A PAPER PRESENTATION ON

SWARM INTELLIGENCE

Prepared for:

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**Topics to be dealt:**

- Architecture of Cloud Computing
- Characteristics of Cloud Computing
- Layers of Cloud Computing
- Deployment Models
- Security Issues of Cloud Computing
- Dimensions of Cloud Security
- Advantages and Disadvantages of Cloud Computing
- Conclusion

**ABSTRACT:**

Swarm intelligence (SI) describes the collective behavior of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. SI systems are typically made up of a population of simple agents or boids interacting locally with one another and with their environment. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling. The application of swarm principles to robots is called swarm robotics, while 'swarm intelligence' refers to the more general set of algorithms. 'Swarm prediction' has been used in the context of forecasting problems.

Swarm describes behavior of an aggregate of animals of similar size and body orientation, often moving en masse or migrating in the same direction. Swarming is a general term that can be applied to any animal that swarms. The term is applied particularly to insects, but can also be applied to birds, fish, various microorganisms such as bacteria, and people. The term flocking is usually used to refer to swarming behavior in birds, while the terms shoaling or schooling are used to refer to swarming behavior in fish. The swarm size is a major parameter of a swarm.

1. **INTRODUCTION:**
SI is the property of a system whereby the collective behaviors of agents interacting locally with their environment cause coherent functional global patterns to emerge. SI provides a basis with which it is possible to explore distributed problem solving without centralized control or the provision of a global model. One of the core tenets of SI work is that often a decentralized, bottom-up approach to controlling a system is much more effective than traditional, centralized approach. Groups performing tasks effectively by using only a small set of rules for individual behavior is called swarm intelligence. Swarm Intelligence is a property of systems of non-intelligent agents exhibiting collectively intelligent behavior. In Swarm Intelligence, two individuals interact indirectly when one of them modifies the environment and the other responds to the new environment at a later time. For years scientists have been studying about insects like ants, bees, termites etc. The most amazing thing about social insect colonies is that there’s no individual in charge. For example consider the case of ants. But the way social insects form highways and other amazing structures such as bridges, chains, nests and can perform complex tasks is very different: they self-organize through direct and indirect interactions. The characteristics of social insects are

1. Flexibility
2. Robustness
3. Self-Organization

II. PROPERTIES OF SWARM INTELLIGENCE

The typical swarm intelligence system has the following properties:

- It is composed of many individuals;
- The individuals are relatively homogeneous;
- The interactions among the individuals are based on simple behavioral rules that exploit only local information that the individuals exchange directly or via the environment;
- The overall behavior of the system results from the interactions of individuals with each other and with their environment, that is, the group behavior self-organizes.

III. MODELLING SWARM BEHAVIOUR

The simplest mathematical models of animal swarms generally represent individual animals as following three rules:

1. Move in the same direction as your neighbor
2. Remain close to your neighbors
3. Avoid collisions with your neighbors

Many current models use variations on these rules, often implementing them by means of concentric "zones" around each animal. In the zone of repulsion, very close to the animal, the focal animal will seek to distance itself from its neighbors to avoid collision. Slightly further away, in the zone of alignment, the focal animal will seek to align its direction of motion with its neighbors. In the outermost zone of attraction, which extends as far away from the focal animal as it is able to sense, the
focal animal will seek to move towards a neighbor. The shape of these zones will necessarily be affected by the sensory capabilities of the given animal. For example the visual field of a bird does not extend behind its body. Fish rely on both vision and on hydrodynamic perceptions relayed through their lateral line, while Antarctic krill rely both on vision and hydrodynamic signals relayed through antennae. Some of the animals that exhibit swarm behavior are

1. Insects – Ants, bees, locusts, termites, mosquitoes and insects migration.
2. Bacteria
3. Birds
4. Land animals
5. Aquatic animals – fish, krill and other aquatic animals
6. People

IV. EXAMPLE ALGORITHMS OF SWARM INTELLIGENCE:

- Ant colony optimization
- River formation dynamics
- Particle swarm optimization
- Stochastic diffusion search
- Gravitational search algorithm
- Intelligent Water Drops
- Charged System Search

1. ANT COLONY OPTIMIZATION

In computer science and operations research, the ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. In the real world, ants wander randomly, and upon finding food return to their colony while laying down pheromone trails. If other ants find such a path, they are likely not to keep travelling at random, but to instead follow the trail, returning and reinforcing it if they eventually find food through that way. This algorithm is inspired by forgiving behavior of the ants.
1. The first ant finds the food source (F), via any way (a), then returns to the nest (N), leaving behind a trail pheromone (b).

2. Ants indiscriminately follow four possible ways, but the strengthening of the runway makes it more attractive as the shortest route.

3. Ants take the shortest route, long portions of other ways lose their trail pheromones.

In a series of experiments on a colony of ants with a choice between two unequal length paths leading to a source of food, biologists have observed that ants tended to use the shortest route. A model explaining this behavior is as follows:

1. An ant (called "blitz") runs more or less at random around the colony;
2. If it discovers a food source, it returns more or less directly to the nest, leaving in its path a trail of pheromone;
3. These pheromones are attractive, nearby ants will be inclined to follow, more or less directly, the track;
4. Returning to the colony, these ants will strengthen the route;
5. If there are two routes to reach the same food source then, in a given amount of time, the shorter one will be traveled by more ants than the long route;
6. The short route will be increasingly enhanced, and therefore become more attractive;
7. The long route will eventually disappear because pheromones are volatile;
8. Eventually, all the ants have determined and therefore "chosen" the shortest route.

2. RIVER FORMATION DYNAMICS

This method is similar to that of the “Ant Colony Optimization”. In fact, this can be seen as a gradient version of Ant Colony Optimization, based on copying how water forms rivers by eroding the ground and depositing sediments. The gradients are followed by subsequent drops to create new gradients, reinforcing the best ones. By doing so, good solutions are given in the form of decreasing altitudes. This method has been applied to solve different NP-complete problems.

3. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is a global optimization algorithm for dealing with problems in which a best solution can be represented as a point or surface in an n-dimensional space. Hypotheses are plotted in this space and seeded with an initial velocity, as well as a communication channel between the particles. Particles then move through the solution space, and are evaluated according to some fitness criterion after each time step. Over time, particles are accelerated towards those particles within their communication grouping which have better fitness values. The main advantage of such an approach over other global minimization...
strategies such as simulated annealing is that the large number of members that make up the particle swarm make the technique impressively resilient to the problem of local minima.

**Ex:** Bird Flocking

4. **STOCHASTIC DIFFUSION SEARCH**

   It belongs to a family of swarm intelligence and naturally inspired search and optimisation algorithms which includes ant colony optimization, particle swarm optimization and genetic algorithms. It is an agent-based probabilistic global search and optimization technique best suited to problems where the objective function can be decomposed into multiple independent partial-functions. Each agent maintains a hypothesis which is iteratively tested by evaluating a randomly selected partial objective function parameterized by the agent's current hypothesis.

5. **GRAVITATIONAL SEARCH ALGORITHM**

   Gravitational search algorithm (GSA) is constructed based on the law of Gravity and the notion of mass interactions. The GSA algorithm uses the theory of Newtonian physics and its searcher agents are the collection of masses. In GSA, we have an isolated system of masses. Using the gravitational force, every mass in the system can see the situation of other masses. The gravitational force is therefore a way of transferring information between different masses.

6. **INTELLIGENT WATER DROPS**

   Intelligent Water Drops algorithm (IWD) is a swarm-based nature-inspired optimization algorithm, which has been inspired from natural rivers and how they find almost optimal paths to their destination. These near optimal or optimal paths follow from actions and reactions occurring among the water drops and the water drops with their riverbeds. In the IWD algorithm, several artificial water drops cooperate to change their environment in such a way that the optimal path is revealed as the one with the lowest soil on its links. The solutions are incrementally constructed by the IWD algorithm. Consequently, the IWD algorithm is generally a constructive population-based optimization algorithm.

7. **CHARGED SYSTEM SEARCH**

   Charged System Search (CSS) is a new optimization algorithm based on some principles from physics and mechanics. CSS is a multi-agent approach in which each agent is a Charged Particle (CP). CPs can affect each other based on their fitness values and their separation distances. The quantity of the resultant force is determined by using the electrostatics laws and the quality of the movement is determined using Newtonian mechanics laws. CSS is applicable to all optimization fields; especially it is suitable for non-smooth or non-convex domains. This algorithm provides a good balance between the exploration and the exploitation paradigms of the
algorithm which can considerably improve the efficiency of the algorithm and therefore the CSS also can be considered as a good global and local optimizer simultaneously.

V. APPLICATIONS OF SWARM INTELLIGENCE

a) CLUSTERING BEHAVIOR OF ANTS

Ants build cemeteries by collecting dead bodies into a single place in the nest. They also organize the spatial disposition of larvae into clusters with the younger, smaller larvae in the cluster center and the older ones at its periphery. This clustering behavior has motivated a number of scientific studies.

b) NEST BUILDING BEHAVIOR OF WASPS AND TERMITES

Wasps build nests with a highly complex internal structure that is well beyond the cognitive capabilities of a single wasp. Termites build nests whose dimensions are enormous when compared to a single individual, which can measure as little as a few millimeters. Scientists have been studying the coordination mechanisms that allow the construction of these structures and have proposed probabilistic models exploiting insects behavior. Some of these models are implemented in computer programs to produce simulated structures that recall the morphology of the real nests.

c) FLOCKING AND SCHOOLING IN BIRDS AND FISH

Scientists have shown that these elegant swarm-level behaviors can be understood as the result of a self-organized process where no leader is in charge and each individual bases its movement decisions solely on locally available information: the distance, perceived speed, and direction of movement of neighbours. These studies have inspired a number of computer simulations that are now used in the computer graphics industry for the realistic reproduction of flocking in movies and computer games.

d) ANT COLONY OPTIMIZATION

In ant colony optimization (ACO), a set of software agents called "artificial ants" search for good solutions to a given optimization problem transformed into the problem of finding the minimum cost path on a weighted graph. The artificial ants incrementally build solutions by moving on the graph. The solution construction process is stochastic and is biased by a pheromone model, that is, a set of parameters associated with graph components the values of which are modified at runtime by the ants.

e) PARTICLE SWARM OPTIMIZATION

It is inspired by social behaviors in flocks of birds and schools of fish. In practice, in the initialization phase each particle is given a random initial position and an initial velocity. The position of the particle represents a solution of the problem and has therefore a value, given by the objective function. At each iteration of the algorithm, each particle moves with a velocity that is a weighted sum of three components: the old velocity, a velocity component that drives the particle towards the location in the
search space where it previously found the best solution so far, and a velocity component that drives the particle towards the location in the search space where the neighbor particles found the best solution so far.

**f) SWARM BASED NETWORK MANAGEMENT**

Schoonderwoerd et al. proposed Ant-based Control (ABC), an algorithm for routing and load balancing in circuit-switched networks; Di Caro and Dorigo proposed AntNet, an algorithm for routing in packet-switched networks. While ABC was a proof-of-concept, AntNet, which is an ACO algorithm, was compared to many state-of-the-art algorithms and its performance was found to be competitive especially in situation of highly dynamic and stochastic data traffic as can be observed in Internet-like networks. An extension of AntNet has been successfully applied to ad-hoc networks.

**g) COOPERATIVE BEHAVIOUR IN SWARMS OF ROBOTS**

There are a number of swarm behaviors observed in natural systems that have inspired innovative ways of solving problems by using swarms of robots. This is what is called swarm robotics. In other words, swarm robotics is the application of swarm intelligence principles to the control of swarms of robots. As with swarm intelligence systems in general, swarm robotics systems can have either a scientific or an engineering flavour. Clustering in a swarm of robots was mentioned above as an example of artificial/scientific system.

**VI. ADVANTAGES OF SI**

- It is easily adoptable as conventional workgroups devise various standard operating procedures to react to predetermined stimuli. But swarms have better ability to adjust to new situations or to change beyond a narrow range of options.

- Evolution is the result of adaptation. Conventional bureaucratic systems can shift the locus of adaptation (slowly) from one part of the system to another. In swarm systems, individual variation and imperfection lead to perpetual novelty, which leads to evolution;

- Resilient. A swarm is a collective system made up of multitudes in parallel, which results in enormous redundancy. Because the swarm is highly adaptable and evolves quickly, failures tend to be minimal.

**VII. DISADVANTAGES OF SI**

- It is non-optimal and uncontrollable as it is very difficult to exercise control over a swarm. Swarm systems require guidance in the way that a shepherd drives a herd by applying force at crucial leverage points.

- It is unpredictable as the complexity of a swarm system leads to unforeseeable results. Emergent novelty is a primary characteristic of self-organisation by adaptive systems.

- Non-understandable – Sequential systems are understandable; complex adaptive
systems, instead, are a jumble of intersecting logic. Instead of A causing B, which in turn causes C, A indirectly causes everything, and everything indirectly causes A

- It is non-immediate as linear systems tend to be very direct. Flip a switch and the light comes on. Simple collective systems tend to operate simply. But complex swarm systems with rich hierarchies take time.

**VIII. CONCLUSION**

The idea of swarm behavior may still seem strange because we are used to relatively linear bureaucratic models. In fact, this kind of behavior characterizes natural systems ranging from flocks of birds to schools of fish. Humans are more complex than ants or fish and have lots more capacity for novel behavior, some unexpected results are likely, and for this reason, leading scientists and organizations will further pursue swarm approaches. Swarm Intelligence provides a distributive approach to the problem solving mimicking the very simple natural process of cooperation. According to my survey many solutions that had been previously solved using other AI approach like genetic algorithm neural network are also solve able by this approach also. Due to its simple architecture and adaptive nature like ACO has it is more likely to be seen much more in the future,