Analysis of Routing Algorithms based on the Natural Inspiration

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Abstract- Nature is a great and immense source of inspiration for solving hard and complex problems in computer science since it exhibits extremely diverse, dynamic, robust, complex and fascinating phenomenon. Nature inspired algorithms are metaheuristics that mimics the nature for solving optimisation problems opening a new era in computation. A new agent-based routing algorithm using optimisation techniques is implemented in this paper. The different optimisation techniques are warty frog fish, artificial ant, ant, ant lion, grey wolf, genetic algorithm (GA) are the combinations used in the packet delivery between the networks. The routing is a process of carrying the data from source to destination in the network. The output of these algorithms is determined by the simulation time. The experiments are implemented with the NS2 software platform, which is based on the basics of C, C++ and TCL scripting language. The results of the algorithm showed that the grey wolf optimiser (GWO) is much better than the other algorithms in the packet delivery between the networks.

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Abstract- Nature is a great and immense source of inspiration for solving hard and complex problems in computer science since it exhibits extremely diverse, dynamic, robust, complex and fascinating phenomenon. Nature inspired algorithms are metaheuristics that mimics the nature for solving optimisation problems opening a new era in computation. A new agent-based routing algorithm using optimisation techniques is implemented in this paper. The different optimisation techniques are warty frog fish, artificial ant, ant, ant lion, grey wolf, genetic algorithm (GA) are the combinations used in the packet delivery between the networks. The routing is a process of carrying the data from source to destination in the network. The output of these algorithms is determined by the simulation time. The experiments are implemented with the NS2 software platform, which is based on the basics of C, C++ and TCL scripting language.   The results of the algorithm showed that the grey wolf optimiser (GWO) is much better than the other algorithms in the packet delivery between the networks.

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I. Introduction

Bio-inspired computing, short form biologically inspired computing, is a field of study that loosely knits together subfields related to the topics of connectionism, social behaviour and emergence. It is often closely related to the field of artificial intelligence (AI), as many of its pursuits can be linked to machine learning. It relies heavily on the fields of biology, computer science and mathematics. Briefly put, it is the use of computers to model the living phenomena, and simultaneously the study of life to improve the usage of computers. Biologically inspired computing is a major subset of natural computation. The way in which bio-inspired computing differs from the traditional AI is in how it takes a more evolutionary approach to learning, as opposed to what could be described as "creationist" methods used in traditional AI. Bio-inspired computing, on the other hand, takes a more bottom-up, decentralised approach; bio-inspired techniques often involve the method of specifying a set of simple rules, a set of simple organisms which adhere to those rules, and a method of iteratively applying those rules. In

internetworking, the process involves moving a packet of data from source to destination. Routing is usually performed by a dedicated device called a router. Routing is a key feature of the Internet because it enables messages to pass from one computer to another and eventually reach the target machine. Each intermediary computer performs routing by passing along the message to the next computer. Part of this process involves analysing a *routing table* to determine the best path. Routing is often confused with *bridging,* which performs a similar function. The principal difference between the two is that bridging occurs at a lower level and is therefore more of a hardware function whereas routing occurs at a higher level where the software component is more important. And because routing occurs at a higher level, it can perform more complex analysis to determine the optimal path for the packet. A computer network or data network is a telecommunications network which allows computers to exchange data. In computer networks, networked computing devices exchange data with each other along network links (data connections). The connections between nodes are established using either cable media or wireless media. The best-known computer network is the Internet. Network computer devices that originate, route and terminate the data are called network nodes [1]. Nodes can include hosts such as personal computers, phones, servers as well as hardware. Two such devices can be said to be networked together when one device is able to exchange information with the other device, whether or not they have a direct connection to each other.

II. Warty Frogfish

Frogfishes are known as anglerfishes in Australia. Frogfishes are found in almost all the tropical and subtropical oceans and seas around the world, the primary exception being the Mediterranean Sea. Frogfishes are small, short and stocky, and sometimes covered in spinules and other appendages to aid in camouflage. The camouflage aids in protection from predators and to enables them to take prey. Many species can change colour; some are covered with other organisms such as algae or hydrozoa. In keeping with this camouflage, frogfishes typically move slowly, lying in wait for prey and then striking extremely rapidly, in as little as 6 ms. Frogfishes live in the tropical and subtropical regions of the Atlantic and Pacific, as well as

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in the Indian Ocean and the Red Sea. Their habitat lies for the most part between the 20-degree isotherms, in areas where the surface level water usually has a temperature of 20 degree Celsius. The greatest diversity of species is in the Indo-Pacific region, with the highest concentration around Indonesia. Frogfish live generally on the ocean floor around coral or rock reefs, at most up to 100 m deep.

Fig. 1: Warty Frog Fish

There are a few exceptions to these general limits. The brackish water frogfish is at home in ocean waters as well as brackish and fresh water around river mouths [4]. The sargassum fish lives in clumps of drifting sargassum, which often floats into the deeper ocean and have been known to take the sargassum fish as far north as Norway [5].Frogfishes generally do not move very much, preferring to lie on the sea floor and wait for prey to approach. Once the prey is spotted, they can approach slowly using their pectoral and pelvic fins to walk along the floor

[8, 10]. They rarely swim, preferring to clamber over the sea bottom with their fins in one of two "gaits" [6]. In the first, they alternately move their pectoral fins forward, propelling themselves somewhat like a two-legged tetra pod, leaving the pelvic fins out. Alternately, they can move in something like a slow gallop, whereby they move their pectoral fins simultaneously forward and back, transferring their weight to the pelvic fins while moving the pectorals forward. With either gait, they can only cover short stretches. In open water, frogfishes can swim with strokes of the tail fin. They also have a kind of jet propulsion that is often used by younger frogfish. It is achieved by rhythmically forcing their breath-water out through their gill openings, which lie behind their pelvic fins [10]. The sargassum frogfish has adapted fins which can grab strands of sargassum, enabling it to "climb" through the seaweed [2].The reproductive behaviour of the normally solitary frogfish is still not fully researched. There are few observations in aquariums and even fewer from the wild. Most species are free-spawning, with females laying the eggs in the water and males coming in behind to fertilise them. Anywhere from eight hours to several days before the egg-laying, the abdomen of the female starts to swell as the eggs absorb water, sometimes as many as 180,000 eggs [7]. The male begins to approach the female around two days before the spawning. It is not known if the spawn is predetermined by some external factor, such as the phase of the moon, or if the male is attracted to a smell or signal released by the female. In all hitherto observed breeding pairs, one partner was noticeably, sometimes as much as ten times, larger than the other. When the gender could be determined, the larger partner was always the female. During the free-spawning courtship ritual, the male swims beside and somewhat behind the female, nudges her with his mouth then remains near her cloaca. Just before the spawning, the female begins to swim above the ocean floor towards the surface. At the highest point of their swim they release the eggs and sperm before descending back. Sometimes the male pulls the eggs out of the female with his mouth. After mating the partners depart quickly as otherwise the smaller male would likely be eaten. A few species are substrate-spawners, notably the genera *Lophiocharon*, *Phyllophryne* and *Rhycherus*, which lay their eggs on a solid surface, such as a plant or rock. Some species guard their eggs, a duty assigned to the male in almost all the species, while most others do not [7] [8]. Several species practice brood carrying, for example the three-spot frogfish, whose eggs are attached to the male, and those in the genus *Histiophryne*, whose brood are carried in the pectoral fins. The eggs are 0.5-1mm (0.02-0.04) large and cohere in a gelatinous mass or long ribbon, which in sargassum fish are up to a metre (3.3 ft) long and 16 cm (6 inches) wide. These egg masses can include up to 180,000 eggs. For most species, the eggs drift on the surface. After two to five days, the fish hatch

and the newly hatched alevin are between 0.8 and 1.6 mm long (0.03 and 0.07 inches). For the first few days they live on the yolk sac while their digestive systems continue to develop. The young have long fin filaments and can resemble tiny, tentacle jellyfish. For one to two months they live planktonically. After this stage, at a length of between 15 and 28 mm (0.6-1.1 in), they have the form of adult frogfish and begin their lives on the sea floor. Young frogfish often mimic the colouration of poisonous sea slugs or flatworms.

III. Artificial Ant Algorithm

In computer science, artificial ants stand for multi-agent methods inspired by the behaviour of real ants. The pheromone-based communication of biological ants is often the predominant paradigm used [2]. Combinations of artificial ants and local search algorithms have become a method of choice for numerous optimisation tasks involving some sort of graph, for example, vehicle routing and internet routing. The burgeoning activity in this field has led to conferences dedicated solely to artificial ants, and to numerous commercial applications by specialised companies such as Ant Optima. As an example, ant colony optimisation (ACO) [3] is a class of optimisation algorithms modelled on the actions of an ant colony. Artificial ants locate optimal solutions by moving through a parameter space representing all possible solutions. Real ants lay down pheromones directing each other to resources while exploring their environment. The simulated ants similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions [4]. One variation on this approach is the Bees Algorithm, which is more analogous to the foraging patterns of the honey bee, another social insect. The inventors are Frans Moyson and Bernard Manderick. Pioneers of the field include Marco Dorigo and Luca Maria Gambardella [5].New concepts are required since intelligence is no longer centralised but can be found throughout all minuscule objects. Anthropocentric concepts have always led us to the production of IT systems in which data processing, control units and calculating forces are centralised. These centralised units have continually increased their performance and can be compared to the human brain. The model of the brain has become the ultimate vision of computers. Ambient networks of intelligent objects and, sooner or later, a new generation of information systems, which are even more diffused and based on nanotechnology, will profoundly change this concept. Small devices that can be compared to insects do not dispose of a high intelligence on their own. Indeed, their intelligence can be classed as fairly limited.

Fig. 2 : Artificial Ants

It is for example, impossible to integrate a high performance calculator with the power to solve any kind of mathematical problem into a biochip that is implanted into the human body or integrated in an intelligent tag which is designed to trace commercial articles. However, once those objects are interconnected they dispose of a form of intelligence that can be compared to a colony of ants or bees. In the case of certain problems, this type of intelligence can be superior to the reasoning of a centralised system similar to the

brain[6].Nature has given us several examples of how minuscule organisms, if they all follow the same basic rule, can create a form of collective intelligence on the macroscopic level. Colonies of social insects perfectly illustrate this model which greatly differs from human societies. This model is based on the co-operation of independent units with simple and unpredictable behaviour [7]. They move through their surrounding area to carry out certain tasks and only possess a very limited amount of information to do so. A colony of ants, for example, represents numerous qualities that can also be applied to a network of ambient objects. Colonies of ants have a very high capacity to adapt themselves to changes in the environment as well as an enormous strength in dealing with situations where one individual fails to carry out a given task. This kind of flexibility would also be very useful for mobile networks of objects which are perpetually developing. Parcels of information that move from a computer to a digital object behave in the same way as ants would do. They move through the network and pass from one knot to the next with the objective of arriving at their final destination as quickly as possible [8].

IV. Ant Lion Optimiser

Ant lion, also spelled ant-lion and ant lion, is a name applied to a group of about 2,000 species of insects in the family myrmeleontidae. The most well-known genus is myrmeleon. Strictly speaking, the term "ant lion" applies to the larval form of the members of this family, but while several languages have their own terms for the adult, there is no widely used word for them in English. Very rarely, the adults are called "ant lion lacewings". The length of a fully-grown well-nourished predatory larva is typically up to 1.2 cm, and that of an adult up to 4cm [1]. The ant lion larva is often called "doodlebug" in North America because of the odd winding, spiralling trails it leaves in the sand while looking for a good location to build its trap, as these trails look as if someone has doodled in the sand [2].

The ant lion optimiser mimics the hunting mechanism of ant lions in nature. Five main steps of hunting prey such as the random walk of ants, building traps, entrapment of ants in traps, catching prey and re-building traps are implemented in this algorithm. This algorithm was proposed in 2015 [5].Ant lions are worldwide in distribution, most common in arid and sandy habitats. A few species occur in cold-temperate places. They can be fairly small to very large neuroptera. The ant lion larvae eat small arthropods mainly ants while the adults of some species eat small pollen and nectar, while others are predators of small arthropods in the adult stage too [3]. In certain species of myrmeleontidae, such as dendroleon pantheormis, the larva, although resembling that of myrmeleon structurally, makes no pitfall, but seizes passing prey from any nook or crevice in which it shelters. The adult has two pairs of long, narrow, multi-veined wings in which the apical veins enclose regular oblong spaces, and a long, slender abdomen. Although they greatly resemble dragonflies or damselflies, they belong to an entirely different infraclass among the winged insects. Ant lions are easily distinguished from damselflies by their prominent, apically clubbed antennae which are about as long as head and thorax combined. Also, the pattern of wing venation differs with the very long hypo stigmatic cell being several times as long as wide. They also are very feeble fliers and are normally found fluttering about in the night, in search of a mate.

Fig 3 : Ant Lion

The adult is thus rarely seen in the wild because it is typically active only in the evening. The life cycle of the ant lion begins with oviposition. The female ant lion repeatedly taps the sand surface with the tip of her abdomen. She then inserts her abdomen into the sand and lays an egg. The ant lion larva is a ferocious-

appearing creature with a robust, fusi form body, a very plump abdomen, the thorax bearing three pairs of walking legs. The prothorax forms a slender mobile '"neck"' for the large, square, flattened head, which bears an enormous pair of sickle like jaws with several sharp, hollow projections. The jaws are formed by the maxillae and mandibles, which in each pincer enclose a canal for injecting venom between them. Depending on species and where it lives, the larvae will either hide under leaves or pieces of wood, in cracks of rocks, or dig pits in sandy areas. Ant lion larvae are unusual among the insects as they lack an anus. All the metabolic waste that is generated during the larval stage is stored and is eventually emitted as meconium near the end of its pupal stage [4]. The pupal stage of the ant lion is quiescent. The larva makes a globular cocoon of sand stuck together with fine silk spun from a slender spinneret at the posterior end of the body. These cocoons may be buried several centimet deep in the sand. It remains there for one month, until the completion of the transformation into the sexually mature insect, which then emerges from the case, leaving the pupal integument behind, and climbs to the surface. After about 20 min, the adult's wings are fully opened and it will fly off in search of a mate. The adult is considerably larger than the larva; they exhibit the greatest disparity in size between larva and adult of any type of holometabolous insects, by virtue of the adults having an extremely thin, flimsy exoskeleton – in other words, they have extremely low mass per unit of volume.

V. GREY WOLF OPTIMISER

The grey wolf optimiser (GWO) algorithm mimics the leadership hierarchy and hunting mechanism of grey wolves in nature proposed by Mirjalili *et al*. In 2014[11], four types of grey wolves such as alpha, beta, delta and omega are employed for simulating the leadership hierarchy. In addition, three main steps of hunting, searching for prey, encircling prey and attacking prey are implemented to perform optimisation. The leaders are a male and female, called alphas. The alpha is mostly responsible for making decisions about hunting, sleeping place, time to wake and so on. The alpha's decisions are dictated to the pack. However, some kind of democratic behaviour has also been observed, in which an alpha follows the other wolves in the pack. In gatherings, the entire pack acknowledges the alpha by holding their tails down. The alpha wolf is also called the dominant wolf since his/her orders should be followed by the pack. The alpha wolves are only allowed to mate in the pack. Interestingly, the alpha is not necessarily the strongest member of the pack but the best in terms of managing the pack. This shows that the organisation and discipline of a pack is much more important than its strength. The second level in the hierarchy of grey wolves is beta. The betas are subordinate wolves that help the alpha in decision-making or other pack activities. The beta wolf can be either male or female, and he/she is probably the best candidate to be the alpha in case one of the alpha wolves passes away or becomes very old. The beta wolf should respect the alpha, but commands the other lower-level wolves as well. It plays the role of an adviser to the alpha and discipliner for the pack. The beta reinforces the alpha's commands throughout the pack and gives feedback to the alpha. The lowest ranking grey wolf is omega. The omega plays the role of scapegoat. Omega wolves always have to submit to all the other dominant wolves.

Fig 4 : Grey   Wolf

They are the last wolves that are allowed to eat. It may seem the omega is not an important individual in the pack, but it has been observed that the whole pack face internal fighting and problems in case of losing the omega. This is due to the venting of violence and frustration of all wolves by the omega(s). This assists satisfying the entire pack and maintaining the dominance structure. In some cases the omega is also the babysitters in the pack. If a wolf is not an alpha, beta or omega, he/she is called subordinate. Delta wolves have to submit to alphas and betas, but they dominate the omega. Scouts, sentinels, elders, hunters, and caretakers belong to this category. Scouts are responsible for watching the boundaries of the territory and warning the pack in case of any danger. Sentinels protect and guarantee the safety of the pack. Elders are the experienced wolves who used to be alpha or beta.

Hunters help the alphas and betas when hunting prey and providing food for the pack. Finally, the caretakers are responsible for caring for the weak, ill and wounded wolves in the pack.

VI. Experimental Results

Table 1 : Packets Dropped Ratio

Algorithm	PacketsDropped- Ratio
Warty frogfish	7.881
Artificial ant	5.725
Ant lion optimiser	8.326
Greywolf optimiser	9.462

Graph 1 : Packets Dropped Ratio
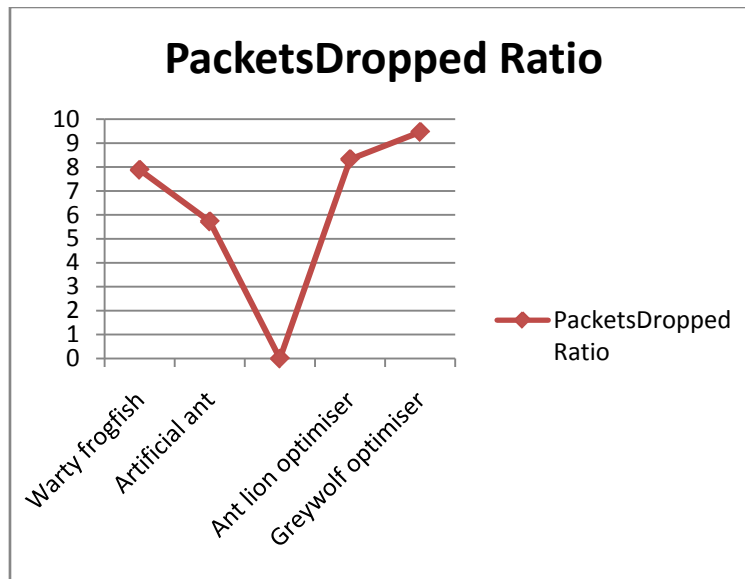
Table 2 : Performance

Algorithm	Performance (%)
Warty frogfish	57
Artificial ant	64
Ant lion optimiser	86
Grey wolf optimiser	99.90

Graph 2 : Performance of the Algorithms
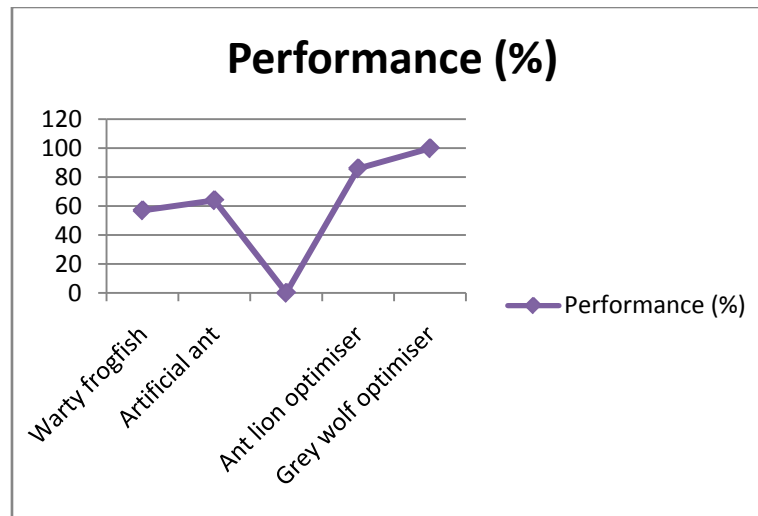
VII. CONCLUSION

The GWO is much suitable for dynamic and real computer networks where the failures of some routers are anticipated. Bio-inspired algorithms are going to be a new revolution in computer science. The scope of this area is really vast since as compared to nature, computer science problems are only a subset, opening a new era in next generation computing, modelling and algorithm engineering. It has been witnessed that the applications and growth of natural computing in the last years is very drastic and has been applied to numerous optimisation problems in computer networks, control systems, bioinformatics, data mining, game theory, music, biometrics, power systems, image processing, industry and engineering, parallel and distributed computing, robotics, economics and finance, forecasting problems, applications involving the security of information systems and so on. The experimental results showed that GWO is better than the other algorithms. Nevertheless, nature-inspired algorithms are among the most powerful algorithms for optimisation which is going to have a wide impact on future generation computing.

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