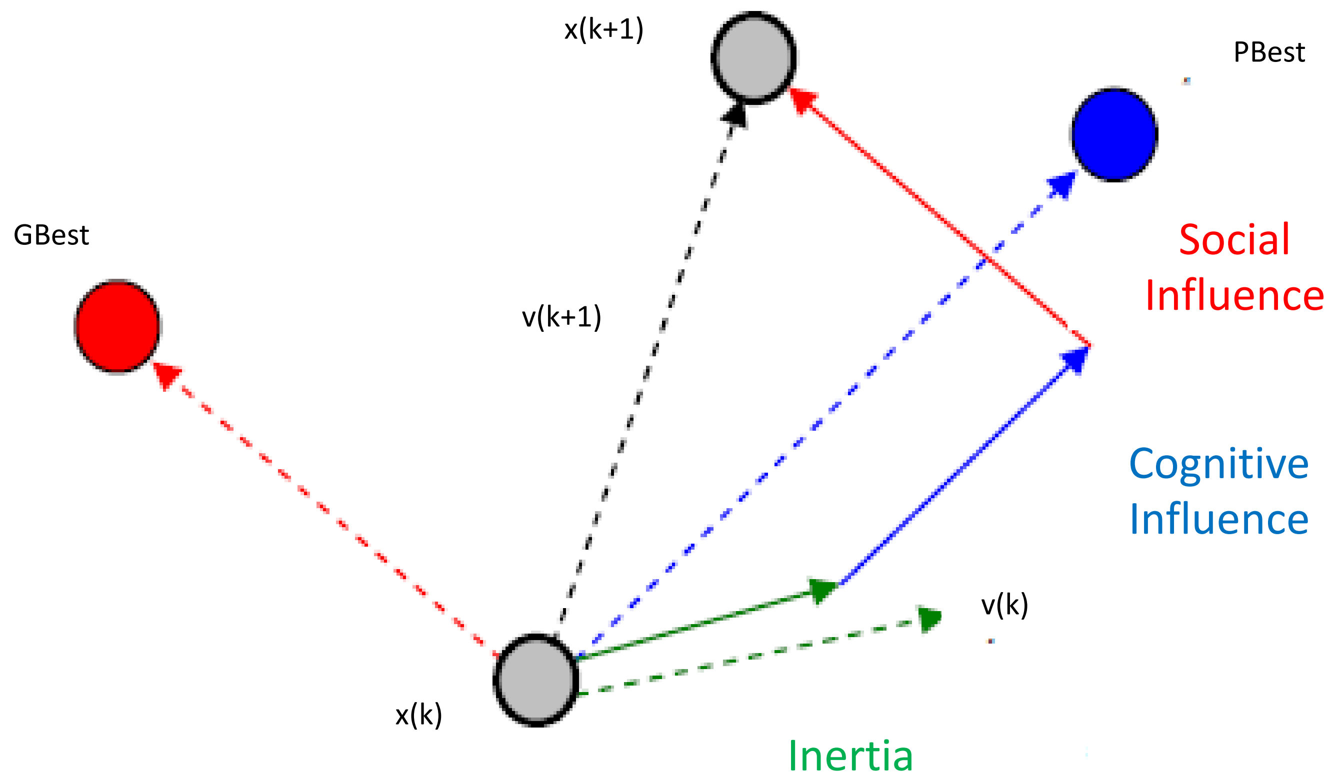
- Position update

$$\mathbf{x}_i(k+1) = \mathbf{x}_i(k) + \mathbf{v}_i(k+1)$$

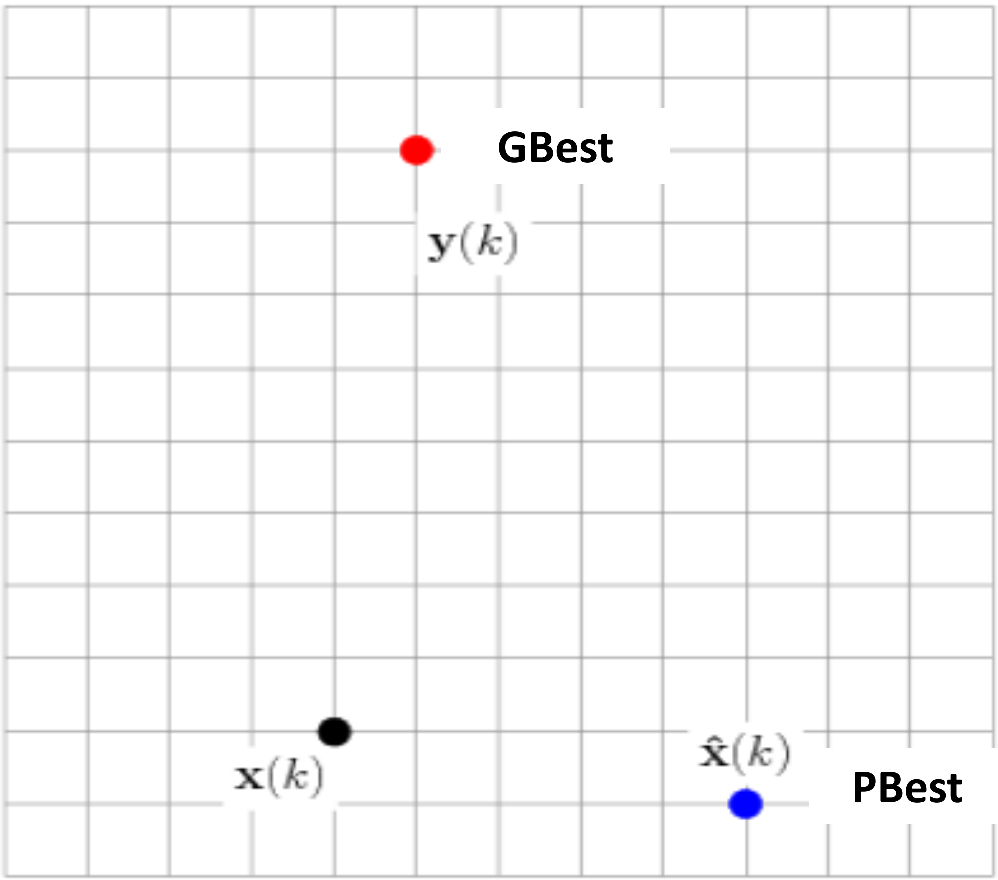
PSO Graphical Representation

- Particle's velocity

$$\mathbf{v}_i(k+1) = \text{Inertia} + \text{cognitive influence} + \text{social influence}$$

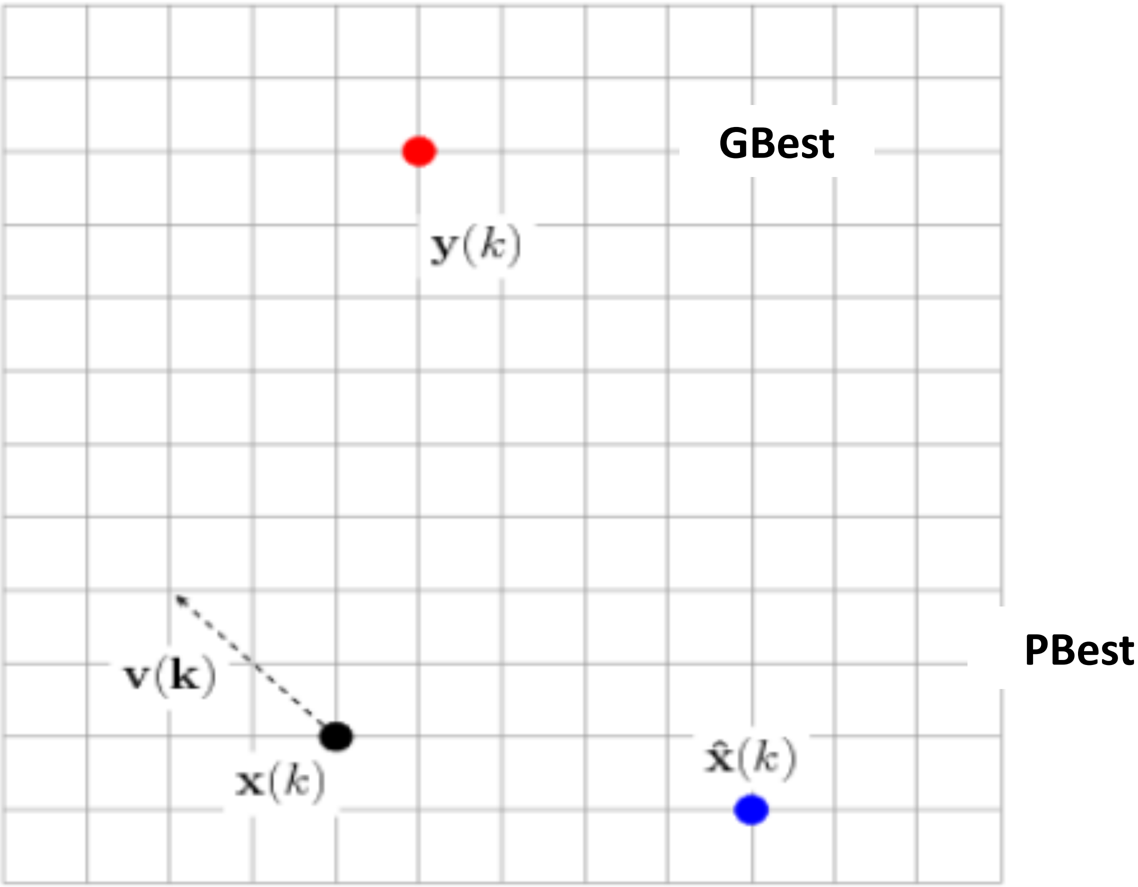


PSO Example



- **x**(*k*) - Current solution (4, 2)
- **PBest** - Particle's best solution (9, 1)
- **GBest**-Global best solution (5, 10)

PSO Example

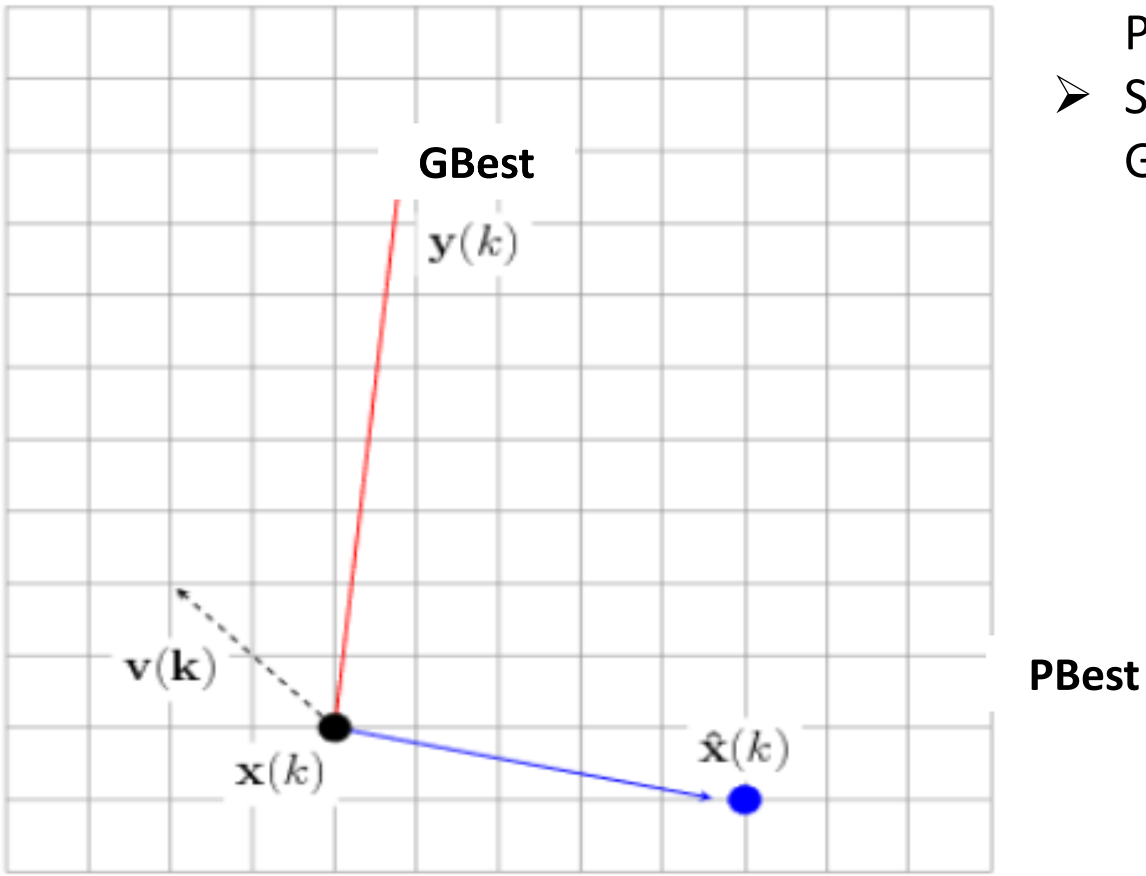


Inertia: **v**(*k*)=(-2, 2)

- **x**(*k*) - Current solution (4, 2)
- PBest - Particle's best solution (9, 1)
- GBest-Global best solution (5, 10)

PSO Example

- Inertia: **v**(*k*)=(-2,2)
- Cognitive: PBest-**x**(*k*)=(9,1)-(4,2)=(5,-1)
- Social: GBest-**x**(*k*)=(5,10)-(4,2)=(1,8)



- **x**(*k*) - Current solution (4, 2)
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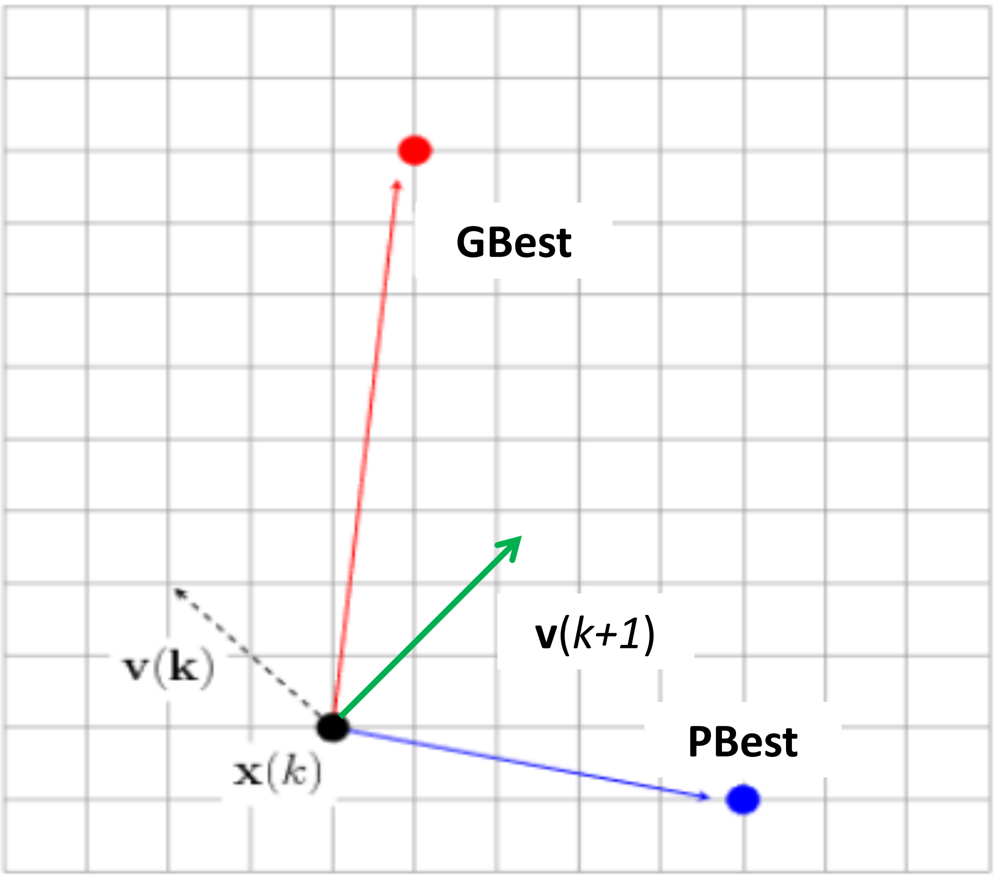
PSO Example

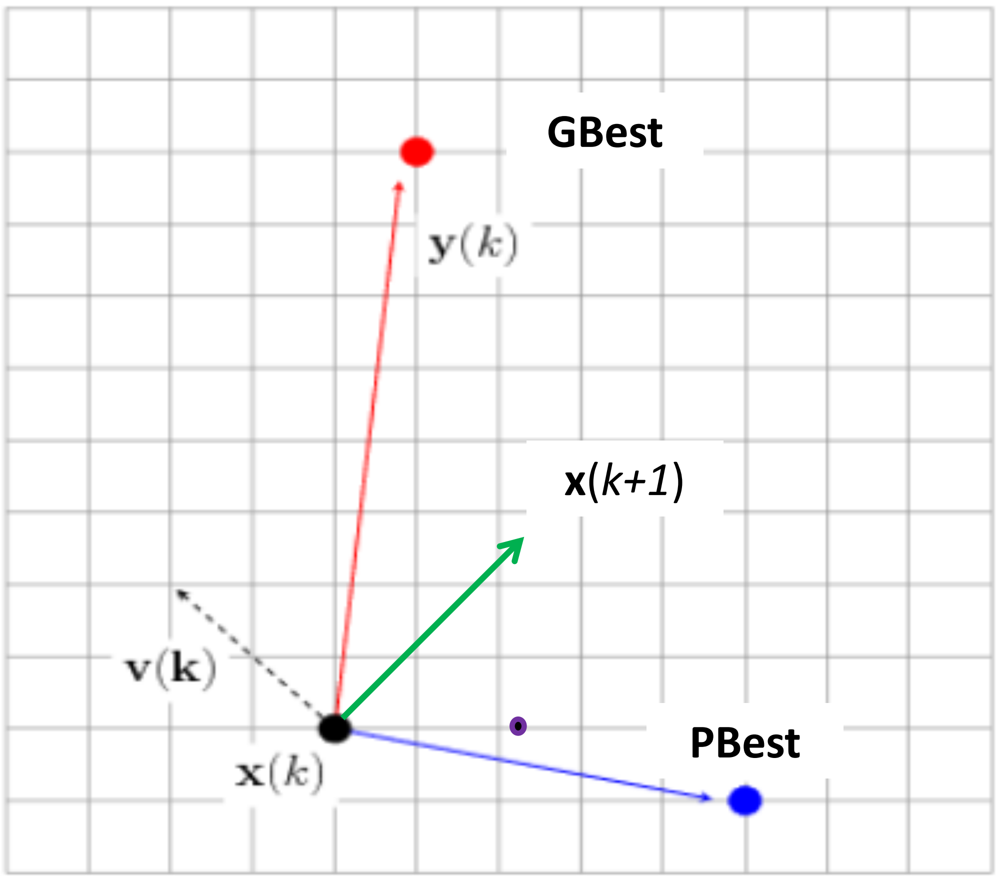


- Inertia: **v**(*k*)=(-2,2)
- Cognitive:
  PBest-**x**(*k*)=(9,1)-(4,2)=(5,-1)
- Social:
  GBest-**x**(*k*)=(5,10)-(4,2)=(1,8)

v(*k+1*)=(-2,2)+0.8*(5,-1) +0.2*(1,8)
= (2.2,2.8)

- **x**(*k*) - Current solution (4, 2)
- PBest - Particle's best solution (9, 1)
- GBest-Global best solution (5, 10)

PSO Example

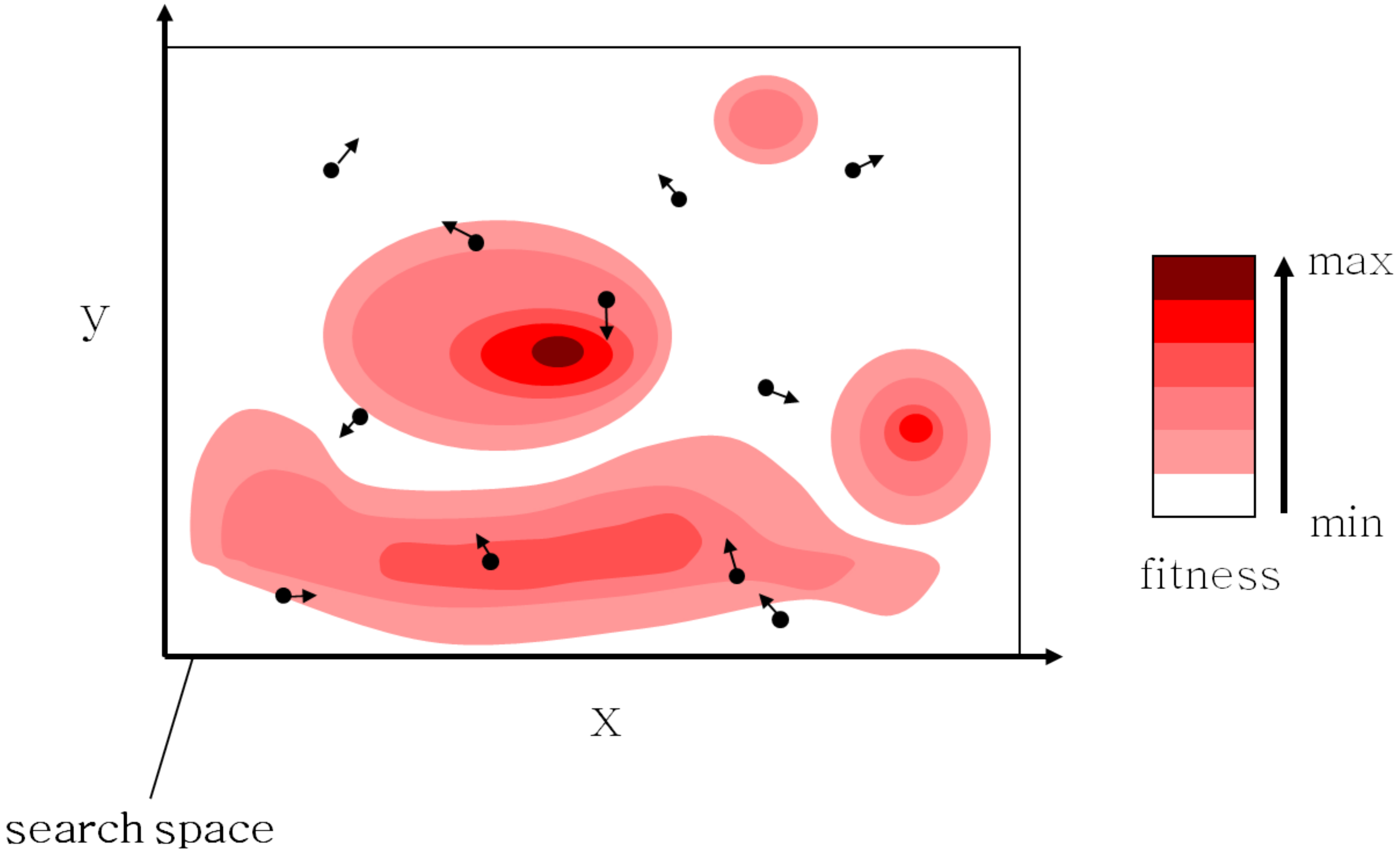


- Inertia: $\mathbf{v}(k)$=(-2,2)
- Cognitive:
  PBest-$\mathbf{x}(k)$=(9,1)-(4,2)=(5,-1)
- Social:
  GBest-$\mathbf{x}(k)$=(5,10)-(4,2)=(1,8)
- $\mathbf{v}(k+1)$=(2.2,2.8)

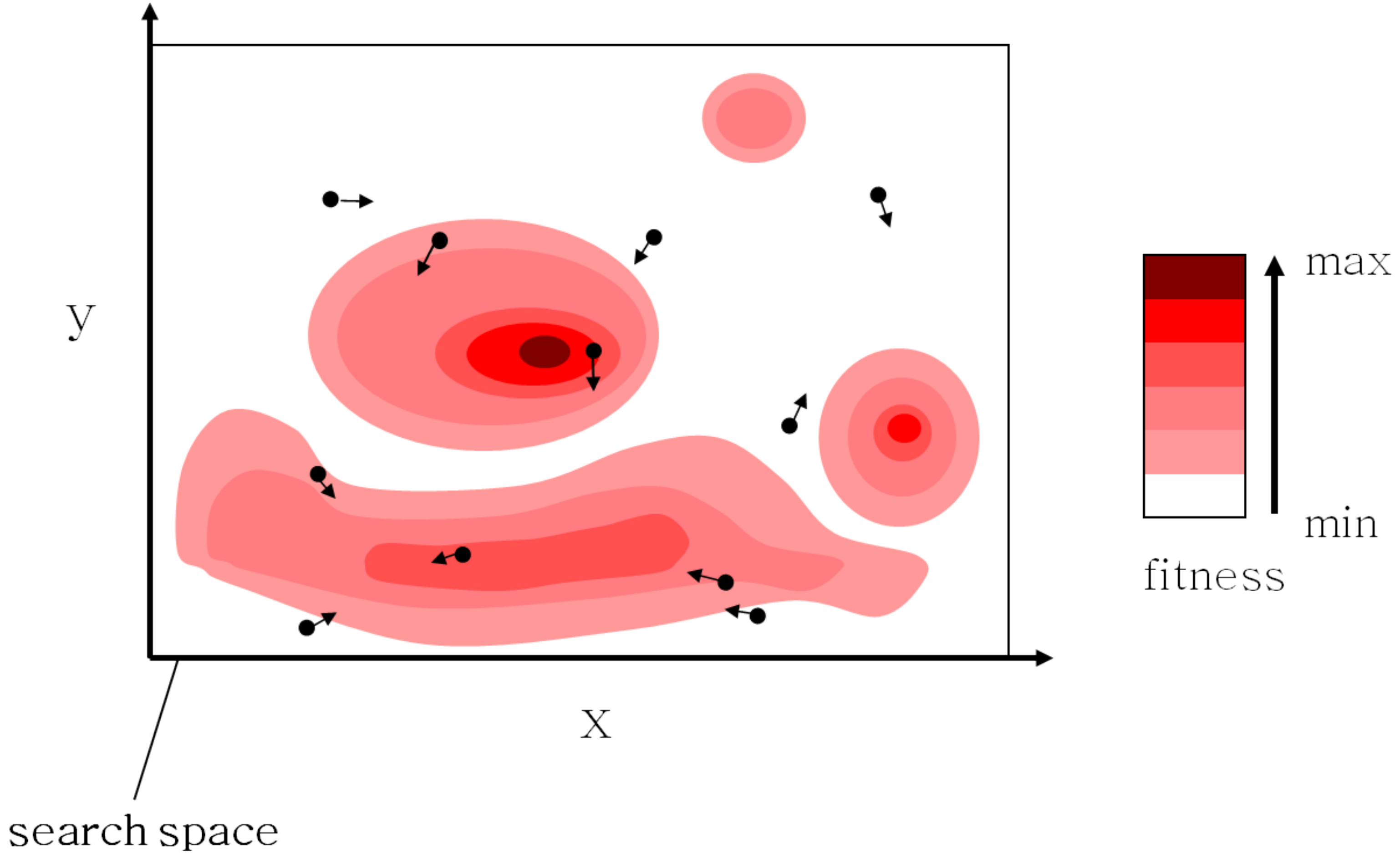
$x(k+1)=x(k)+v(k+1)$
= (4,2)+(2.2,2.8)=(6.2,4.8)

- $\mathbf{x}(k)$ - Current solution (4, 2)
- PBest - Particle's best solution (9, 1)
- GBest-Global best solution (5, 10)

PSO Example



PSO Example



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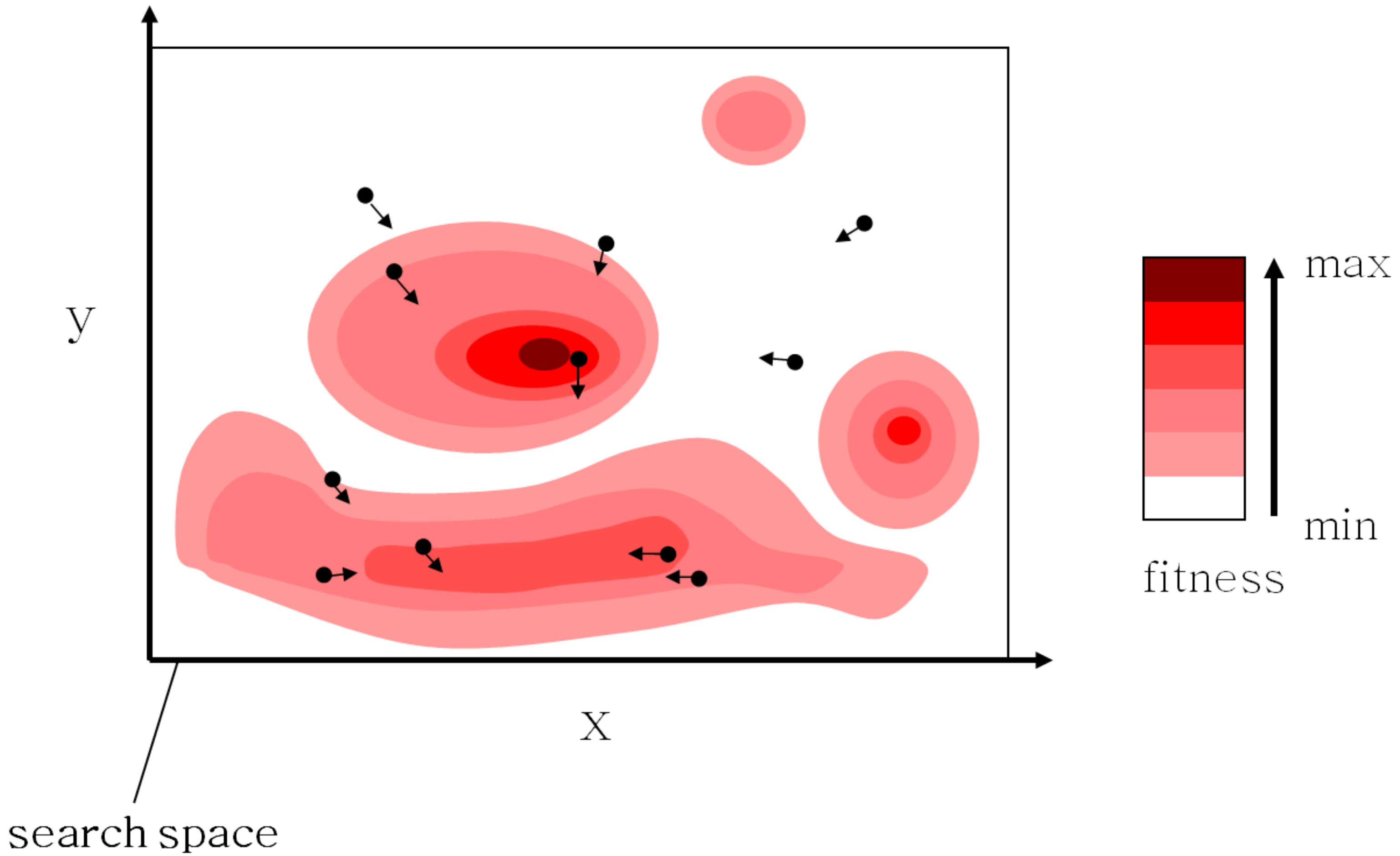

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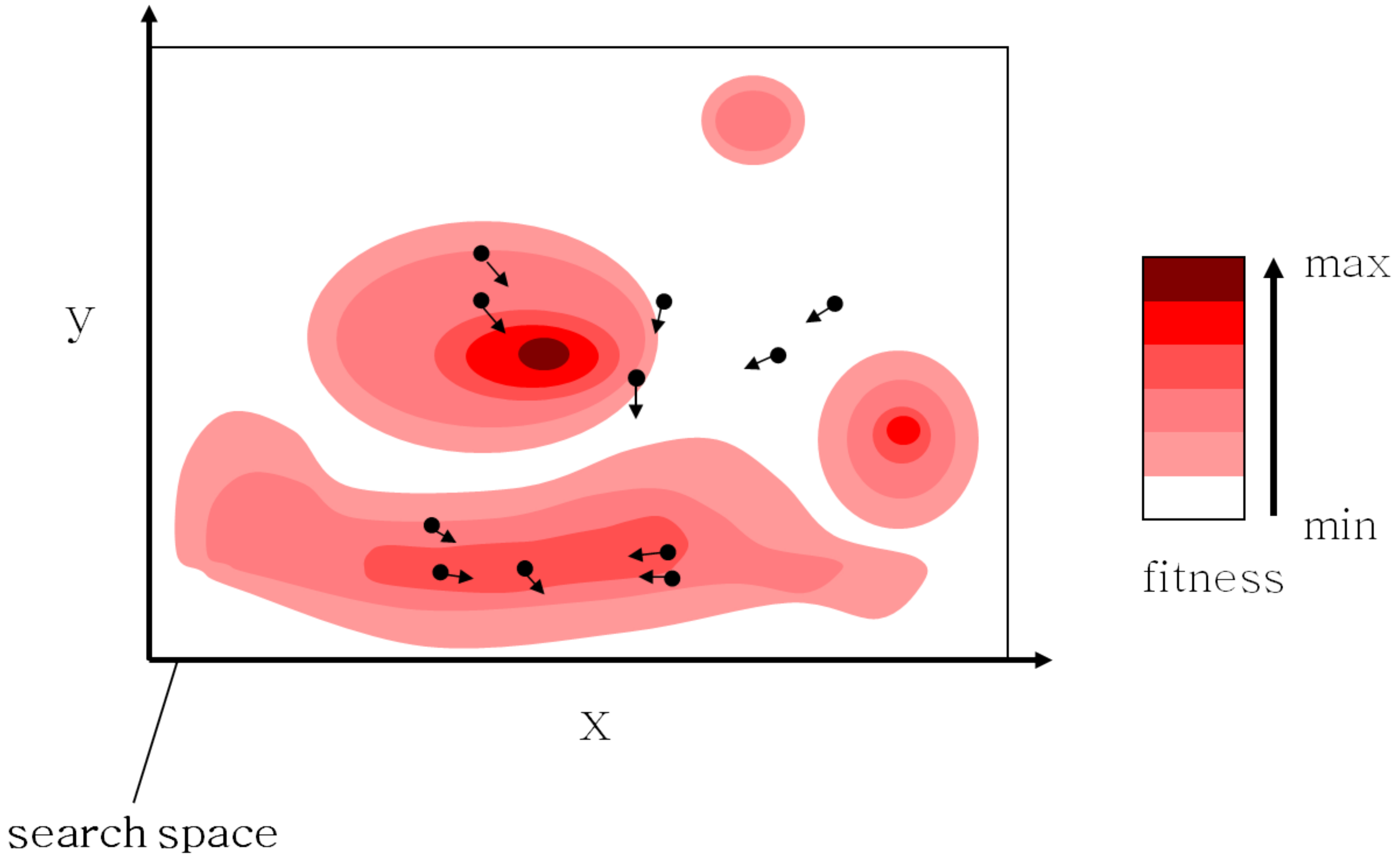

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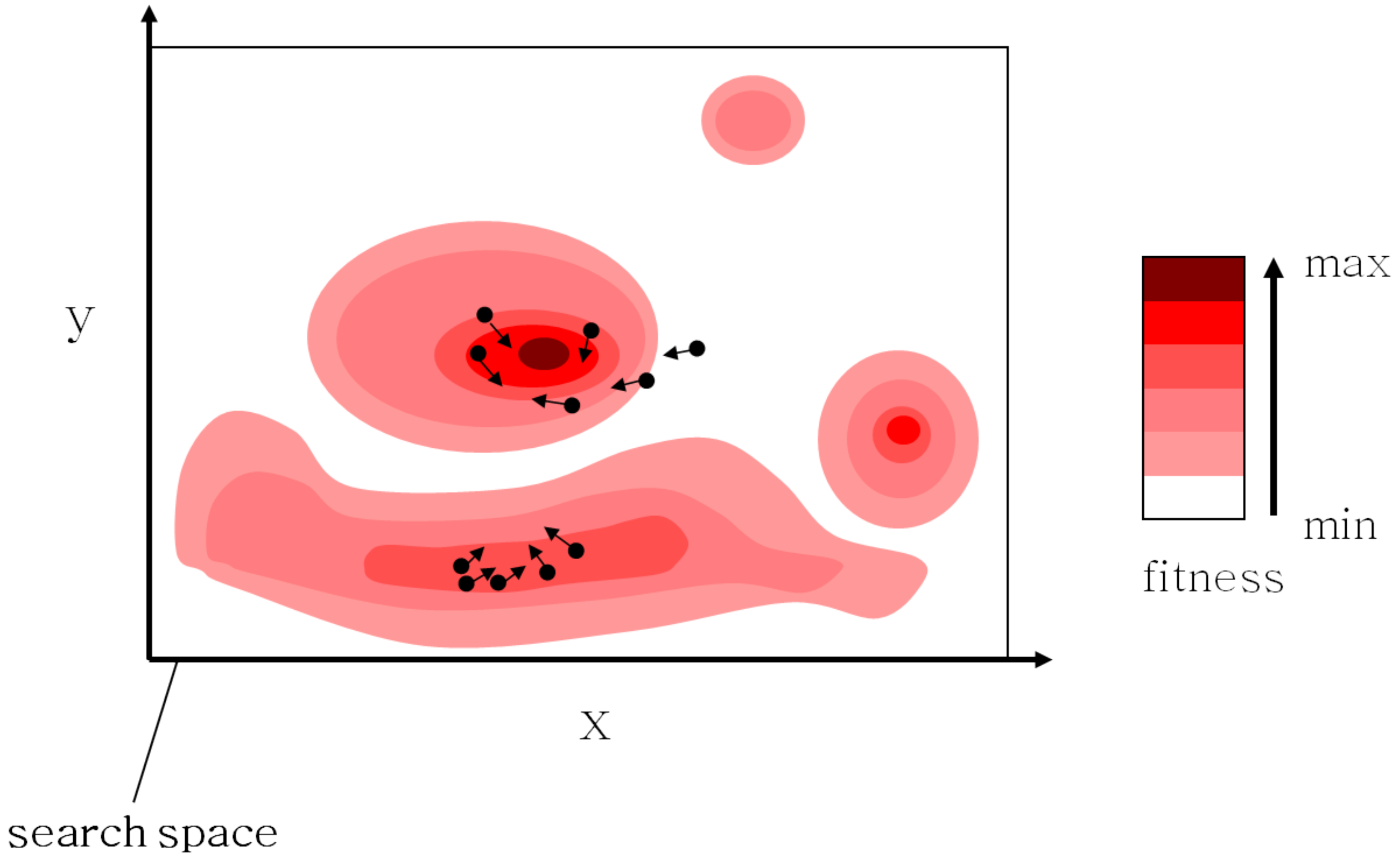
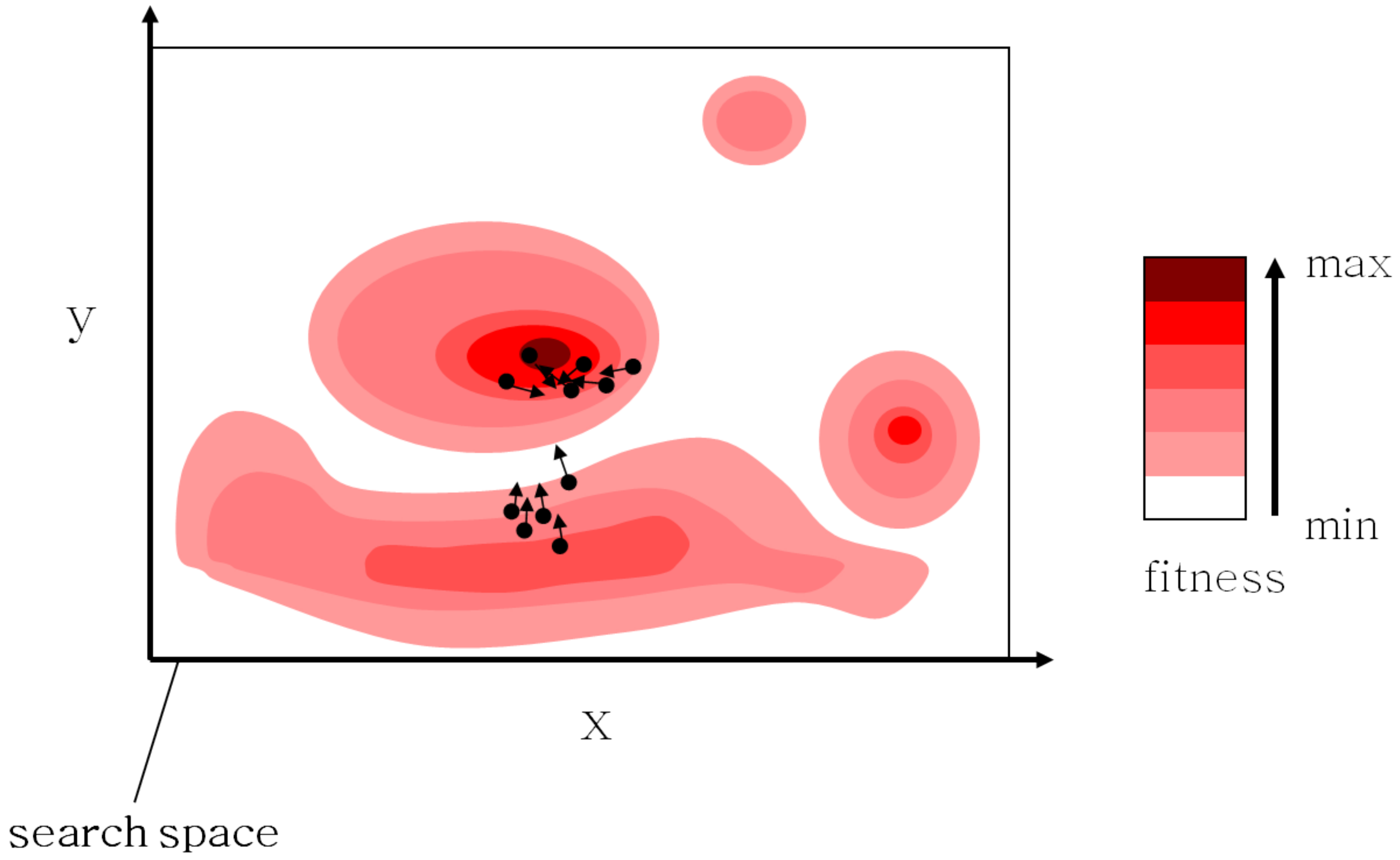


PSO Example



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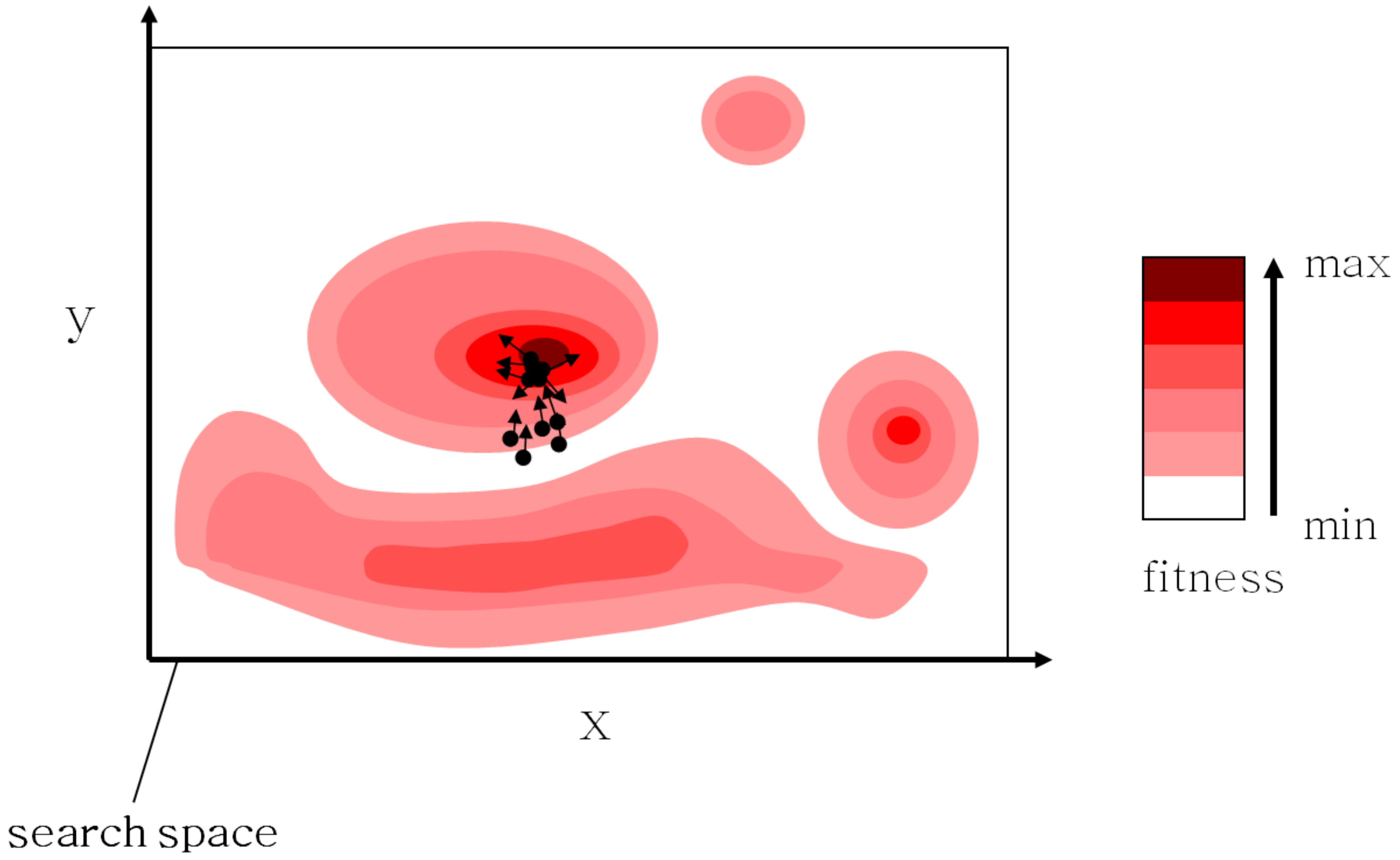
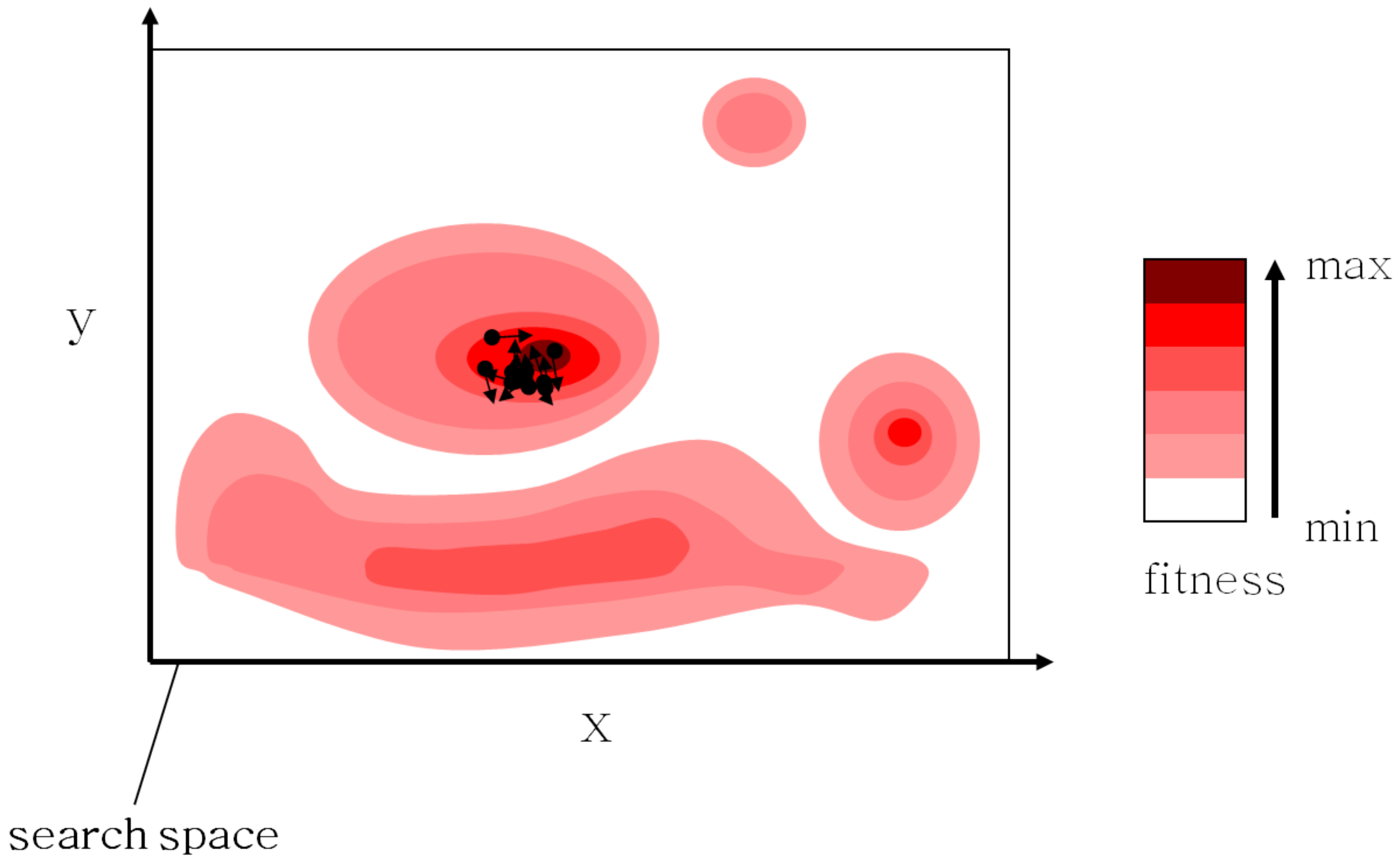
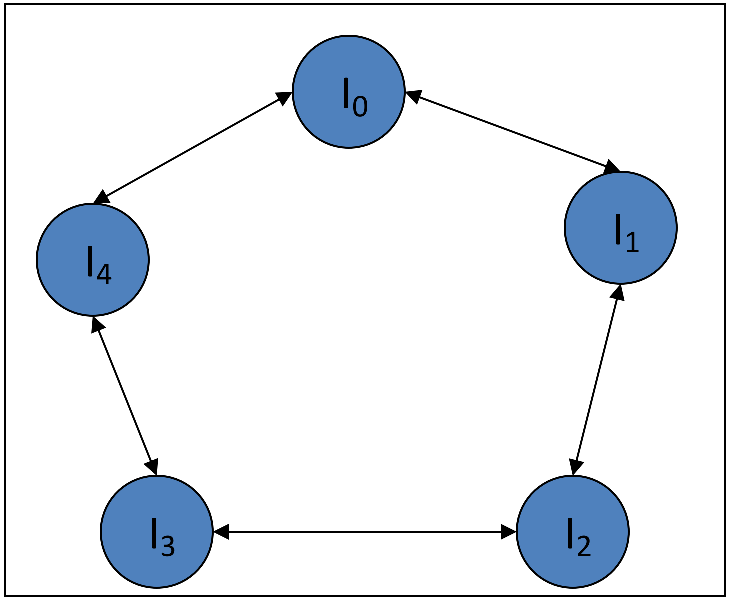


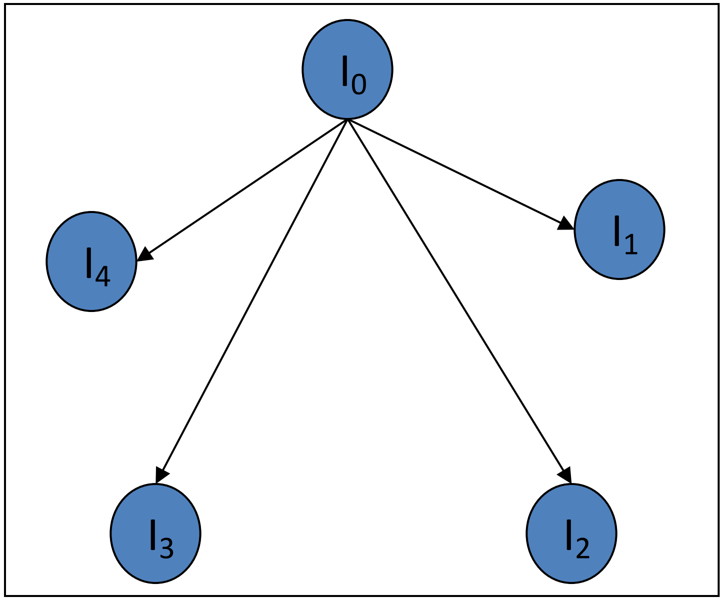
PSO Example



Particle Swarm Optimization: Swarm Topology

- In PSO, there have been two basic topologies used in the literature
  - Ring Topology (neighborhood of 3)
  - Star Topology (global neighborhood)





PSO Parameters

- PSO algorithm's behavior and performance are affected by many parameters:
  - Number of particles
  - Number of iterations
  - Inertia weight
  - Acceleration constants
  - Local grouping of particles
  - Number of neighbors

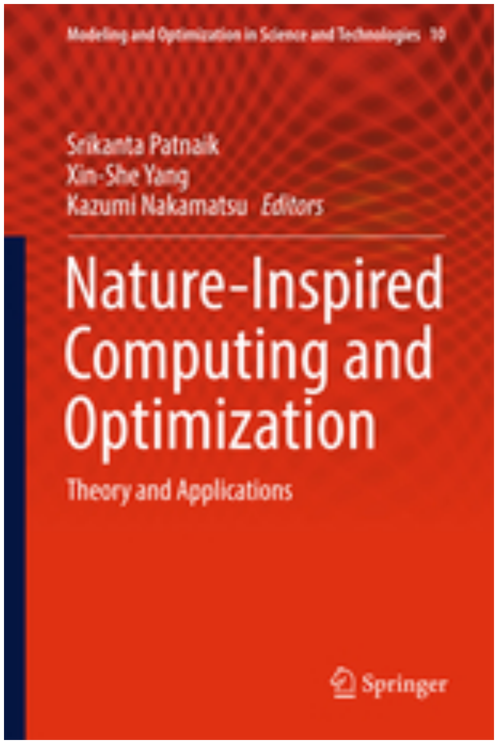
Advantages

- Advantages
  - Simple implementation
  - Easily parallelized for concurrent processing
  - Derivative free
  - Very few algorithm parameters
  - Very efficient global search algorithm
- Disadvantages
  - Tendency to a fast and premature convergence in mid optimum points
  - Slow convergence in refined search stage (weak local search ability)

Crocodile Predatory Strategy

- Wait & Watch Strategy
- Ambush Planning
- Dominance Heirarchy

Book on Nature-Inspired Computing



Nature-Inspired Computing and Optimization

Theory and Applications

Editors: **Patnaik**, Srikanta, **Yang**, Xin-She, **Nakamatsu**, Kazumi (Eds.)

Chapter: Multi-Agent Optimization of Resource-Constrained Project Scheduling Problem Using Nature-Inspired Computing

Springer

Crocodile Predatory Strategy

- Crocodile is a magnificent creature with high intelligence.
- Possess complex behaviors (parental care, complex communication, cooperative hunting and uses tools for hunting).
- Also known as classic opportunistic predators, having complex hunting behavior and excellent teamwork.
- Each individual crocodile tries to maximize the probability of catching the prey for itself.
- Crocodiles are good nocturnal hunters excellent night vision.

Physical Traits

- Physical traits such as streamlined body and webbed feet makes them successful predator.
- Webbed-feet allow them to walk around in shallow water and on ground.
- Dorsal surface is armored with bony deposits forming scales known as osteoderms.
- These scales consist of small sensory pores.
- Presence of eyes, ears and nostrils on top of head allows them to remain submerged in the water for long durations and hide from prey.

Wait and Watch cycle

Figure shows the wait and watch cycle of the crocodiles in a river. A group of crocodile line up in the narrows of the river against the current and wait for fish shoals migrating from north to south. The crocodiles block the passage of the fish shoal and snap at the migrating fish.

Source: https://www.flmnh.ufl. edu/herpetology/links/cooperative-feeding

Perception cycle

Figure shows the crocodile silently observing the movements of the nearest zebras that are potential preys. The crocodile observes the zebra movements and tries to move slowly to bring the prey into its attacking range and once the zebra is within the attacking range it will attack the zebra with full force.

Source: http://www.telegraph.co.uk/news/earth/ earthpicturegalleries/10542224/Crocodiles-attack-zebras-crossing-the-Mara-River-in-Kenya.html?frame=2777158

Ambush Planning

Figure shows the ambush planning where a group of crocodiles are setting a trap for a school of fish also known as bait-ball approach. Here some of the group members play the role of chasers and the other group of crocodiles tries to block the passage of the fish school and the individual crocodiles take their turn and snap through the fish school.

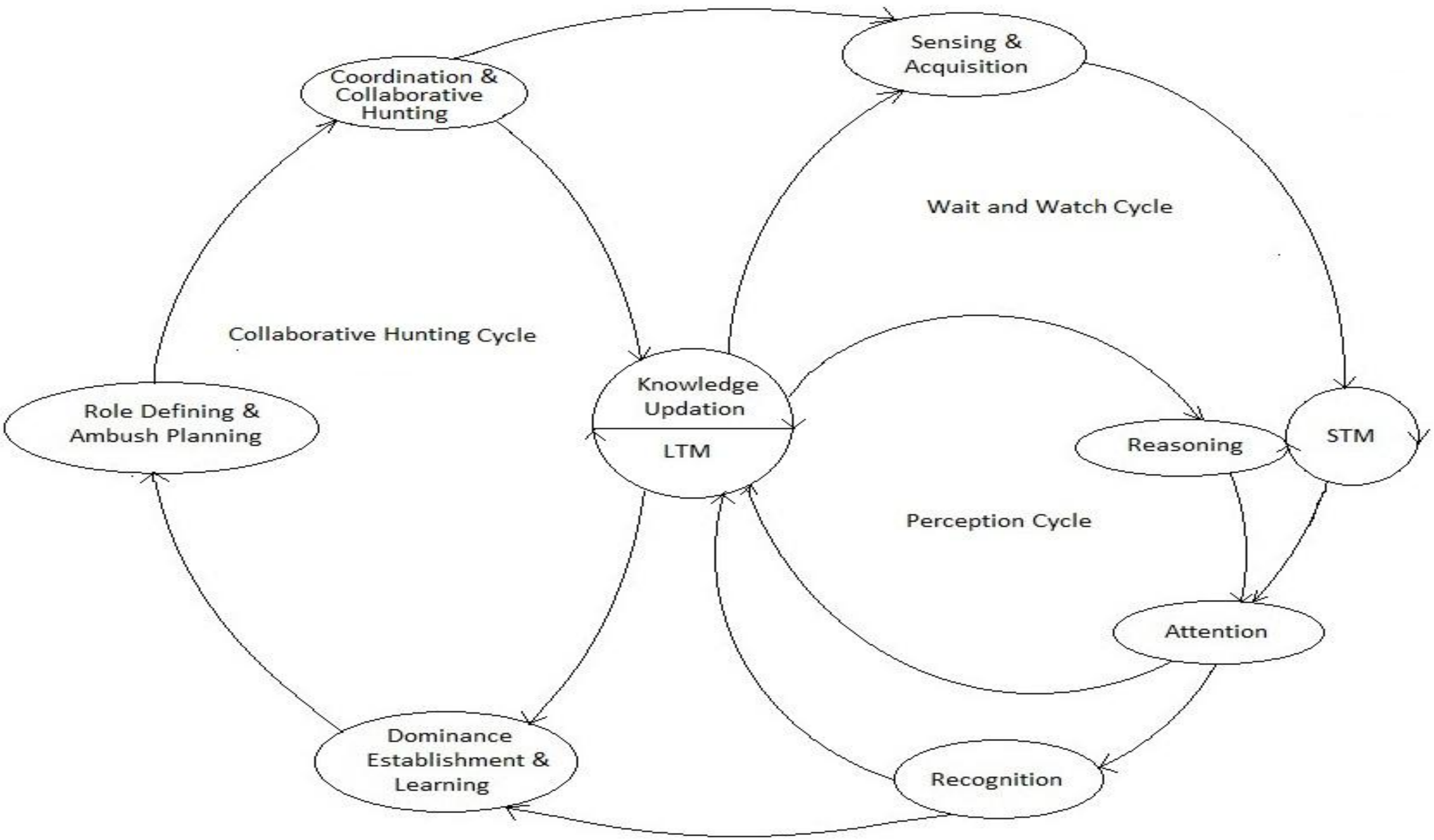
Source: http://www.iflscience.com/plants-and-animals/unknown-crocodiles

Ambush Planning

Figure shows another case of ambush planning adopted by crocodiles where the crocodile highlighted by the white circle is hiding among the migrating wild-beests trying to cross the river.

Source: http://reptilis.net/crocodylia/crocs/niloticus.html

Crocodile predatory behavioral cycle



Crocodile Predatory Behavioral Cycle

Crocodile Predatory behavioral cycle

The crocodile predatory behavioral cycle shown in the previous figure, consists of three sub-cycles:

(i) the wait and watch cycle

(ii) the perception cycle

(iii) the collaborative hunting cycle

The crocodile predatory behavioral cycle further consists of seven behavioral states

i. Sensing and acquisition

ii. Reasoning

iii. Attention

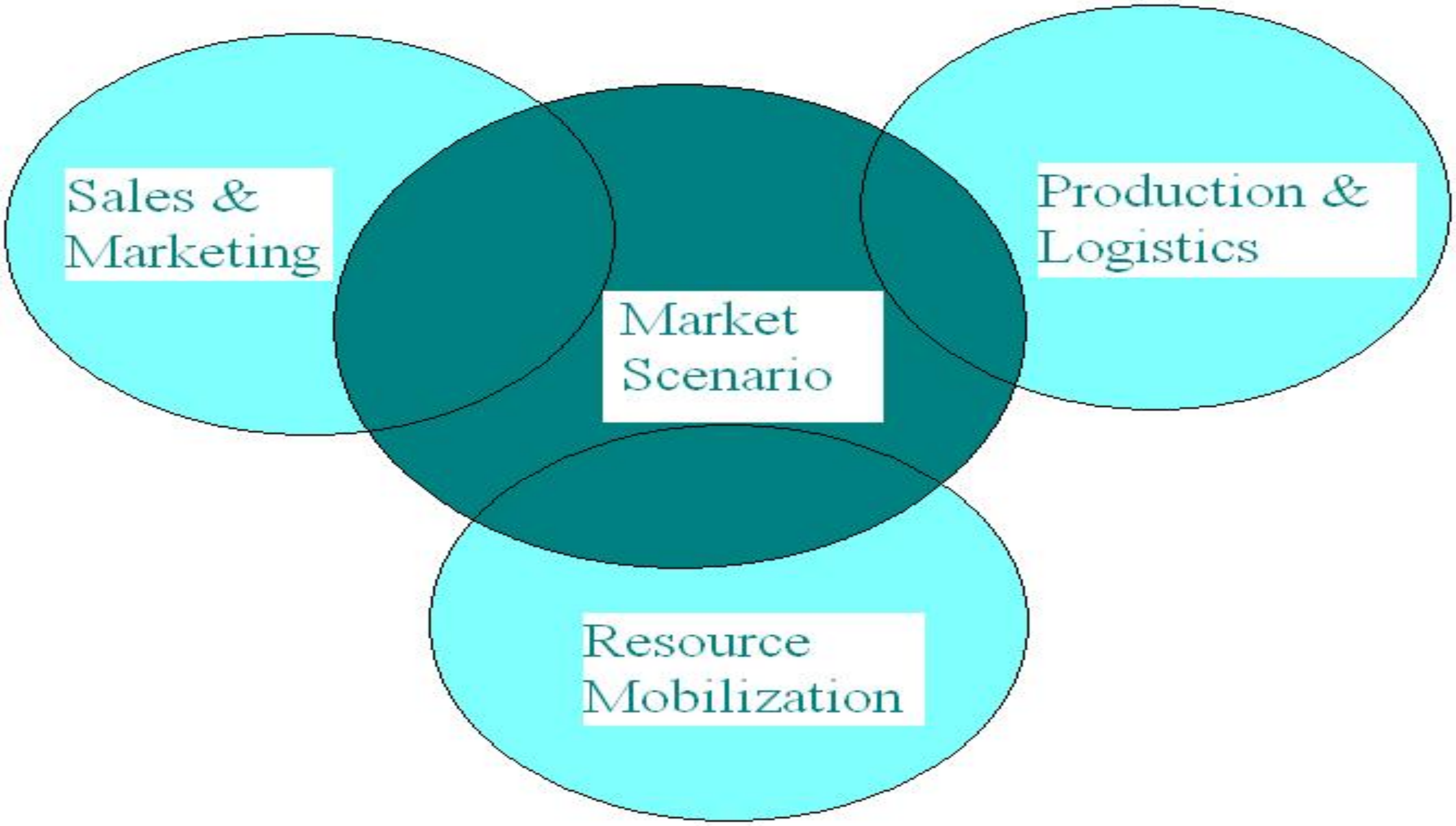
iv. Recognition

v. Dominance establishment and learning

vi. Role defining and ambush planning

vii. Coordination and collaborative hunting

Apparel Industry Structure & Logic



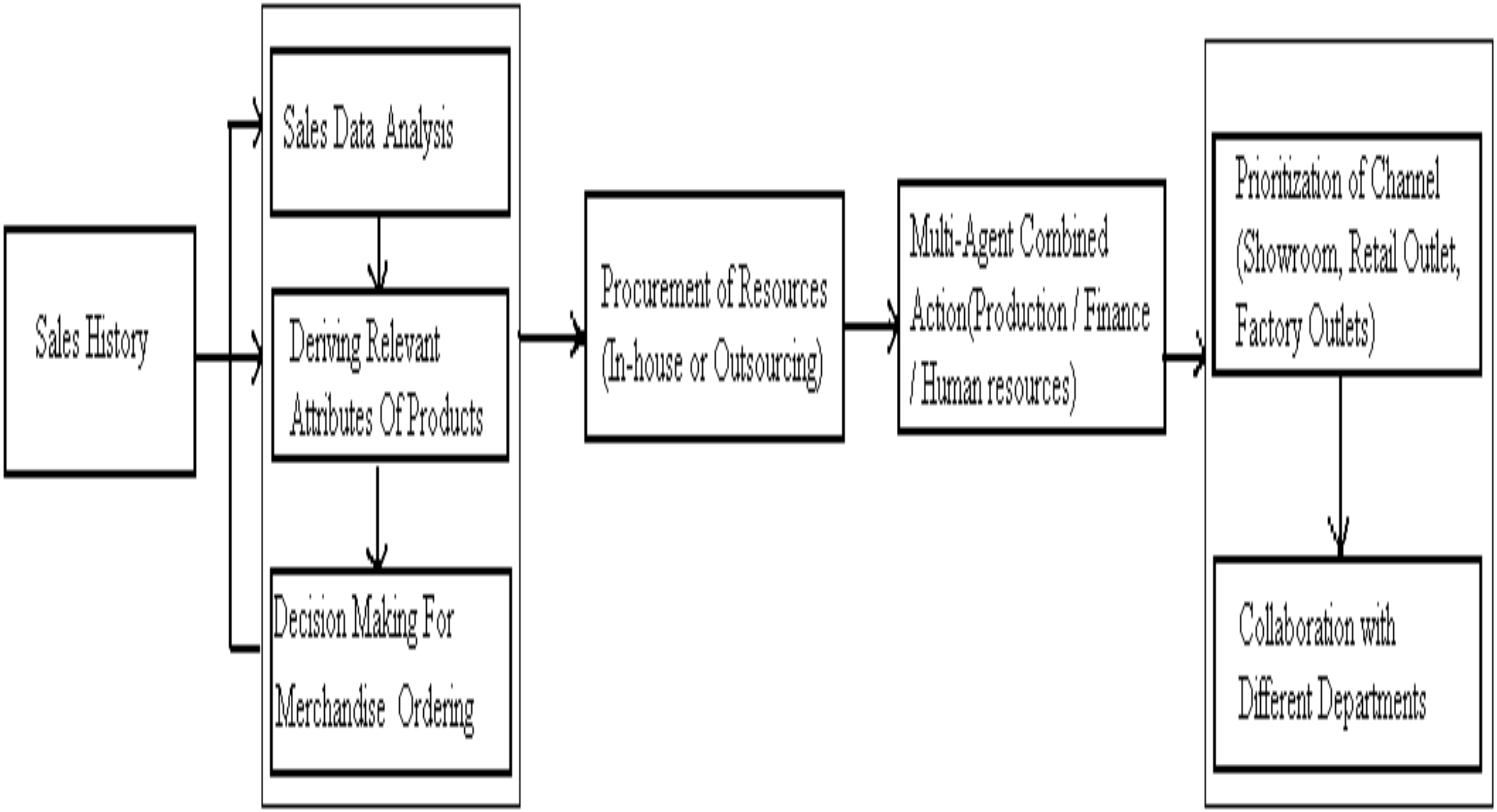
Apparel Industry Structure & Logic

- Bulk Production during festive Season
- Uncertainty of time for right product Arrival in the market
- Sales through various Discount Schemes
- After the season, again Bulk Discount and Clearance Sale

Which leads to:

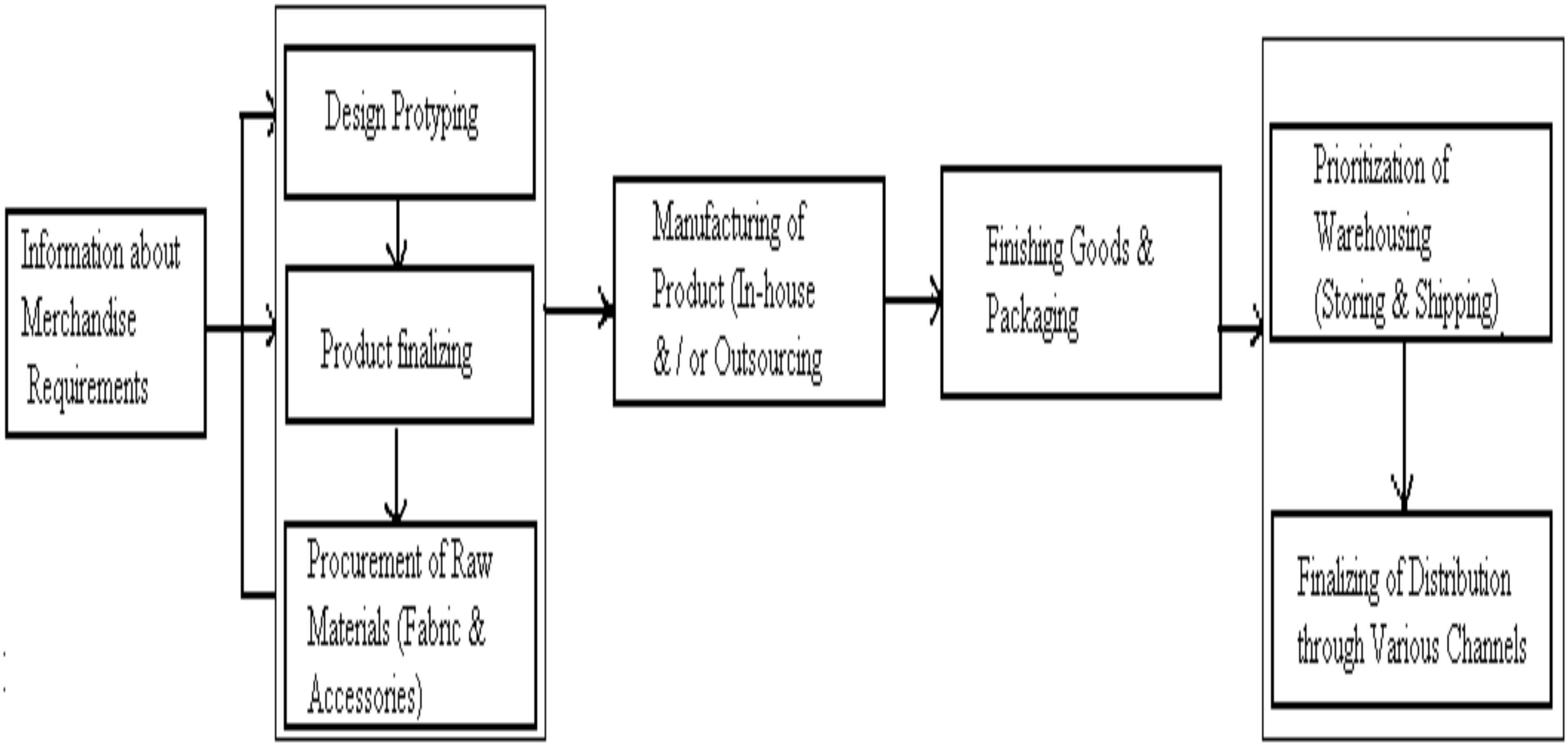
- Style becomes obsolete very frequently
- Increase in pricing model of the apparels
- Compulsion to sale at heavy discounted price during the clearance sale

Sales & Marketing



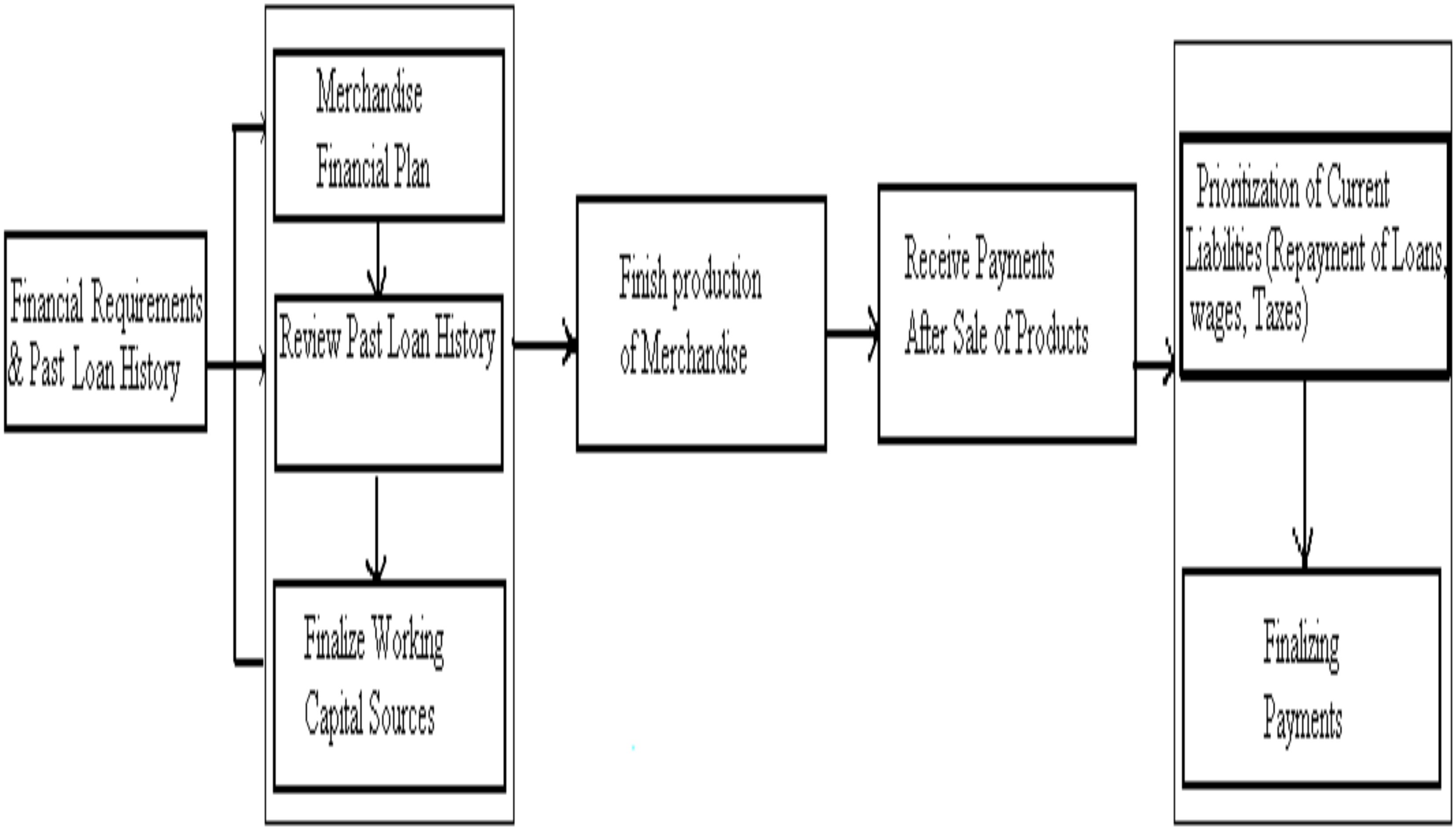
Crocodile Predatory Strategy for Sales & Marketing Section of Apparel Business

Production & Logistics



Crocodile Predatory Strategy for Production & Logistic Section of Apparel Business

Resource Mobilization



Crocodile Predatory Strategy for Resource Mobilization Section

Summary

- The predatory strategy of crocodiles has been modeled as a coordination strategy in multi-agent systems for solving large and complex problems.
- Each individual agent is limited by its capabilities.
- Since the nature of prey is dynamic, therefore it can be applied to problems with dynamic environment.
- The agents cooperate and coordinate with each other to achieve the common goal which in-turn is an outcome of accomplishment of sub-goals by individual agents.
- Thus the proposed model suits for large and complex problems in distributed and dynamic environments such as e-commerce, disaster management, trading in stock market.

Any Query?

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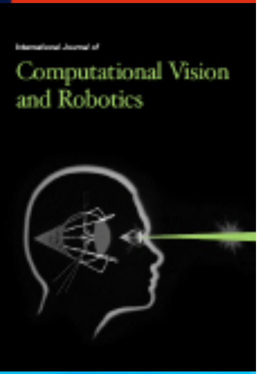

International Conference on Digital Business: Cloud Computing, Device Mesh and Business Algorithm
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Venue: IIMT, Bhubaneswar

Detail is available at:

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