Communications in Mathematics and Applications
Vol. 12, No. 3, pp. 755–772, 2021
ISSN 0975-8607 (online); 0976-5905 (print)
Published by RGN Publications

http://www.rgnpublications.com

DOI: 10.26713/cma.v12i3.1637

Research Article

An Inspired Self-Organizing Emergent Approach for Autonomous (IoT) Systems

Besma Bekkai[1], Hakim Bendjenna*[1] and Kitouni Ilham[2]

[1] *Laboratory of Mathematics, Informatics and Systems (LAMIS), Laarbi Tebessi university, Tebessa, Algeria*
[2] *LISIA Laboratory, Constantine 2 - Abdelhamid Mehri University, Algeria*

Received: May 30, 2021 **Accepted:** August 2, 2021

Abstract. The IoT progressively happens in effective applications like security equipment, military and medicine use, transportation control, smart communications, meteorology methods. As long as these applications dimension is dreadful, appliance abilities are limited, specifically when it comes to delays and power consumption. IoT is a prototype like any human-made establishment which is exposed to interruptions, catastrophes, and different contradictory circumstances. Supplied communications fail in such conditions, interpreting this prototype with almost no utility. Therefore, network self-organization amongst these appliances would be required so as to empower communication flexibility and afterwards operative system. This article aims to suggest a self-organizing emergent approach for the IoT inspired by the nerve cell's mechanism. For every node across the network, it may interact efficiently with its neighbors and carry out auto-command in accordance with its standing. In presenting the neuromediator system like the intermediate for transmitting and distributing data, the nodes may work together cooperatively. The aptitude to successfully identify service produced unintentionally may as well be ensured in the potential partly operating IoT by providing the delivery method of neuromediators. To further demonstrate the effectiveness of the proposed approach, we also present a case study and a novel algorithm for autonomous monitoring of power consumption in networked IoT devices.

Keywords. Internet of things; Self-organization; Service discovery; Smart cities; Fire detection

Mathematics Subject Classification (2020). 68M10; 68M18

*Corresponding author: hbendjenna@gmail.com

1. Introduction

Over several generations remarkable achievements have been marked in technological communication and networking that have produced different data network structures and majority appliances in our environment nowadays assists some kind of communication and informatics. Widespread being within the environment of a wide range of items or articles which can throughout both wireless and wired joins and particular solving plans cooperate between them and with other items or articles so as to produce late applications or facilities and achieve shared objectives, these items involving security footage, cell phones, scanners wired and wireless, smart cars and identification of chip card applications fit in our daily living.

This sort of paradigm is called the Internet of Things. By this explanation of IoT, it became famous that the IoT is consisting of extensive miscellaneous network components not merely the prospect of processing power in addition to communication abilities. Consequently, the purpose of IoT, is to always permit the conjunction of items, anywhere, with whatever and whosoever preferably employing some trajectory or across the network and some utility. It has been greatly employed in mechanization industry, localization services, ecological control and different other applications ([17], [25]).

Certain investigators defined the Internet of Things like an independent method. The independent approach is based on the independent nervous system of the human organism. It may efficiently, control, track and adjust the human organism avoiding outside interference. An independent system allows these abilities for an extensive complicated miscellaneous system [2]. ACS may accommodate unforeseen Circumstances of the IT surroundings, lead and preserve themselves retrieve from failings with a minimal human involvement. Like determined by GivenNamePersonNamePaul SnHorn, the independent schemes show diverse features, these features are commonly called self-properties. It is quite usual to have intersections that join and quit a network voluntarily in the IoT schemes specifically in wireless and controller networking. The network should have the capacity to rearrange themselves towards this changeable topology [35].

Self-organization and power saving transport conventions are severe in IoT applications to insure the trade of equivalent information throughout miscellaneous networks. It would be preferable to take into account proposals without a command center point as a consequence of a lot of intersections. Whilst working on self-arrangement, it is equally crucial to estimate intersections' power use and seek resolutions which improve the duration of the IoT system and the performance of communication among its system [12], [8].

It's a great idea since constructing evolving systems are composed of a huge range of subsystems. Enhancing adaptivity and energetic adjustment to ecological change circumstances are the essential goals of self-organization. The existences continuously accommodate the changes in a coherent way, therefore the system constantly rearranges responding to numerous inner and outer causes alternatively. The mixture of these innate adaptive capacities to the distribution character of self-arranged systems results in another major benefit: strength against imperfections. No issue happening and the system may restore or modify the harm without external assistance. Consequently, the structure of self-arranging systems for shared ones is undoubtedly seen as the resolution to the difficulties of the enormous, energetic, complicated and varied IoT, that solicits shared information and produces smart items (or a division of it) independently respond to a variety of circumstances, without external assistance [27].

As of today, several algorithms for self-arrangement and processes were established for telecommunication systems, and ad hoc networks and especially sensory systems. These networks are usually much like IoT or are elements of IoT, yet there are abstract contrasts between these networks and important IoT ([4], [28]).

Whereas these issues suchlike adaptively, diversity, and complication are somewhat ancient, they have been effectively handled by goods of the communications skills development with character based on body systems self-organization monitor acquired significant consideration as an encouraging idea in order to reach strength, adaptivity and expandability ([13], [20]).

The species of these approaches have been proposed and have figured out their path in communication and web search due to the similarity between biological systems and grids [26], [5] for the ant farm enhancement [24], improving particle swarm [9], [19], and other comparable ways [15], [22].

The fake hormonal system (also called AES) is a different variety of bio-stimulated device but does not have a lot of consideration considering its restrictions in concrete implementation. Shen *et al*. [36] suggested the principle of a hormonal communication and monitoring in modulating auto-reconfigurable robotics. Ding *et al*. [10] introduced an approach based on the hormone-immunity system for the mechanical structure and energetic control of network services. The execution of these methods that suggest natural inspired impact their properties can likely be used to the research for self-organization and matching approaches in IoT.

The remainder of this paper is organized as follows: Section 2 provides the related works. Next, in Section 3, we discuss the proposed SELFOA for IoT system. Then, in Section 4, we present the implementation of the self-organizing approach. In Section 5, we discuss in details a case study for a system of the prevention of cities from disasters that may occur around a smart city and its components. Finally, we conclude this work in Section 6.

2. Related Works

According to our best of knowledge, there isn't detailed works of self-organization in IoT, self-organization has been thought out and algorithms proposed for network environments such as the self-organization of communications in sensor networks and mobile ad-hoc networks [39], [1]. The goal of self-organization is to supervene connectivity of all network nodes to a data collector in a homogeneous network. Bio-inspired communication methodologies promise to enable more scalable self-organizing network infra-structures. Especially in the area of mobile ad hoc sensor networks, such solutions are required in order to fit them for simplified development and deployment based on sovereign evolving mechanisms to work on global tasks, i.e. to show an emergent behavior. Fuchs *et al*. [16] introduce their ongoing research of Autonomic Networking focused on the developments on efficient data dissemination in sensor networks. A particular example of how to study biological processes and to adapt the results in communication networks, the feedback loop mechanism, depicts the potentials of this research area.

Ding *et al*. [11] proposed self-organizing scheme based on an endocrine regulation mechanism, for service discovery. The hormonal exchange acts as a mechanism via which information is exchanged between the nodes. Thus, nodes cooperate by exchanging information locally. An overview of bio-inspired algorithmic approaches for self-organization in contemporary cellular networks and M2M is given in [40].

The problem of self-organization has been a complex topic of research in wireless ad hoc networks including mobile and sensor networks. An excellent discussion of different algorithms supporting cluster-based organizations is furnished in [18].

Sohrabi *et al*. [37] discuss a protocol for self-organization of ad-hoc wireless sensor networks which allows nodes to build transmission schedules to conserve energy.

Learning approaches for self-organization are discussed in [31] and [30]. These are based on reinforcement learning and sequential learning. In addition, the authors also introduce cognitive hierarchy theory for handling the device heterogeneity.

Low Energy Adaptive Clustering Hierarchy (LEACH) was intended as a clustering scheme for the wireless sensor networks [18]. Outcomes of this work could help reform cluster head selection in the IoT if there is vary in radio technologies on a multi-radio platform. But it is still stays to be explored of how this could decode the energy management problem in self-organization in the IoT. Additionally, all these schemes of self-organization and clustering have been studied for homogeneous networks and thus it is not entirely obvious if they will be directly useful for heterogeneous networks in the IoT paradigm. However, these solutions will serve as a starting point for understanding the changes or new proposals needed for the local connectivity and path establishment and the service recovery management components of self-organization in the IoT. Wireless mesh networks have been proposed and studied with the goal of improving the distributed nature of networking [3]. Heterogeneity has been part of designs for wireless mesh networks. Wireless mesh networks have the property of self-healing when routes fail among the mesh routers. This property is proper when the lower layer mesh clients have other mesh routers to reach to ensuring that connectivity to the internet is still not lost. But when no mesh router is in the vicinity, then the neighbor discovery and local connectivity and path establishment components have to work together to establish paths to a functioning mesh router.

A wireless mesh based multi-hop self-organizing scheme was proposed for the smart meter infrastructure in the smart grid, as an enhancement to *Routing Protocol for Low Power and Lossy networks* (RPL) [23]. Their proposal is seen to work for 50 smart meters which were linked within 4 hops and mooted the possibilities of using multi-channel communication for self-organization techniques. But, the use of *Carrier Sense Multiple Access* (CSMA) provides no network performance guarantees over multiple hops, thus limiting their scale [34]. However, their alteration to the RPL serves as a good insight of how neighbor discovery, local connectivity and path establishment and service recovery management can be implemented as one system.

Naranjo et al. guarantee agreeable levels of coverage and data rate for *Intelligent Transport System* (ITS) applications. ITS is formed of *Vehicle to Vehicle* (V2V) and *Vehicle to Infrastructure* (V2I) communications. The authors use mesh communications for both approaches. The main goal of the authors is to produce a self-configurable topology that can fit to the high mobility environment of V2V and V2I. To that end, the authors use a modified version of the *Collection Tree Protocol* (CTP) for mesh topologies that pledges a data rate of 250 kbps. The profit of the application is that it was experimented in a real environment at the Technical University of Madrid using three vehicles equipped with nodes MTM-CM3100 which are based on the TelosB platform [29].

Krishnan *et al*. [21] present a message effective clustering algorithm for sensor networks. Clare *et al*. [7] explain different self-organizing procedures. Particular protocols are examined in [38]. Sohrabi *et al*. [37] discuss a protocol which permits nodes to build transmission schedules to conserve energy. Impact of energy conservation techniques (sleep/active schedules) on the performance of sensors (in terms of delivery delay) has been studied in [6].

In 2016, Qiu *et al*. [33] have put forth a routing protocol, named as [*Global Information Decision* (ERGID)], to aid the emergency response IoT. They have dealt with the problems that are related with the ejection of valid paths through a process for delay assessment, called, Delay Iterative Method (DIM). Additionally, load balancing in the network was attained through the Residual Energy Probability Choice. This approach considered the simulation results, which were got for energy consumption, packet loss, and delay. The network's real-time response potential was proved with all the testing results.

In 2016, Qiu *et al*. [32] have ensured enhanced performance and sustained robustness for the IoT structure using *Greedy Model with Small World* (GMSW). The Greedy criterion alleviated the conclusion of a node's local significance. It was assumed that the small world model only helps in yielding the feasibility of the optimization algorithm. As a result, their approach rendered a network using little world attributes through summing up the shortcuts that exist within the nodes, in accordance with the local significance. The speed that corresponds to the SMSW algorithm for making access to the network, which includes fewer shortcuts, was obtained through assessing the performance of their approach and conventional approaches.

3. The Self-Organizing Approach (SELFOA) for IoT System

In this section, we present the mechanism of nerve cells with its functions and implication in the internet of things and we also show the great similarities between the nervous system and the IoT.

- The nerve cell mechanism with its implication to the IoT

The person's brain is certainly the most complicate object in the world. It is the control center of the body. The brain is the organ that thinks acts and perceives thus permitting it to afford meaning to existence. It manipulates itself and everything so it is responsible for our behavior, our interactions with people. In fact, it is formed of various parts or parts joined to each other in a very specific way. Each place of the brain has specific tasks to act while being complementary to each other.

The brain sends and receives messages for uninterrupted communication between the outside world and the self. The cerebral hemispheres form the larger parts of the brain. They are separated into two parts, right hemisphere and left hemisphere. These hemispheres manage all our mental functions above, voluntary movements, thinking, learning, and memory. Each one is itself divided into different parts called lobes in which these functions are managed: the frontal lobe is the place of reasoning, speech, and language, decision-making, personality, movement, judgment; parietal lobe is for reading, sensitivity, location in space; occipital lobe for vision and the temporal lobe is the center of the hearing, emotions, and memory.

The nervous system is formed of different neurons; it includes about 25 billion neurons. A neuron is the brain's basic unit of work, it is a nerve cell whose discharge is to conduct nerve messages, and so it is responsible for the transmission of information to other nerve cells. Each neuron consists of a cell body, dendrites, and an axon. The cell body is the center of the cell, contains the nucleus and organelles. It has variable measurements (between 5 and 120 microns). The information from neurons upstream is sent through dendrites (nerve messages they collect from other cells). The axon is a part of the cell body and often as many smaller branches before ending at nerve endings. It is also a type of nerve fiber which leads the messages emitted by the neuron, a length of a few millimeters may vary up to 1 m. A neuron maintains contact with many other nerve cells through a link of electrical signals named nerve impulse or action potential and chemical.

The signal propagating within nerve branches is naturally electrical. In the case of the transmission from one neuron to another, there is no persistence between the nerve cells forming the synapse which is the area where the end of an axon makes touch with another neuron. The synaptic contacts are the granted places where information passes from one neuron to another. They have also formed junctions with other nerve cells where the presynaptic terminal of a cell comes into contact with the postsynaptic membrane of the other. Here, the transmission of information is done through a chemical message. These substances also have known as molecules, neurotransmitters stored at the end of a presynaptic neuron, they are released to the arrival of an action potential and transmits the information to the postsynaptic neuron. The nerve impulse travels along the axon to complete his way at the synaptic terminal.

The higher the frequency thereof, the greater the neuron produces chemicals (neurotransmitters or neurotransmitter). They contained in the vesicles are released into the extracellular medium at the synapse and will, in turn, activate or inhibit a second neuron dendrite at his or her cell body. Again, the nerve force continues its path along this second neuron and so on. There are various kinds of neurotransmitters, the famous are dopamine, serotonin, histamine, and acetylcholine. For example, the responsible neurons for producing dopamine situated in a deep area of the brain named the "black stuff" which is the key to movement control.

The same principle is in the case of message transmission from one neuron to an effector cell but the neurotransmitter lost by the postsynaptic cell will bind to the membrane of the effector cell triggering a response from the cell proportional to the amount of neurotransmitter set plays. The neurons form neural network connections in which the message can travel in two types: when a presynaptic neuron establishes synapses with many postsynaptic neurons, then we talk about divergent circulation and when many presynaptic neurons synapse with the postsynaptic neuron, it is merging traffic.

For the IoT system with a numerous number of heterogeneous nodes spread. Therefore, it is a challenge to strengthen the nodes with self-management and with independent capabilities. As a self-organized system, the nervous system has different elements such as the heterogeneity of cells distributed in various places and also scalability, the nervous system is made up of 100 billion nerve cells in which carries huge similarities between it and the IoT as follows:

- The nervous system consists of billions of nerve cells that involve different heterogeneous nodes in the IoT system.
- Nerve cells (neurons) of the nervous system release and exchange of chemical molecules (neurotransmitters) between them in the synaptic area. The interaction between nodes by these neurotransmitters built a network for information exchange for the IoT system where nodes can work cooperatively to adequate the tasks and objectives of the IoT.

4. The Implementation of the Self-Organizing Approach

We propose a self-organizing approach inspired by the mechanism of the nerve cell for IoT systems in other words how the system self-organizes in case of breakdown or failure that can monitor and keep his work. We assume in our approach a procedure that consists of several rounds `k(1,...,n)` and each round consists of three phases denoted as phase 1, phase 2, and phase 3 (Figure 1).

The first phase is the phase of the transmission and reception of the neurotransmitter, the second phase is the treatment of neurotransmitter and the last phase is system status determination. The transmission and reception of the neurotransmitter is the period of the correspondence and the judgment on the node status wherein two exclusive working states are designed for each node:

- *Waking Status*: a node in waking status can communicate, exchange and send data to other nodes in its area or its autonomous region and receive service requests that are sent by neighboring nodes. The nodes in this status consume energy more compared to other nodes that are in a dead status.

- *Dead Status*: a node in dead status ceases to transmit information to other nodes and it cannot detect service requests that are sent by neighboring nodes. The node with this status requires less energy and waits up to arrive at the next cycle.

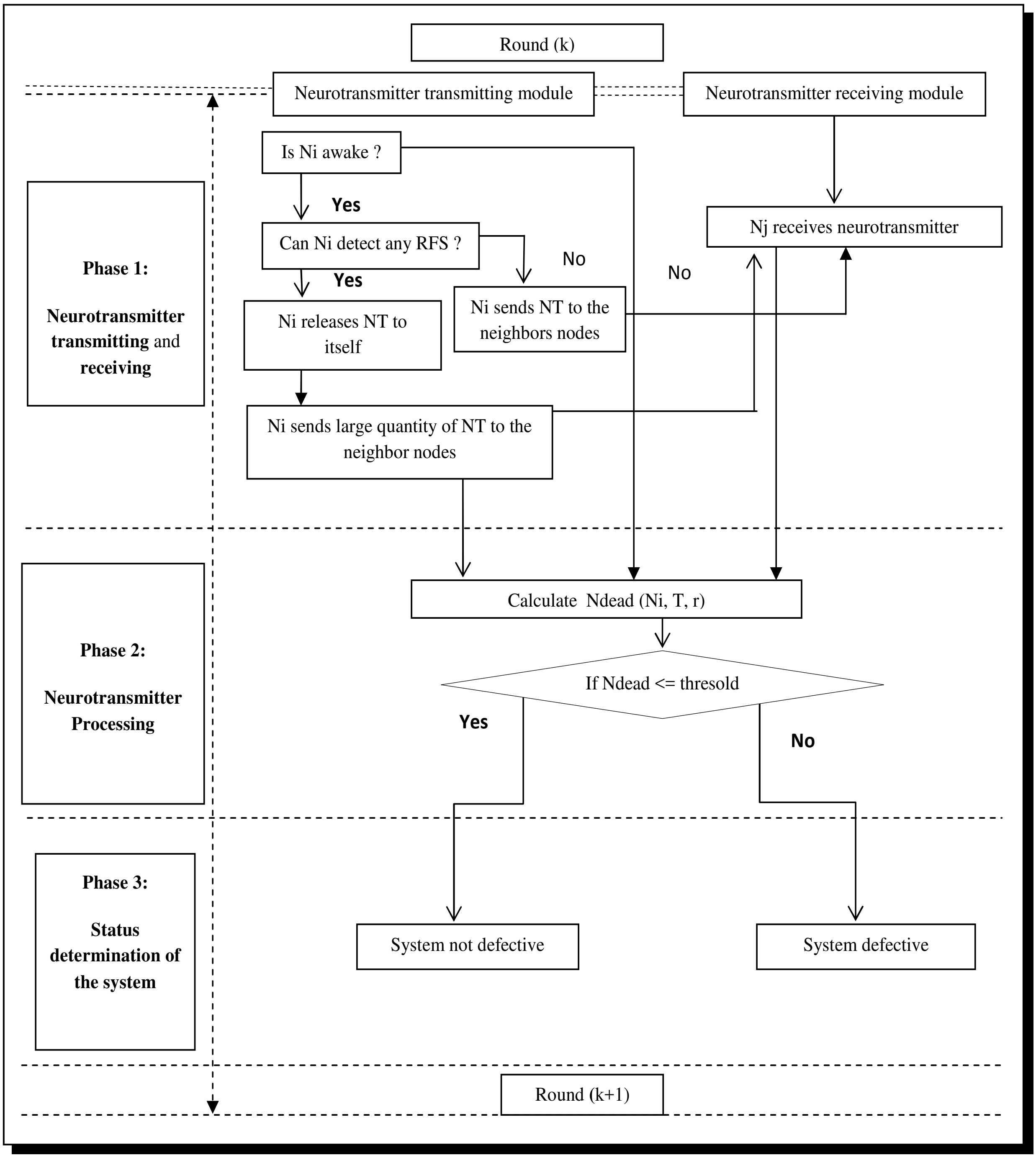

Figure 1. The flowchart of the SELFOA

Consider IoT consists of N nodes deployed randomly in a predefined area, here a status list is set to indicate whether the node Ni is not in its awaking status or dead in the round k, which can be expressed as follows:

- Status node (i,k)=1, if Ni is awake
- Status node (i,k)=0, if Ni is dead

The interconnections between the nodes are one of the fundamental characteristics of the IoT which must rely on the transmission of information through certain types of environment. Biological organisms in a nervous system have varieties of neurotransmitters circulating and connect them. This indicates that the neurotransmitter can be introduced to build the information exchange network for IoT. Also, the autonomous areas combined with neurotransmitters have the potential to strengthen the links between certain nodes to improve their cooperation and their functions.

(a) Neurotransmitter Transmission and Reception

In this step, the nodes in IoT mainly acquire information represented by molecules or neurotransmitter that is transmitted and received by the other neighbor's nodes. At the beginning of each round, a node firstly checks the value of its working status register. If the status node (i,k)=1 and a node will periodically send an amount of the *neurotransmitter* (NT) to the other nodes so the node Ni is awake and both the neurotransmitter transmitting module and receiving module are activated.

If Status node (i,k)=0 and a node periodically does not send any amount of NT to other nodes so the node Ni is dead.

For an awake node Ni, an RFS_ind indicator is set for recording whether any RFS around has been received, so:

- RFS_ind (i,t)=1, if any RFS is detected or received at time t.
- RFS_ind (i,t)=0, otherwise.

These statuses bring two different cases that can be observed as below:

(1) The node Ni is awake and has received at least one RFS. This indicates that at least one client asking for service is located around the node Ni. When Ni receives a RFS, it releases an amount of the neurotransmitter in the round k, and sends it to itself for increasing the value of its neurotransmitter and also improves his status that he is awake. After that, Ni send an additional quantity of its NT to other nodes so this indicates that he can communicate with them, exchange information, well justify and improve its working status. It's the case of (Ni sends large quantity of NT to the neighbor nodes).

(2) If the node Ni is awake but it does not discover any RFS which indicates that no client in need of service are located around this node. Ni sends an amount of the NT to the other nodes in order to communicate with them and further clarify its status. It's the case of (Ni Sends quantity of NT to the neighbor nodes).

Nj **received** NT: Each node Nj periodically receives a quantity of NT sent by Ni from the two transmitting and receiving modules.

(b) Neurotransmitter Processing

During the neurotransmitter processing stage, we calculate periodically the number of nodes that do not work at a time `T` in a specific region `r` using a function called `Ndead` constituting of three parameters which are the node `Ni`, an instant `T` and a specific region `r` which can be expressed as follows:

∀ `i`, `T-Told(Ni)>=P` such as:

`T`: the current time that the node `Ni` receives an amount of neurotransmitter.

`Told`: the time during which the node `Ni` receives a quantity of neurotransmitter later;

`P`: a period of time by second (e.g. `P`=10s)

As we know, the brain of the human being is composed of two parts called cerebral right and left hemispheres each of which has specific roles while being complementary to each other. Each hemisphere is itself divided into four sections called lobes, in which these various functions are supported: the frontal lobe, parietal lobe, temporal lobe, and occipital lobe. Therefore, in the IoT system, this region means a space or an area contains nodes communicate with each other and they provide a well-defined functionality. After this calculation, we compare this number of non-functioning nodes with a threshold which is a value or a function defined in advance by the system designer and from this comparison, determining the state of the system will be established.

(c) System Status Determination

This step aims to determine the system status from the previous step. The detailed procedures of such approach including the determination of system status can be described in the third part of Figure 1. If the number of nodes that do not work is less than threshold so there is no impact on the overall operation of the system, this indicates that the system is not defective and waking nodes self-organize implicitly to keep and follow the same system functionality. Otherwise, the system do an alarm if the nodes are faulty or fail, the alarm is given as soon have done that the first node that detects a violation of the threshold, it starts an alarm. Our approach of self-organization aims to detect as early as possible the system failure.

5. Case Study: Fire Detection System for Smart Cities Based on IoT

In this section, we present a system for the prevention of cities from disasters that may occur around a smart city. We propose an architectural design for the detection of fire events across smart cities. The features of the proposed fire detection model are to develop a system for forest fire detection utilizing wireless sensor networks and internet of things, to gather real time data information for several environmental parameters like temperature, humidity and smoke through IoT devices, to prove the occurrence of fire events and to generate an early alarm and warning message or notification in case of fire. The goal of this model is to develop an early fire detection system to determine the exact areas and locations of fire in forests.

5.1 Fire Detection System based on WSNs and IoT for Smart Cities

Recently, the wireless sensor network is one of the most essential techniques for forest fire detection around smart cities. Sensors furnish real time data from the fire zone and also can remark the neighboring physical parameters. WSN offers a scalable network to connect multiple devices and can adjoin various sensors to gather information regarding numerous parameters. Sensors can be deployed in several locations and places. Sensors are able to discover and broadcast the information through IoT applications for real time analysis. The IoT based sensor network collaboratively can detect and predict forest fire more effectively in comparison to the ancient approach. In a wireless sensor network, huge numbers of sensors are densely deployed in the forest area. Sensor nodes gather the sensed data like temperature, humidity, etc., and send the information gathered from this data to their relative cluster node, which further sends the data to cluster head forming a network. The on field deployed sensor nodes communicates with each other utilizing RF (radio-frequency) links. The gateway node is deployed for enabling a connection among WSN and the rest of the universe through cloud. The gateway sends the information to a server or cloud. The IoT enabled cloud platform stores the data and analyses it for decision making, after analyzing data, a fire warning and alert message can be generated. The scenario of fire events has been investigated from various perspectives along with various research trends like IoT, future internet technologies.

5.2 Proposed System

In this section, we present network components and operation of the proposed algorithm is explained. The confirmation phase is the important challenge for any fire detection system which is necessary to reduce the number of wrong alarms. Figure 1 presents a general overview of an integrated system for detection of fire event in a zone in smart city. The information is gathered through devices and it is sent to the cloud through a gateway. Generally, a smart city is bordered by an area that may be a forest area, agriculture field or any terrain. The proposed case study plays an important role for protecting areas from natural or manmade disasters. The proposed system is categorized into five parts i.e. sensors and detectors deployment (temperature sensors, wind sensors, fire detectors, drone and mobile application (smartphone)). The specification of each sensor node is discussed in the next section.

(a) Network Components

(1) Temperature Sensors

Temperature sensor is a sensor which will sense the temperature surrounding an area. The temperature sensors are deployed in the field area for the collection of environmental parameter (temperature) in real time. They co-operate among each other using radio frequency links and transfers data to the sink node.

(2) Wind Sensors

The conventional wind measurement system is the cup anemometer; it is formed of two different sensors, one measurement the speed and the other the direction. The speed sensor consists of a reel with 3 cups, arranged at 120 degrees and whose speed of rotation is proportional to the velocity of the wind. The anemometer is an electronic tool used to monitor the wind speed, to prevent air turbulence. It is also an instrument that makes it possible to measure the speed and the pressure of the wind linked with a vane, it can provide details about its direction. It is mainly used in meteorology. Wind speed measurements are important to different fields like air transportation, weather forecast, energy conversion, architecture, sealing, and farming. For example, in the building, the circulation of air, in terms of both speed and direction, has been recognized as a critical factor for the wellness of people inside. For many years, wind sensing was accomplished using large-scale mechanical flow meters such as anemometers, turbines, Pitot tubes, and so forth. Mechanical anemometers, usually consisting of propellers or cups to measure the wind speed and vanes to expose the wind direction, still represent the simplest and cheapest way of measuring the wind velocity.

(3) Fire detectors

A fire detector is an electronic device that analyzes the air at ceiling level. As soon as it perceives a fire, it emits an audible alarm. Autonomous smoke alarm detector is designed to prevent fire risks by detecting white smoke from the combustion of flammable materials (plastic, paper, wood ...). Smoke detectors are more expensive than heat detectors, but their response time is around a few seconds. This is why smoke detectors are very effective in places where the protection of people is primordial. There are several causes causing fires, they can be natural or human. Human beings have a remarkable responsibility in triggering forest fires, voluntarily and unintentionally imprudence or accident.

(4) Drone

Designates an aircraft without a pilot or passenger on board, which is driven remotely or that steals autonomously. It is able of holding a payload, having numerous forms as needed and having a level of IA (artificial intelligence) more or less evolved according to the models and applications they are intended. This level of IA permits it to be partially or totally independent of human actions to fulfill its tasks. The drone deploy provides the high resolution images of the target area. The sensed information is transferred to the ground station for processing in real time.

(b) Network Model

This section briefly describes the network model of the proposed system. The offered system is made up of five elements that are interconnected: a temperature sensor, wind detector (speed and direction), fire detector, a drone equipped with a camera and a Smartphone. If the detected temperature has exceeded a certain value and the fire detector detects a fire event in a specific area in a smart city which may be a forest or an agriculture area or other, and if the wind speed which is detected by the sensor of vend is very strong exceeds the limit, in this case, the fire will be increased because the higher the wind speed, the more the fire will burn so the drone is activated and it takes images of fire then sends them to the user's Smartphone or to the fire brigade and the latter receives a notification that it has a fire in such an area to prevent the spread of the fire and extinguish it.

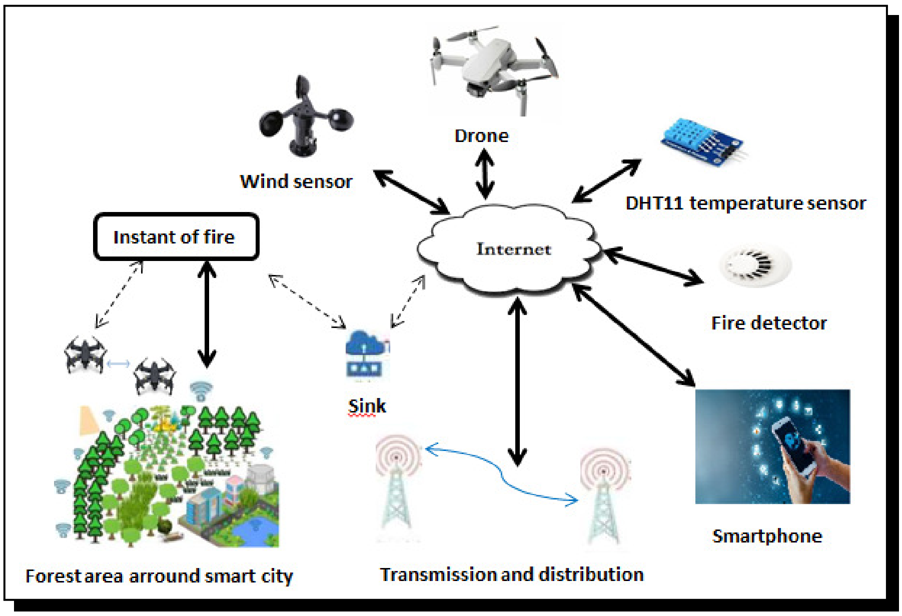

Figure 2. Vision of a proposed system for detection of fire event in Smart City

(c) Algorithm for Smart Cities Based on Internet of Things

In this section, we present an algorithm of fire detection system for smart cities.

Algorithm: Smart cities system algorithm

```
extract inf from data set
value=data['value'];
type=data['type'];
%Simple logic to control /handle the drone
if(type=='temperature')
If (value>=50)
\{
data=\{'state act drone'='ON'\};
print ('temperature=\%c>=50, state act drone ON' value);
\} else
data=\{'state act drone'='OFF'\};
print('temperature=\%c<50, state act drone OFF' value);
if(type=='speed wind')
\{if(value>=25)
\{
data=\{'state act drone'='ON'\};
print ('speed wind \%m/s>=25, state act drone ON'\% value);
\}
else
\{
```

```
data=\{'state act drone'=='OFF'\};
print('speed wind=\% m/s<25, state act drone OFF' \% value);
\}
\}
if (type=='fire detector')
\{
if (value=='true')
\{
data=\{'state act drone'='ON'\};
print('fire detector==true, state act drone ON'\% value);
else
data=\{'state act drone'='OFF'\}
print('fire detector=false. state act drone OFF'\% value);
%(Speed of fire increased with the increase in speed wind)
end;
if[(temperature>=50)or(speed wind>=25)or(fire detector==true)]
data=\{'state act drone'='ON'\};
end;
i=0; NT=1; int N; int tab[i]; Boolean state node; int threshold;
for(i=0 to N)
\{
tab[i]=state;
if(state node==true)
Nt=Nt+1;
else
function count dead node (Ni,t,r)
\{
 for all i: T-Told (Ni)>=P;
\}
end;
if (dead node<=threshold)
\{
print(state of the system: 'system not defective');
\}
else
print(state of the system: 'system defective');
end;
```

6. Conclusions and Perspectives

In this paper, a smart self-organization draft infused by the nerve cell's mechanism for the nodes in IoT is offered. The blanket interconnection and interaction among nodes by neurotransmitters builds a notification exchange network for the IoT where the nodes are able to work in a cooperative way to achieve tasks and goals attributed to the IoT. The fire around clever cities or forest fires are grave affairs across many countries. Researchers or experts across the world accord that for the stoppage of these disasters the foremost requirement is to enthrone in effective technologies. An IoT based algorithm is tendered for the fire detection system for intelligent cities. The system is able to perceive numerous environmental parameters and effective in the detection of an issue, by studying real-time data. The system empowers the monitoring of an event at any time, supplies a powerful key to diminish the opportunities for the happening of fire. The system is also able of transmitting an early warning alert of the detected event along with coordinates in the shape of notification on smartphone or emails to users. Forthcoming research may be taken to involve possible approaches to get comprehensive smart services where physical objects are actively implicated in the serving process. It demands not only mechanisms for service discovery but also the modes to deploy and form services during the runtime in a distributed fashion, which should be supported autonomously within all phases of the service lifecycle. Some interactive and collaborative mechanisms should also be applied to accomplish some more clever and omnipresent data exchange and resources allocation strategies in the IoT's dynamic environment.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

References

[1] A. A. Abbasi and M. Younis, A survey on clustering algorithms for wireless sensor networks, *Computer Communications* **30**(14-15) (2007), 2826 – 2841, DOI: 10.1016/j.comcom.2007.05.024.

[2] K. Ahuja and H. Dangey, Autonomic computing: An emerging perspective and issues, *International Conference on Issues and Challenges in Intelligent Computing Techniques* (ICICT), IEEE 2014, pp. 471 – 475, DOI: 10.1109/ICICICT.2014.6781328.

[3] I. Akyildiz and X. Wang, A survey on wireless mesh networks, *IEEE Communications Magazine* **43**(9) (2005), S23 – S30, DOI: 10.1109/MCOM.2005.1509968.

[4] B. Atakan and O. B. Akan, Distributed audio sensing with homeostasis-inspired autonomous communication, *Ad Hoc Networks* **9**(4) (2011), 552 – 564, DOI: 10.1016/j.adhoc.2010.08.009.

[5] J. C. Bezdek, S. Rajasegarar, M. Moshtaghi, C. Leckie, M. Palaniswami and T. C. Havens, Anomaly detection in environmental monitoring networks, *IEEE Computational Intelligence Magazine* **6**(2) (2011), 52 – 58, DOI: 10.1109/MCI.2011.940751.

[6] C. Chiasserini and M. Garetto, Modeling the performance of wireless sensor networks, in *IEEE INFOCOM 2004*, 7-11 March 2004, IEEE (2004), DOI: 10.1109/INFCOM.2004.1354496.

[7] L. Clare, G. Pottie and J. Agre, Self-organizing distributed sensor networks, in *SPIE — International Society for Optics and Photonics*, pp. 229 – 237 (1999).

[8] M. F. De Castro, L. B. Ribeiro and C. H. S. Oliveira, An autonomic bio-inspired algorithm for wireless sensor network self-organization and efficient routing, *Journal of Network and Computer Applications* **35**(6) (2012), 2003 – 2015, DOI: 10.1016/j.jnca.2012.07.023.

[9] M. F. De Castro, L. B. Ribeiro and C. H. S. Oliveira, An autonomic bio-inspired algorithm for wireless sensor network self-organization and efficient routing, *Journal of Network and Computer Applications* **35**(6) (2012), 2003 – 2015, DOI: 10.1016/j.jnca.2012.07.023.

[10] Y. Ding, H. Sun and K. Hao, A bio-inspired emergent system for intelligent web service composition and management, *Knowledge-Based Systems* **20**(5) (2007), 457 – 465, DOI: 10.1016/j.knosys.2007.01.007.

[11] Y. Ding, Y. Jin, L. Ren and K. Hao, An intelligent self-organization scheme for the internet of things, *IEEE Computational Intelligence Magazine* **8**(3) (2013), 41 – 53, DOI: 10.1109/MCI.2013.2264251.

[12] F. Dressler, A study of self-organization mechanisms in ad hoc and sensor networks, *Computer Communications* **31**(13) (2008), 3018 – 3029, DOI: 10.1016/j.comcom.2008.02.001.

[13] F. Dressler and O. B. Akan, A survey on bio-inspired networking, *Computer Networks* **54**(6) (2010), 881 – 900, DOI: 10.1016/j.comnet.2009.10.024.

[14] F. Dressler, I. Dietrich, R. German and B. Kruger, A rule-based system for programming self-organized sensor and actor networks, *Computer Networks* **53**(10) (2009), 1737 – 1750, DOI: 10.1016/j.comnet.2008.09.007.

[15] L. Filipe, M. Vieira, U. Lee and M. Gerla, Phero-trail: A bio-inspired location service for mobile underwater sensor networks, *IEEE Journal on Selected Areas in Communications* **28**(4) (2010), 553 – 563, DOI: 10.1109/JSAC.2010.100505.

[16] G. Fuchs, R. German, F. Dressler and B. Krger, Self-organization in sensor networks using bio-inspired mechanisms, (2005), URL: `https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.91.7667&rep=rep1&type=pdf`

[17] G. Han, J. Jiang, C. Zhang, T. Duong, M. Guizani and G. Karagiannidis, A survey on mobile anchor node assisted localization in wireless sensor networks, *IEEE Communications Surveys & Tutorials* **18**(3) (2016), 2220 – 2243, DOI: 10.1109/COMST.2016.2544751.

[18] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, An application-specific protocol architecture for wireless microsensor networks, *IEEE Transactions on Wireless Communications* **1**(4) (2002), 660 – 670, DOI: 10.1109/TWC.2002.804190.

[19] Y. Hu, Y. Ding and K. Hao, An immune cooperative particle swarm optimization algorithm for fault-tolerant routing optimization in heterogeneous wireless sensor networks, *Mathematical Problems in Engineering* **2012** (2012), Article ID 743728, 1 – 19, DOI: 10.1155/2012/743728.

[20] Y. Jin and B. Bernhard, A systems approach to evolutionary multiobjective structural optimization and beyond, *IEEE Computational Intelligence Magazine* **4**(3) (2009), 62 – 76, DOI: 10.1109/MCI.2009.933094.

[21] R. Krishnan and D. Starobinski, Message-efficient self-organization of wireless sensor networks, in: *2003 IEEE Wireless Communications and Networking*, (WCNC 2003), 16-20 March 2003, IEEE (2003), DOI: 10.1109/WCNC.2003.1200626

[22] R. V. Kulkarni and G. K. Venayagamoorthy, Bio-inspired algorithms for autonomous deployment and localization of sensor nodes, *IEEE Trans. Syst. Man, Cybern. C* **40**(6) (2010), 663 – 675, DOI: 10.1109/TSMCC.2010.2049649.

[23] P. Kulkarni, S. Gormus, Z. Fan and B. Motz, A self-organising mesh networking solution based on enhanced RPL for smart metering communications, in *2011 IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks* (WoWMoM), pp. 1–6 (2011).

[24] J.-W. Lee, B.-S. Choi and J.-J. Lee, Energy-efficient coverage of wireless sensor networks using ant colony optimization with three types of pheromones, *IEEE Transactions on Industrial Informatics* **7**(3) (2011), 419 – 427, DOI: 10.1109/TII.2011.2158836.

[25] S. Lu, Z. Wang, Z. Wang and S. Zhou, Throughput of underwater wireless ad hoc networks with random access: A physical layer perspective, *IEEE Transactions on Wireless Communications* **14**(11) (2015), 6257 – 6268, DOI: 10.1109/TWC.2015.2451625.

[26] M. Meisel, V. Pappas and L. Zhang, A taxonomy of biologically inspired research in computer networking, *Computer Networks* **54**(6) (2010), 901 – 916, DOI: 10.1016/j.comnet.2009.08.022.

[27] D. Miorandi, S. Sicari, F. De Pellegrini and I. Chlamtac, Internet of Things: Vision, applications and research challenges, *Ad hoc Networks* **10**(7) (2012), 1497 – 1516, DOI: 10.1016/j.adhoc.2012.02.016.

[28] A. Mutazono, M. Sugano and M. Murata, Energy efficient self-organizing control for wireless sensor networks inspired by calling behavior of frogs, *Computer Communications* **35**(6) (2012), 661 – 669, DOI: 10.1016/j.comcom.2011.09.013.

[29] J. E. Naranjo, E. Talavera, J. J. Anaya, F. Jimenez, J. G. Zato and N. Gomez, Highway test of V2V mesh communications over WSN, in *2012 15th International IEEE Conference on Intelligent Transportation Systems*, pp. 25 – 30 (2012), DOI: 10.1109/ITSC.2012.6338754.

[30] T. Park and W. Saad, Learning with finite memory for machine type communication, in: *2016 Annual Conference on Information Science and Systems*, 16-18 March 2016, IEEE (2016), DOI: 10.1109/CISS.2016.7460572.

[31] T. Park, N. Abuzainab and W. Saad, Learning how to communicate in the internet of things: finite resources and heterogeneity, *IEEE Access* **4** (2016), 7063 – 7073, DOI: 10.1109/ACCESS.2016.2615643.

[32] T. Qiu, D. Luo, F. Xia, N. Deonauth, W. Si and A. Tolba, A greedy model with small world for improving the robustness of heterogeneous Internet of Things, *Computer Networks* **101** (2016), 127 – 143, DOI: 10.1016/j.comnet.2015.12.019.

[33] T. Qiu, Y. Lv, F. Xia, N. Chen, J. Wan and A. Tolba, ERGID: an efficient routing protocol for emergency response, Internet of Things, *Journal of Network and Computer Applications* **72** (2016), 104 – 112, DOI: 10.1016/j.jnca.2016.06.009.

[34] I. Rhee, A. Warrier, J. Min and L. Xu, DRAND: Distributed randomized TDMA scheduling for wireless ad hoc networks, *IEEE Transactions on Mobile Computing* **8**(10) (2009), 1384 – 1396.

[35] M. Salehie and L. Tahvildari, Autonomic computing: Emerging trends and open problems, *ACM SIGSOFT Software Engineering Notes* **30**(4) (2005), 1 – 7, DOI: 10.1145/1082983.1083082.

[36] W. Shen, B. Salemi and P. Will, Hormone-inspired adaptive communication and distributed control for CONRO self-reconfigurable robots, *IEEE Transactions on Robotics and Automation* **18**(5) (2002), 700 – 712, DOI: 10.1109/TRA.2002.804502.

[37] K. Sohrabi and G. Pottie, Performance of a novel self-organisation protocol for wireless ad hoc sensor networks, in: *Gateway to 21st Century Communications Village*, VTC 1999-Fall, IEEE VTS 50th Vehicular Technology Conference (Cat. No. 99CH36324), IEEE (2002), DOI: 10.1109/VETECF.1999.798631

[38] K. Sohrabi, J. Gao, V. Ailawadhi and G. Pottie, Protocols for self-organization of a wireless sensor network, *IEEE Personal Communications* **7**(5) (2000), 16 – 27.

[39] J. Yu and P. Chong, A survey of clustering schemes for mobile ad hoc networks, *IEEE Communications Surveys & Tutorials* **7**(1) (2005), 32 – 48, DOI: 10.1109/COMST.2005.1423333.

[40] Z. Zhang, K. Long, J. Wang and F. Dressler, On swarm intelligence inspired self-organized networking: Its bionic mechanisms, designing principles and optimization approaches, *IEEE Communications Surveys & Tutorials* **16**(1) (2014), 513 – 537, DOI: 10.1109/SURV.2013.062613.00014.