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On Resiliency in Cyber-Road Traffic Control System using Modified Danger Theory based Optimized Artificial Immune Network

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ABSTRACT : *Cyber-Road Traffic control is a sub domain of Intelligent Transport System to make daily road traffic system as smart. Towards this various types of heterogeneous, federated, distributed infrastructure are in use, with diverse has be robust, reliable and secure for nominal operation of successful utilization of smart infrastructure, needs resiliency operation. The resiliency is a nonfunctional software requirement define as maintaining state awareness among them and if abnormality identified healing process occur to rollback normal operation. The proposal of road traffic infrastructure differentiates into In-vehicle, vehicle-vehicle, vehicle-infrastructure and, infrastructure-infrastructure and identify its infrastructural compounds, working operations, and possible nominal and abnormal behaviour of infrastructure. This infrastructure maintain nominal operation, by population based various multi Agent paradigm using Modified Danger Theory based Optimized Artificial Immune Network. This Artificial Immune network interaction is demonstrates in different infrastructure of road traffic system and validate through numerical and simulation environment.*

Keywords *– Cyber-Road Traffic control system, resiliency, Artificial Immune Network, Multi Agent System*

I. INTRODUCTION

Cyber-Physical system (CPS) is viewed as a new technology with next generation architecture to incorporate the computation and communication with the physical world. The application like cyber-road Traffic Control system where the environment is diverse in nature needs resiliency, which plays a major role in developing reliability and robustness [1]. The Traffic management is widely accepted as an important problem in modern society as it is responsible for keeping a steady flow of people, goods and services within cities. The quality of this flow directly affects the city's economy and general well-being of the population. Recently Various CPS based approaches have been introduced such as GPS equipped smart phones and sensor based frameworks which have been proposed to provide various services i.e. environment estimation, road safety improvement but they encounter certain limitations like high energy consumption and high computation cost.

To achieve efficient and safe road transportation is one of the motivations to carry out the research on CPS and is one of the most challenging areas, as it possesses the information, physical and social features [2] Cyber-Road Traffic control System can play a major role in reducing risks, high accidents rate, traffic congestion, carbon emissions, air pollution and on the other hand increasing safety and reliability, travel speeds, traffic flow and satisfied travelers for all modes. To meet safety and high reliability requirements, the Cyber-Road Traffic control System is modeled in the lines of Cyber-Road Traffic control system with Multi Agent Paradigm [3] and biological inspired Danger Theory based-modified Artificial immune Network is applied in MAS to develop resiliency. The proposal develops algorithm, defines resiliency as state awareness and healing process, with dendritic cells as Threshold-based agent population concentration and Artificial Recognition Ball as memory agent correspondingly [4]. This algorithm is validated with simulation results as well as numerical analysis.

TABLE I
COMPARISON OF MULTI AGENT SYSTEM ARTIFICIAL IMMUNE SYSTEM AND PROPOSED DANGER THEORY BASED-MULTI AGENT CYBER-PHYSICAL SYSTEM ARCHITECTURE[4]

Multi Agent System	Artificial Immune System	Proposed Architecture
Distributed System	*Cooperative work by Immune cell*	*Heterogeneous Multi Agent*
Self Maintained System	Seeing and Being seen	State awareness
Adaptive System	Somatic Level evolution by selection	Self healing Module

The contribution of the paper is to model the Cyber-Road Traffic control System with Multi Agent System Paradigm and apply biological inspired Human Immune System of Danger theory based optimized Artificial Immune Network Algorithm methodology as shown in Table 1. An outcome of these is to achieve resiliency operation in real time, diverse environment. Hence overall goal of this paper is to integrate all the Cyber-Road Traffic control System charactertics as multi agent population of Artificial immune network, where focus is on information flow and information processing such as recognition, learning, memory, and adaptation to achieve state awareness and healing process towards resiliency in cyber-physical system as shown in Figure 1.

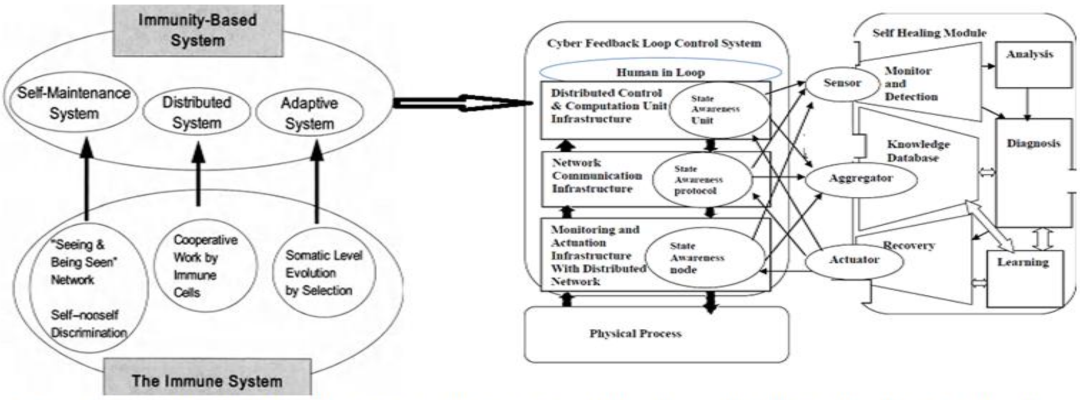

Fig. 1.Features of immunity-based system [5] and Autonomic Self Healing Architecture for Resiliency in Cyber Physical System [6]

The flow of the paper as follows: In Section 2 resiliency development methods and resiliency in Cyber-Road Traffic control System. Section 3 explains propose model of cyber-physical system through Multi Agent Paradigm on resiliency development. Section 4 Danger Theory Based Artificial Immune Network Algorithm is modified as a resiliency algorithm with state awareness and healing process. Section 5 Simulation parameter setting towards validating proposed algorithm and results is discussed.

II. RELATED WORK

Cyber physical system has been recognized as a key technique for providing next generation application which improves electricity delivery and usage, health care, transportation management system [7]. For the road traffic control, CPS studies elaborate, coordinated, efficient information space operations, realizing the traffic system control and travel behavior control [8] to make road traffic more safely and efficiently. The domain of traffic and transportation systems is well suited to an agent-based approach because of its geographically distributed nature and its alternating busy-idle operating characteristics [9], [10]. To meet the high reliability and safety requirements for these systems, various GPS based applications, frameworks have been proposed. [7] Describe how the mobile internet is changing the face of transportation CPS. They built a traffic monitoring system known as mobile millennium by using GPS equipped mobile devices, in this system collect traffic data from GPS-equipped mobile phones and estimate traffic condition in real time. The major drawback of this approach is high battery consumption, each mobile phone should be GPS equipped.CPS is not about the application methods of advanced information technology, but about the theory constructing new systems by integration of information processes and physical processes. Therefore, the research of traffic control physical systems start from the re-analysis of the model and construction [11]. Proposed a web of-thing based CPS architecture to improve road safety and to achieve high demand response in smart grids. [12] Proposed a framework on SIP/ ZigBee architecture. In this by using SIP and its extension, a seamless convergence of traffic measurement and short-range wireless sensor and equator networks can be achieved. [13] Proposed traffic monitoring system based on vehicle based sensor networks. These vehicle based sensors are embedded in vehicle for monitoring the traffic. These sensors are used due to its low communication cost and avoid the network congestion. The major drawback of this system is that it does not define the relationship between accuracy and number of speed elements (SE). So, these proposed systems suffer with some drawbacks and does not provide the services efficiently. To provide these services like Environment estimation, Road Condition estimation, Velocity and Travel Time estimation and Traffic Congestion information [14] TIS based on QCPS that provides services according to user's query. But the implementation of this needs a lot of server maintenance and highly qualified professionals which elevates the actual cost.

III. CYBER-ROAD TRAFFIC CONTROL SYSTEM WITH ARTIFICIAL IMMUNE MULTI AGENT SYSTEM PARADIGM

This section gives a broad overview of layered cyber-physical system [6], with the agent based paradigm. In each layer, different agents are defined with their roles for developing resiliency in cyber-physical system [15][16]. We understood the generic system of cyber process that is applicable to road traffic control system (intelligent transportation system). Cyber-Road Traffic control System has diverse environment with large scale, federated, distributed, heterogeneous components. For monitoring and actuation of these processes with communication and computation capabilities, it needs a real time abnormality monitoring, quick and accurate healing process [17][18]. Due to the nature of Cyber-Road Traffic control System discussed, developing nonfunctional requirement like resiliency are proposed with a multi-agent paradigm and Biological inspired computational methodology of Artificial Immune System which is adopted for Multi-level defense in both parallel and sequential fashion[5].

We understand the comparison between Cyber Physical Multi Agent Paradigm System and Road Traffic Control System. Also, the various interaction between vehicles and infrastructure or we can say the different entities along the road, how they interact by using different standards and their various applications and features. It is composed of three levels [11],

- the application of the CPS theory of integrating information process into transportation process
- traffic detection and control of information on the implementation of technical solutions
- support of modern computing, communication and control technology

Road Traffic Process with Multi Agent Paradigm

The road transportation system is a large-scale human-made engineering system which cannot operate safely and efficiently. The mechanics changing process of key transportation infrastructure like bridge, culvert, tunnel, subgrade, and slope, roadside and so on are Traffic physical processes. While, the ubiquitous sensing detection in a wide range of reliable interconnected, depth perception, forecast, warning and monitoring are Information processes. The Functions of this system are to achieve real-time monitoring of road facilities and transportation, meteorological environment detection. As in the figure 2,

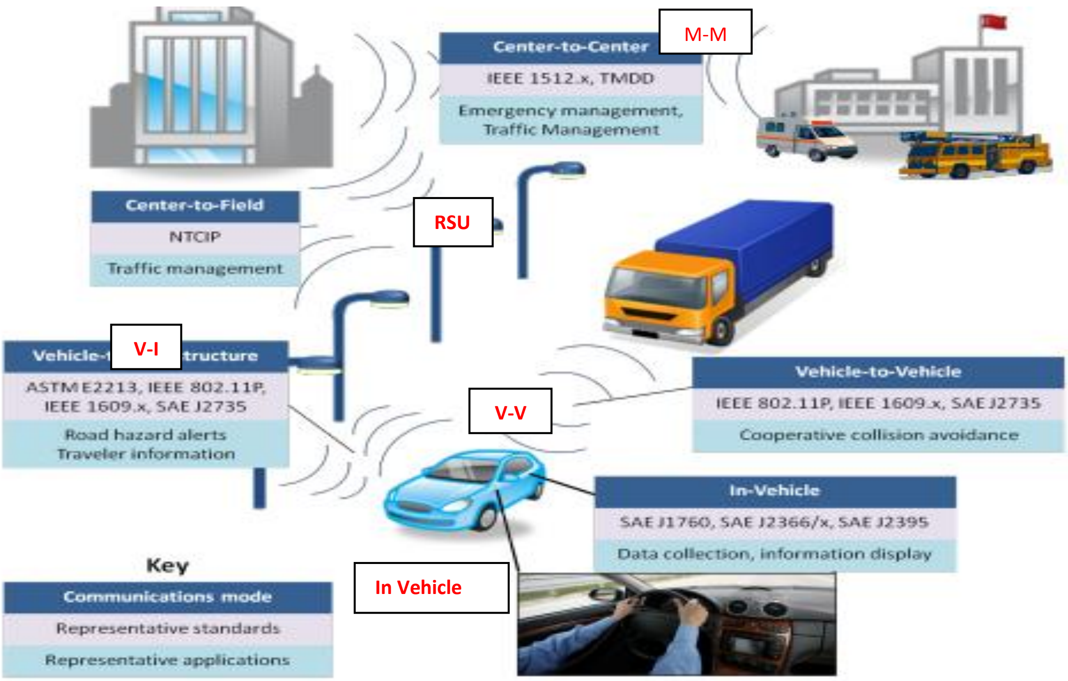

Fig. 2.Intelligent Road Traffic control system and its infrastructure [19]

In-Vehicle:

The evolution in mobile and wireless communication technology has led to use of Built-in equipment in cars or trucks can easily access traveling-related dynamic information, such as the current situation on the roads, weather forecasts, or information on local points of interests using internet. However, personal information of the vehicle's passengers – which could be also very useful for their travel. This information is not easily accessible by the driver or the built-in equipment.

To help manage the information, we need a mechanism to orchestrate the operations of the in-vehicle devices so that such frustration due to an influx of individual messages from a lot of new devices can be eased. In this study, we propose an in-vehicle communication scheme for multi-system integration, where an effective system service discovery protocol is used. This proposed design also contains mutual communication methods and the data exchange methodologies for system integration. In- vehicles the information useful for traveling is usually not located at one device – it is distributed over various mobile and handheld devices: The mobile phones contain their phone books, PDAs (Personal Digital Assistants) manage the passengers' time schedules. The navigation unit has the current information of the road situation and is able to specify the route with the estimated time to reach the specified destination, vehicle's radio receives periodically the current weather conditions, Laptop contains e-mails or documents that should be sent.

The various standards used are: SAE J1760, SAE J2366/x, SAE J2395.

TABLE II MONITOR NETWORK AS IN-VEHICLE

CPS Infrastructure	simple sensors with limited capabilities
CPS Nominalcy Behavior	Set of sensors are used to gather continuous information about the physical system.
Effect due to internal and External source	Electromechanical transducer which measures certain attributes of the physical system such as speed, temperature, and pressure and converts it to an electrical signal
Issue to be handle	Control System centric-*multiple control loops*
Agents Type	Reactive
Local Decision	• Sensor Agent • Resource Agent • Tactical Survival Agent
Global Performance	• Tactical Survival Agent • Resource Agent • Connection Admission control Agent

- The monitor network shown in figure 2 has set of sensors, and is of Reactive Agents as a proposal, Sensor Agent, Resource Agent ,Tactical Survival Agent, Connection Admission control Agent are define as shown
- The actuator network shown in figure 2 has set of actuator device as Actuator Agent, Tactical Survival Agent, Resource Agent and Connection Admission control Agent are proposal and it is reactive Agent in Nature.

Vehicle-Vehicle:

Vehicle-to-Vehicle Communications is used for cooperative collision avoidance. By exchanging anonymous, vehicle-based data regarding position, speed, and location (at a minimum), V2V communications enables a vehicle to: sense threats and hazards with a 360 degree awareness of the position of other vehicles and the threat or hazard they present; calculate risk; issue driver advisories or warnings; or take pre-emptive actions to avoid and mitigate crashes. At the heart of V2V communications is a basic application known as the Here I Am data message. This message can be derived using non-vehicle-based technologies such as GPS to identify location and speed of a vehicle, or vehicle-based sensor data wherein the location and speed data is derived from the vehicle's computer and is combined with other data such as latitude, longitude, or angle to produce a richer, more detailed situational awareness of the position of other vehicles. Because the Here I Am data message can be derived from non-vehicle-based technologies.

The Features are Emergency Brake Light Warning, Forward Collision Warning, Intersection Movement Assist, Blind Spot and Lane Change Warning, Do not pass Warning, Control Loss Warning.

- The monitor network shown in figure 2 has set of sensors, Reactive Agents as a proposal, Sensor Agent, Resource Agent ,Tactical Survival Agent, Connection Admission control Agent are define as shown

- The actuator network shown in figure 2 has set of actuator device as Actuator Agent, Tactical Survival Agent, Resource Agent and Connection Admission control Agent are proposal and it is reactive Agent in Nature.

Example of Application: Traffic control technology, e.g. Intelligent Transportation System,

– ***Realise traffic control***

The road traffic system process and the traffic control process is the Traffic physical process.Traffic control system model description, traffic system control and traffic behaviour control instruction optimization calculation is Information process

The Function is to achieve a more secure and efficient dynamic road traffic control

TABLE III ACTUATOR NETWORK AS VEHICLE – INFRASTRUCTURE

CPS Infrastructure	Simple Sensors with limited capabilities
CPS Nominalcy Behavior	Set of sensors are used to gather continuous information about the physical system.
Affect due to internal and External source	Electromechanical transducer which measures certain attributes of the physical system such as speed, temperature, and pressure and converts it to an electrical signal
Issue to be handle	Control system centric-*multiple control loops*
Agents Type	Reactive
Local Decision	• Sensor Agent • Resource Agent • Tactical Survival Agent
Global Performance	• Tactical Survival Agent • Resource Agent • Connection Admission control Agent

Vehicle-to-Infrastructure:

Vehicle-to-Infrastructure (V2I) Communications for Safety is the wireless exchange of critical safety and operational data between vehicles and roadway infrastructure, intended primarily to avoid motor vehicle crashes.V2I provides road hazards alert and traveler information. V2I communications for safety is a key research program of the Intelligent Transportation Systems. Data and communication standards have been developed through this research effort which includes the SAE J2735 Basic Safety Message; and a standard communications architecture/ platform communicating in the 5.9 GHz band of radio spectrum. V2I applications can be designed to help improve critical safety situations. The various standards used are: ASTM E2213, IEEE 802.11P, IEEE 1609.x, SAE J2735.

The Features are intersection safety, roadway departure prevention, speed management, transit safety and operations, commercial vehicle enforcement and operations, at-grade rail crossing operations, priority assignment for emergency vehicles

- The monitor network shown in figure 2 has set of sensors, and it as Reactive Agents as a proposal, Sensor Agent, Resource Agent ,Tactical Survival Agent, Connection Admission control Agent are define as shown
- The actuator network shown in figure 2 has set of actuator device as Actuator Agent, Tactical Survival Agent, Resource Agent and Connection Admission control Agent are proposal and it is reactive Agent in Nature.

Example of Application: Connected vehicles and autonomous driving have been rapidly gaining momentum in recent years

– ***cyber transportation systems (CTS)***

The relation between the synergic relationship process of car-to-car and car-to-road which are running in the road and communication process is the Traffic physical process. The Wireless, high-speed, high reliability, security communications, automatic driving safer and self-adaption is Information process. The Functions are High speed information exchange, in order to guarantee the safety of vehicles in efficient access.

TABLE IV COMMUNICATION NETWORK LAYER AS CENTRE – FIELD

CPS Infrastructure	wired and wireless communication and networking devices
CPS Nominalcy Behavior	Real-time data between sensors, computing subsystems, and actuators
Affect due to internal and External source	Communication between different CPS elements is vulnerable to various computer network threats such as eaves-dropping, DoS, data modification, man-in-the-middle, and many other attacks
Issue to be handle	Buffer Maintenance, ability to share, and ultimately negotiate resource-*a* wireless network segment
Agents Type	Hybrid
Local Decision	• Tactical Survival Agent • Resource Agent • Connection Admission control Agent
Global Performance	• Tactical Survival Agent • Resource Agent • Connection Admission control Agent

Cyber Process with Multi Agent Paradigm

The Communication layer and computation and control layer shown in Figure 2, enhances embedded control system in physical process as

Center-to-Field:

This is used for traffic management. The National Transportation Communication for Intelligent system transportation protocol is a family of standards designed to achieve Interoperability and interchangeability between computers and electronic traffic control equipment from different manufacturers. NTCIP has enabled the center to field communication and command/control of equipment from different manufacturers to be specified, procured, deployed, and tested.

The Features are Improved collaboration and cooperation between jurisdictions, Improved traveler information quality and timeliness, Decreased emergency response times which reduces the impact to traffic and reduces the number of secondary crashes, Cost savings to emergency responders as the appropriate response equipment is identified much earlier, and inappropriate response equipment is not dispatched to the incident scene, Improved response across jurisdictional boundaries. This includes reduced delay as traffic signals are optimized across jurisdictional boundaries, reduced delay and improved mobility for the traveler

- The communication network layer has hybrid Multi Agent of Tactical Survival Agent, Resource Agent, Connection Admission control Agent in this layer as shown figure 2.
- The population based Artificial Immune methodology for optimal resources utilization in communication layer.

Center-to-Center:

Center to center (C2C) communication involves peer-to-peer communications between computers involved in information exchange in real-time transportation management in a many-to-many network. This is used for traffic management, emergency management. This type of communication is similar to the Internet, in that any center can request information from, or provide information to, any number of other centers. An example of center to center communications is two traffic management centers that exchange real-time information about the inventory and status of traffic control devices. This allows each center system to know what timing plan, for example, the other center system is running to allow traffic signal coordination across center geographic boundaries. The various standards used are: IEEE 1512.x, TMDD.

Connection Admission control Agent in communication layer as shown in figure 2.

- The Computation and Control Unit layered shown in figure 2 and it as hybrid Multi Agent of Computation Agent, Control Agent and Tactical Survival Agent as shown in Figure 2.
- The Computation Agent which helps in generation control command with the Control Agent. Control Agents take higher level policy either by expert system or human in loop, is managed by utilizing available resources through a resource agent. The Resource Agent is used to maintain control command to be generated by the service provider. There will be each Resource Agent for Souce-Destination pair of request as shown in figure 2. The Connection Admission control Agent is responsible for providing available resources to computation Agent and control Agent for operation for local and global stability is maintained on resiliency development.

TABLE V COMPUTATION AND CONTROL UNIT AS CENTRE – CENTRE

CPS Infrastructure	Embedded computing systems
CPS Nominalcy Behavior	A number of embedded controllers process sensing data and compute feedback decisions
Affect due to internal and External source	Computational Platform incorporating a mixture of software-based and hardware-based processing devices, storage elements, I/O peripherals, and communication devices interacting together
Issue to be handle	Consensus Fuzzy Logic *-predictable network traffic and legacy components*
Agents Type	Hybrid
Local Decision	• Computation Agent • Control Agent • Tactical Survival Agent • Resource Agent
Global Performance	• Computation Agent • Control Agent • Tactical Survival Agent

IV. APPLICABLE OF IMMUNE CONCEPT IN DEFINED AGENTS

This section defines immune agents used in the developing resiliency in cyber-physical system as Multi Agent Paradigm. The previous section defines generic agent in each layer of cyber-physical system, defined agents are applied immune charactertics as shown in Table 2. In the context of Immune system antigen, Dendritic Cell, T-cell and Responding, properties are defined as Antigen Agent, Dendritic Cell Agent, T-Cell Agent, and Responding Agent [15] and for healing process and Preliminary information for healing process is adopted in [16]. Signals are represented as real-valued numbers, proportional to values derived from the context information of the dataset in use. The antigen is only used for the labeling and tracking of data. This is applied to propose application.

- **Antigen Agent:** The Antigen is represented as binary strings extracted by neighbor Agent in the population. An Agent that contains an abnormal profile of data item in the data set.
- **Dendritic Cell Agent:** The Dendritic Cell has special characteristics for sensitivity of input signal to collect and capable of data Per-processing that is classify collected signal and transform to either one of the state, this state is formed through the population of agent having same decision have mature context antigen value (MCAV) for triggering T-cell Agent activation for response. **-**
- **T-Cell Agent*:*** The Agent receives mature context antigen value depends on the MCAV value take appropriate decides for different type of cause.
- **Responding Agent:** The agent acts like a helper to all agent operations mentioned.
- **Training Agent:** the Training Agent is the Antigen of same class represent by cells like dendritic cell or T-cell which acts as Anomaly Detector.
- **Artificial Recognition Ball:** The ARB (Artificial Recognition Ball) which is also known as B Cell in Human Immune System having capable of generating immune response. It consists of Antigen, count of resource hold and current stimulation value.
- **Candidate Agent:** the Candidate Agent is an antibody of ARB of same class as the training antigen, which most stimulated after expose to the given antigen.
- **Clonal rate:** the clonal rate is the number of mutated clones a given ARB is allowed to attempt to produce. It is an integer value to determine (clonal rate * stimulation value) mutated clones after responding to a given antigen.

The Artificial Immune Network [17] in cyber-physical system for resiliency development. Since CPS is represented as MAS layered discussed above section. Each layer works with different type of population of Agent for their Local Decision and Global Performance. We adopted Danger theory concept, such that Danger signal and Danger Zone of an agent, dendritic cell and Artificial Recognition Ball concept for state awareness

TABLE II

COMPARING ABOVE CONCEPT WITH PROPOSED CONCEPT[4]

Artificial Immune Concept	**Agent Interaction for state awareness in Cyber-Physical System**	**Agent State in Cyber-physical System Architecture**
PAMPs	Signal from Signature Based	Activate outer Self-healing Module
Danger Signals	Signal from Behavior of other Agent	Activate outer Self-healing Module
Safe Signals	Signal within variable threshold value	Present in Inner State awareness loop
Initialization of Abnormal Agent	Random generation of memory Agent by stimulation threshold of Abnormal Agent	Present in Inner State awareness loop
Clone operation	Memory Agent	Activate outer Self-healing Module
Mutation operation	ARB Agent	Activate outer Self-healing Module

and healing process. So individual Agent population, acts as data fusion and its anomaly detection are identifying depends on danger signal and danger zone for each environment

An abstract view of CPS interaction is Shown Figure 3. The algorithm is based on a multi-agent framework, where each Agent processes its own environmental signals and collects antigens. The diversity is generated within the Agent population through the application of a 'migration threshold'- this value limits the number of signal instances an individual the agent can process during its lifespan. This creates a variable Time window effect, with different cells processing the signal and antigen input streams over a range of time periods [20]

The combination of signal/antigen correlation and the dynamics of a cell population are responsible for the anomaly detection capabilities of the DCA.

Let Agents in the population is defined as follows, If **S** is the set of Agent with its lifespan, $s(t) = \{Ag_1(t), Ag_2(t), \ldots\ldots\ldots\ldots Ag_n(t) \in R^n\}$, $\mathbf{R}^{\mathbf{n}}$ is the decision variable with **n** variable dimension,

Let Antigen set, $Ag_1(t) = \{a_0, a_1, a_2 \ldots\ldots\ldots\ldots\ldots a_n\}$ has attribute value in the set, may act as Antigen in the process.

Let, $f(Ag(t))$ be the function of each Agent. Agent population has to normalize as, $\min\{f(Ag_i(t)), Ag_j(t) \in R^n\} or \max\{f(Ag_i(t)), Ag_j(t) \in R^n\}$. The Signal transformation between Agents is represented as, $w_{ij} \in$ **R** weight matrix of signal transformation as W in matrix with two rows and three columns used to categories state of the agent.

Let Agents in the population for training to healing process is defined as follows,

If AnAgAg.c(t) is the set of Abnormal Agent with its lifespan from state awareness module for healing process by training shown in Fig. 3

$$AnAg_{Ag.c}(t) = \{AnAg_1(t), AnAg_2(t), \ldots\ldots\ldots AnAg_{Ag.cn}(t) \in R^n\},$$

$\mathbf{R^n}$ is the decision variable with n variable dimension,

If MgMg.c(t) is the set of memory Agent with its lifespan for the corresponding Abnormal Agent. Since Rn is same, memory cell and Abnormal Antigen should belong to a same class.

$$Mg_{Mg.c}(t) = \{Mg_1(t), Mg_2(t), \ldots\ldots\ldots Mg_{Mg.cn}(t) \in R^n\}$$

If $ARB_{Agent.c(t)}$ is the set of Artificial Recognition Ball Agent with its lifespan act as healing Agent for the corresponding Abnormal Agent with the help of memory Agent of the same class.

$$ARB_{Agent.c(t)} = \{ARB_1(t), ARB_2(t), \ldots\ldots\ldots ARB_{Agent.cn}(t) \in AbAg_{Ag.c}\}$$

Let Abnormal Agent Stimulation level represent, AbAg.stim of the ARB AbAg.

Let number of resources held by the ARB AbAg represent AbAg.resources.

Let TotalNumResources represent the total number of systems wide resources allowed.

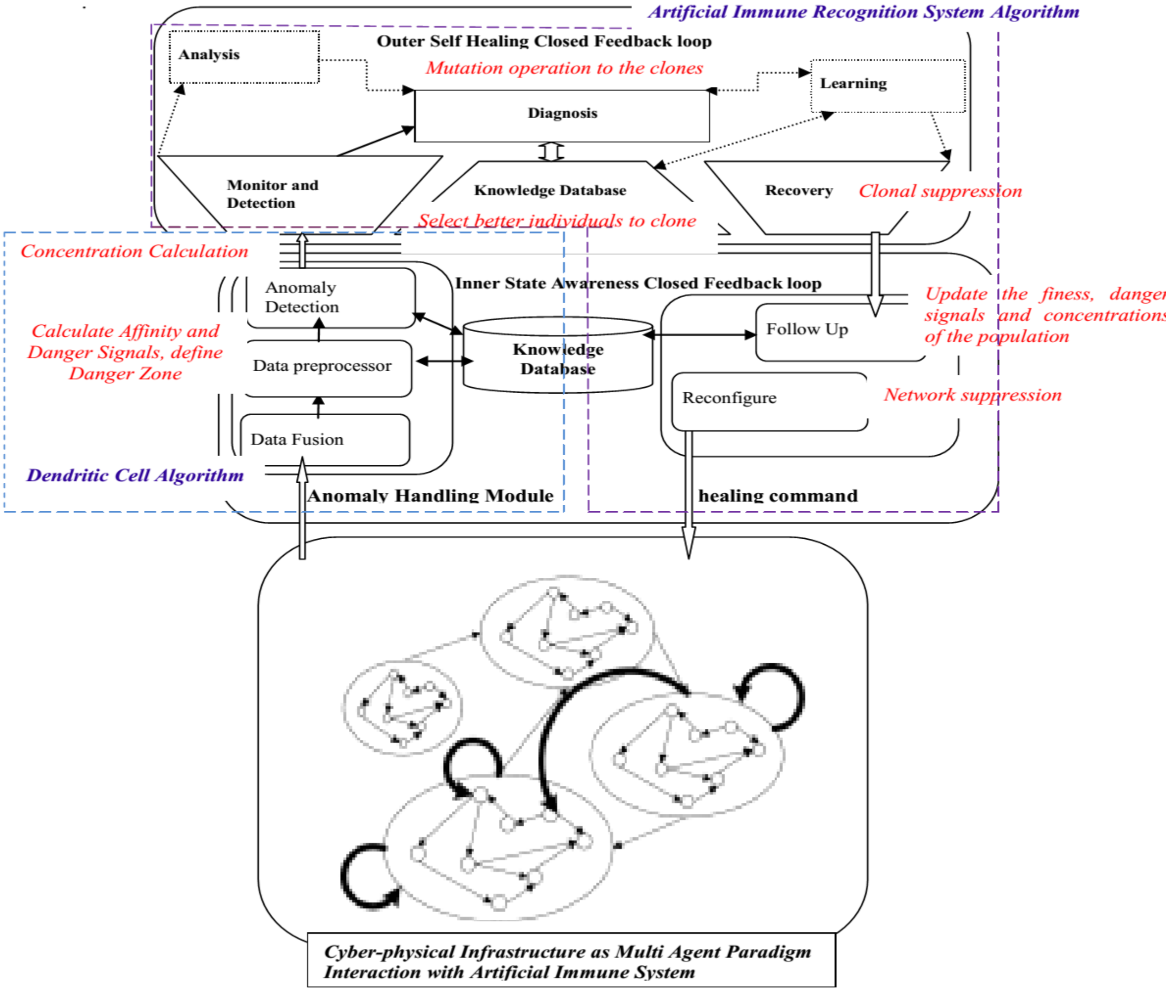

Fig. 3. Agent Population Interaction in each Layer with Danger Theory concept[22]

An Algorithm for resiliency using Artificial Immune Network[4]

Step 1: Initialize, initial network population of Monitored Agent with affinity function, normalization with max and min population. If the same type of Agent Eq(1) will calculate by,

$$affinity(Ag_i(t)) = \begin{cases} \dfrac{f(Ag_i(t)) - f_{min}}{f_{max} - f_{min}}, P = \max f(x) \\ 1 - \dfrac{f(Ag_i(t)) - f_{min}}{f_{max} - f_{min}}, P = \text{mix } f(x) \end{cases}$$

If the Agent has different type Eq (2) will calculated Euclidean distance by

$$affinity(Ag_i(t), Ag_j(t)) = \frac{1}{\sqrt{\sum_{k=1}^{n} (Ag_{ik}(t) - Ag_{jk}(t))^2}}$$

Step 2: Each Monitored Agent in the population should calculate its danger zone, which reflects the working environment to maintain local stability in the population.

$$Dz(Ag_i(t)) = \{Ag_j(t) \mid \frac{1}{\sqrt{\sum_{k=1}^{n} (Ag_{ik}(t) - Ag_{jk}(t))^2}} < r_{danger}$$

An agent in the Danger zone should maintain its state by interaction with another Agent with its environment state.

Step 3: If the concentration of Agent whose affinity is greater than of another Agent in the danger zone and also distance among them, then danger signal is generated in that Agent.

$$Ds(Ag_i(t)) = \sum_{Ag_j \in Ds(Ag_i(t)) \cap \text{affinity}(Ag_j(t)) > \text{affinity}(Ag_i(t))} \frac{con(Ag_j).}{(r_{danger} - \text{affinity}(Ag_i(t), Ag_j(t)))}$$

Step 4: Danger Signal depends on the concentration of Agent Population where, concentration of Agent signal for the next time cycle.

If $Ds(Ag_i(t)) > 0$ the Population of Agent concentration is normal and No Danger Signal.

If $Ds(Ag_i(t)) = 0$ $con(Ag_j(t))_{\tau+1} = \{con(Ag(t)_i)_\tau (1 + \exp(\text{affinity}(Ag_i)^{0.25}))\}$

The Ranges from $Con(Ag_i(t)) \in [0,1]$, if "0" danger signal high and "1" danger Signal low.

Step 5: If $Con\ (Ag_i(t)) = 0$, Dendritic Cell Agent are sensitive to signal and collects the signal to its Data Structure. This signal is Per-categorize as PAMP, Danger Signal, Safe Signal along with predefine Safe Signal information and inflammation signal as a threshold define in DC Agent and decide either one of the *Agent State* as CSM, Semi Mature and Mature State as the output signal of DC.

$$Con(Ag_j(t))_{\tau+1State} = \begin{bmatrix} W_{00} & W_{01} & W_{0n} \\ & & \\ & & \\ W_{m0} & & W_{mn} \end{bmatrix}$$

This Signal Category uses approximate theories [26] as step 6-8.

Step 6.If DC Agent output is in CSM state it in **immature State,** if DC Agent input calculation weight is below migration threshold categories as Safe Signal along with danger signal and inflammation signal.

$$Con(Ag_j(t))_{\tau+1immatureState} = \begin{bmatrix} W_{00} & W_{01} & W_{0n} \\ & & \\ & & \\ W_{m0} & & W_{mn} \end{bmatrix} * Con(Ag_j(t))_{\tau+1State}(1 - 3\,I)$$

The weight of the Matrix will update by receiving Danger Signal and compared with Predefined Safe Signal and inflammation signal.

It is initialized once to All the Agent in the population uniformly till the next Danger Signal arrives.

The calculation of Matrix Weight as follows, if signal Weight less than population of agent concentration. $W_{mXnInitialThreshold} = Sf(Ag_i(t)) + nxI < Con(Ag_j(t))_{\tau+1}$ Where I is inflammation signal and "**n**" Natural number depends on the number of Signal. The Predefined Safe Signal and Inflammation signal act as a threshold dynamically in the population.

Step 7 If the agent is ***Semi mature state***, if DC Agent input calculation weight is above migration threshold categories as a PAMP Signal along with inflammation signal and calculate severity and sensitivity of abnormal Agent.

$$Con(Ag_j(t))_{\tau+1SemimatureState} = \begin{bmatrix} W_{00} & W_{01} & W_{0n} \\ & & \\ W_{m0} & & W_{mn} \end{bmatrix} * Con(Ag_j(t))_{\tau+1State}(1-3I)$$

The Weight of this matrix updates if the condition is it satisfy

$$W_{mXnSemiMature} = Sf(Ag_i(t)) + nxI > Con(Ag_j(t))_{\tau+1}$$

The Final update in this state in the DC Agent acts as threshold for signal categorize to Mature State

$$W_{mXnSemiMature} = W_{mXnThresholdSemiMature} .$$

Step 8: If the agent is mature state, if DC Agent input calculation weight is above semi mature threshold categories as, Danger Signal and along with inflammation signals through weight is calculated in the DC Agent data structure.

$$Con(Ag_j(t))_{\tau+1matureState} = \begin{bmatrix} W_{00} & W_{01} & W_{0n} \\ & & \\ W_{m0} & & W_{mn} \end{bmatrix} * Con(Ag_j(t))_{\tau+1State}(1-3I)$$

The Weight of the matrix will update if

$$W_{mXnSemiMature} > W_{mXnThresholdSemiMature} .$$

Step 9: Above State of the Agent having similar type of antigen concentration in DC Data structure. Output DC Agent calculates mature context antigen value as $MCAV_a = \dfrac{\sum 1_{R^+}.s(t)}{Ag_n(t)}$

$\sum 1_{R^+}.s(t)$ is indicate of anomaly collected abnormal Agent otherwise its value is 0.

"a" is the attribute value in the dataset S(t) of attribute set. Similar type of attribute value collected will triggers an alarm to T Agent (healing module) with the causes of abnormal Agent to immune response.

Step 10: If MCAV not "0" that means the value having either one of the threshold value, then Initialize, from state awareness population to healing in the one-shot incremental algorithm. This Abnormal Agent population from state awareness should identify and generation ARB Agent for given specific training Abnormal Agent $AnAg_i$ population, to find memory Agent, Mg_{match} should have following property,

$$Mg_{match} = \arg\max_{mg \in Mg_{AnAg.c}} stimulation(AnAg, mg)$$

where stimulation(x, y) =1 - affinity(x, y), AnAg.c is class of given Abnormal Agent.

If $Mg_{AnAg.c} \equiv 0$ then $Mg_{match} \leftarrow AnAg$ and $Mg_{AnAg.c} \leftarrow Mg_{AnAg.c} \cup AnAg$.

That is, if the set of memory Agents of the same classification as the Abnormal Agent is empty, then add the Abnormal Agent to the set of memory Agents and denote this newly added memory Agent as the match memory Agent, Mg_{match}.

If the stimulation function for the current work depends on Euclidean distance, then above stimulation is not applicable.

The identified memory Agent Mg_{match}, is used to generate a population of pre exiting ARBAgent for as follows

$$ARB_{generation(x)} = \begin{cases} drandom() & (0-1) \\ lrandom() \bmod nc & (0-nc) \end{cases}$$

The drandom() generation of ARBAgent within mutation rate threshold else lrandom()mod nc is used as above.
Step 11: After creating population of ARBAgent, the corresponding candidate Agent should generate to classify a given AnAg. This is done three methods as follows, as the algorithm is one-shot, only one Abnormal Agent goes through the entire process at a time.

First, competition for system wide resources that is allocation of resources to ARBAgent depends on its normalized stimulation value that indicates fitness of Abnormal Agent. Is represented as follow,

$$ARB_{Agent}.resources \leftarrow AnAg.stim * clonal\ rate =$$

$$\begin{cases} AnAg.stim & \min stim < stim > \max stim \\ AnAg.stim < -- \dfrac{AnAg.stim - \min stim}{\max .stim - \min stim} & \\ else & ARB_{Agent}.c \equiv AnAg.c \\ AnAg.stim < --1 - \dfrac{AnAg.stim - \min stim}{\max .stim - \min stim} & \end{cases}$$

Second, use of mutation for diversification and shape-space exploration. If number of class of AnAg, then resource allocation as follow,

$$resAllco = \begin{cases} \sum_{j=1}^{|ARB_i|} AnAg_j.resources & ARB_j.c \in ARB_i \\ \dfrac{TotalNum\ Resources}{2} & AnAg_j \in ARB_i \\ else & \\ \dfrac{TotalNum\ Resources}{2*(\max stim - 1)} & \end{cases}$$

Third, are the uses of an average stimulation threshold as a criterion for determining when to stop training on Abnormal Agent.

$$ARB_{remove.resource} =$$

$$\begin{cases} \arg\min ARB \in ARB_i(AbAg.stim) & Num\ ResAllow < reAlloc > Num\ ResRemove \\ & else \\ & ARB_{remove.resource} - NumResRemove \end{cases}$$

Once candidate memory Agent is generated for addition into set of training set, one Abnormal Agent training is completed and the next Abnormal Agent is selected for the healing process.

Step 12: All the healing process of the individual Abnormal Agent is completed in the ARB population. Fitness, Danger Signal and concentration of population fixed by state awareness that is fitness rechecked with the network by the newly generated Agent are calculated.

$$Resiliency\ rate = \frac{Average\ Cost\ in\ each\ iteration}{rate\ of\ occurrence\ of\ fluctuation}$$

This achieves resiliency.

V.Simulation Results

Cyber-Road traffic system infrastructure contains a large number of sensors and actuator device with wireless communication and computation, with limited constrain like battery power, sensitivity, time delay, heterogeneous and federated diversity working environment effect of large scale. The state of these compounds is monitored by deploying large scale Software entity called Multi Agent System and it maintain its state through proposed biological inspire Algorithm.

TABLE IV
Summay of Compound in Cyber-Road Traffic Control System[28]

Communication Mode	Representative Standards	Representative Applications
In-Vehicle	SAE J1760, SAE J2366/x, SAE J2395	Data Collection and Information Display
Vehicle-to-vehicle	IEEE 802.11P, IEEE 1609.x, SAE J2735	Cooperative Collision avoidance
Vehicle to Infrastructure	ASTM E2213, IEEE802.11P, IEEE 1609.x, SAE J2735	Road hazard alert Traveler Information
Center-to-Field	NTCIP	Traffic Management
Center-to-center	IEEE 1512.x TMDD	Emergency management, Traffic Management

Test Data Set

The Random number dataset is taken to demonstrate propose an algorithm depends on the general characteristics of cyber-road traffic control infrastructure used in each layer . The dataset contains signal of each layer, is a measure of monitoring system's status with certain time periods. This is maintained with corresponding Agent. This Agent acts as system state to maintain agent concentration, using the methodology, dendritic cell and if any variation with specified threshold semi-mature and mature state, trigger healing module, this healing module uses Artificial Immune Recognization 2 concept for its process, then it terms Artificial Immune Network which acts as resiliency in cyber-Road Traffic control system.

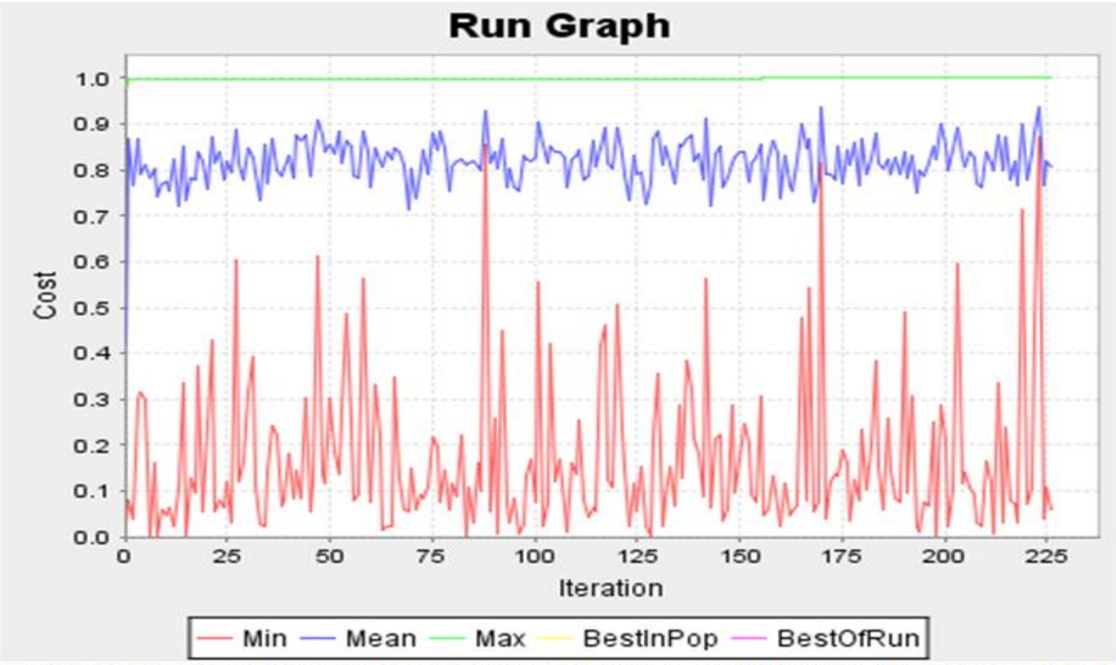

Fig. 5.Shows dynamic threshold change for each state green line indicate threshold of danger state with cost of 12.4.Blue line indicates PAMP signal with its threshold with cost 7.6 and Red line indicate initial danger signal trigger form Safe signal with cost of 2.

The Graph shows iteration 84, 170, 223 triggers healing process. Between this iteration, 19 times cost occurs in 84th iteration defines resiliency rate. Similarly 14 times cost occurs at 170th iteration and 13 times cost occurs at 223rd iteration. That shows that number of iteration at run time reduce occurrence of even is reducing. Indicates the cost of the healing process is less compared to the consequent iteration. This defines the resiliency activity in the Multi Agent system.

Results Discussion

The Table 3 and 4 show results with different population in each layer. Corresponding threshold as 0.34, 0.39, 0.28, 0.32, 0.4, 0.45 shown in table 4 above this threshold is considered as Semi-Mature State. Mature state threshold 0.77, 0.8, 0.69, 0.7, 0.8, 0.89 as an initial threshold to identify abnormal. Healing Participated percentage of agent should create a memory agent for semi mature state as 98, 195, 149, 244, 198, 299 and mature state as 96, 194, 145, 246, 197, 297 similar calculations and analysis for different number of agent population and corresponding results are in the table 5 and table 6 for each state of the population.

TABLE V MATURE STATE AND HEALING PROCESS FOR RESILIENCY IN CYBER-ROAD TRAFFIC AGENT SYSTEM

CPS Layer	Test Case No.	Agent Population	State of Population of Agent		Anomaly	Normal	Memory Agent	State awareness			Healing process			Resiliency rate
			Semi Mature State Threshold PAMP Signal	***Mature State Threshold***	MACV	*MACV*	ARB_{Agent}	*fitness*			*cost*			Avg. cost/ rate of fitness
Monitor As In-Vehicle and Actuator As Vehicle – Infrastructure	1	100	0.77	0.98	0.9	0.1	96	83	79	50	0.33	0.31	0.24	0.058
	2	200	0.8	0.99	0.93	0.07	194	88	90	57	0.35	0.32	0.25	0.059
Communication As Centre – Field	1	150	0.69	0.82	0.92	0.08	145	87	87	55	0.34	0.31	0.23	0.057
	2	250	0.7	0.89	0.91	0.09	246	89	91	60	0.39	0.35	0.27	0.060
Computation And Control Unit As Centre – Centre	1	200	0.8	0.89	0.92	0.08	197	87	92	60	0.39	0.35	0.27	0.063
	2	300	0.89	0.9	0.94	0.08	297	91	94	64	0.4	0.36	0.28	0.066

TABLE VI SEMI MATURE AND HEALING PROCESS TOWARDS RESILIENCY IN CYBER-ROAD TRAFFIC AGENT SYSTEM

CPS Layer	Test Case No.	Agent Population	State of Population of Agent		Anomaly	Normal	Memory Agent	State awareness			Healing process			Resiliency rate
			Initial Threshold Safe Signal	***Semi Mature State Threshold PAMP Signal***	*MACV*	*MACV*	ARB_{Agent}	*fitness*			*cost*			*Avg. cost/ rate of fitness*
Monitor As In-Vehicle and Actuator As Vehicle – Infrastructure	1	100	0.34	0.76	0.89	0.11	98	84	80	53	0.34	0.32	0.25	0.059
	2	200	0.39	0.79	0.91	0.09	195	89	91	58	0.35	0.33	0.26	0.06
Communication As Centre – Field	1	150	0.28	0.67	0.78	0.22	149	88	89	56	0.33	0.32	0.24	0.058
	2	250	0.32	0.68	0.87	0.13	244	90	92	61	0.38	0.36	0.28	0.061
Computation And Control Unit As Centre – Centre	1	200	0.4	0.78	0.76	0.24	198	88	91	59	0.38	0.36	0.28	0.064
	2	300	0.45	0.8	0.79	0.21	299	92	93	63	0.39	0.37	0.29	0.067

VI. CONCLUSION

The paper objective to show, how biological inspired methodologies are applicable in resiliency development to heterogeneous, federated application. This is modelled with Multi Agent Paradigm and shown in cyber-physical system.Artificial Immune Network is modified with dendritic cell and Artifical Recongiztion towards state awareness and healing process as resiliency development is shown to algorithmic work. This algorithm is simulated and results are discussed.In this paper the resiliency development is demonstrated on generic algorithm and framework, their is a scope of real world application to further validate, the results discussed in this paper.

REFERENCES

[1] Liviu, Sanislav, T. (2011). About Dependability in Cyber-Physical System. IEEE Conference Publications, 17-21. Lee E.(2008). Cyber Physical Systems: Design Challenges. University of California, Berkeley Technical Report. No. UCB/EECS-2008-8.

[2] Sycara, Katia, et al. "Distributed intelligent agents." IEEE Intelligent Systems 6 (1996): 36-46.

[3] Lokesh. M. R, Y.S. Kumaraswamy "Modified Danger Theory based Optimized Artificial Immune Network on Resiliency in Cyber-Physical System "IEEE Part Number: CFP15C35-USB IEEE ISBN: 978-1-4673-7909-0, International Conference on Green Computing and Internet of Things (ICGCIoT 2015) 8-10 oct 2015

[4] Ishida, Yoshiteru. Immunity-based systems: a design perspective. Springer Science & Business Media, 2004.

[5] Lokesh. M. R, Y.S. Kumaraswamy Nov 2014"On Autonomic Self Healing Architecture for Resiliency in Cyber Physical System" International Journal of Multimedia and Ubiquitous Engineering ISSN No. 1975-0080 Volume 9, No. 11, Nov 2014

[6] Work, D., and A. Bayen, 2008, Impacts of the mobile internet on transportation cyberphysical systems: traffic monitoring using smartphones, In National Workshop for Research on High-Confidence Transportation CyberPhysical Systems: Automotive, Aviation, & Rail, pp. 1820.

[7] F. Y. Wang, "Agent-based control for networked traffic management systems," IEEE Intell. Syst., vol. 20, no. 5, pp. 92–96, Sep./Oct. 2005.

[8] F. Y. Wang, "Toward a revolution in transportation operations: AI for complex systems," IEEE Intell. Syst., vol. 23, no. 6, pp.

8–13, Nov./Dec. 2005

[9] Shi, J. (2009). “Principles of traffic behavior control”. Beijing: China Commmunications press, 54-58.

[10] Shi Jianjuna,*, Wu Xub, Guan Jizhenc, Chen Yangzhoua “The analysis of traffic control cyber-physical systems” 13th COTA International Conference of Transportation Professionals (CICTP 2013) pp 1877-0428

[11] Zhou, Jianhe, Chungui Li, and Zengfang Zhang, 2011, Intelligent transportation system based on SIP/ZigBee architecture." In Image Analysis and Signal Processing (IASP), 2011 IEEE International Conference on, pp. 405409.

[12] Li, Xu, Wei Shu, Ming-Lu Li, and Min-You Wu, 2008, Vehicle-based Sensor Networks for Traffic Monitoring." In Proc. of 17th IEEE International Conference on Computer Communications and Networks.

[13] Mundra, Ankit, et al. "Transport Information System using Query Centric Cyber Physical Systems (QCPS)." arXiv preprint arXiv:1401.3623 (2014).

[14] Q. Zhu, “Game-Theoretic Methods for Security and Resilience in Cyber-Physical Systems”, PhD thesis (2013).

[15] M. Mahmoud Mahmoud Azab, “Cooperative Autonomous Resilient Defense Platform for Cyber-Physical Systems”, PhD thesis, (2013) January.

[16] I. Hong, H. Youn, I. Chun and E. Lee, “Autonomic Computing Framework for Cyber-Physical Systems”, Proc. of Int. Conf. on Advances in Computing, Control, and Telecommunication Technologies, (2011).

[17] A. Jones, M. Merabti and M. Randles “Resilience Framework for Critical Infrastructure Using Autonomics”, International Journal of computer Applications, (2012).

[18] John A. Volpe National Transportation Systems Center "Intelligent Transportation Systems (ITS) Standards Program Strategic Plan for 2011 —2014" Noblis, Inc., with cooperation from the USDOT’s

[19] J. Greensmith, “Dendritic Cell Algorithm”, Ph.D. Thesis, The University of Nottingham, (2007).

[20] Andrew Watkins and Jon Timmis, Lois Boggess” Artificial Immune Recognition System (AIRS): An Immune Inspired Supervised Learning Algorithm” Kluwer Academic Publishers. Printed in the Netherlands 2003

[22] Lokesh. M. R, Y.S. Kumaraswamy "Demonstration of Inner State Awareness and Outer Self Healing Closed Feedback Loop for Resiliency in Traffic Control Cyber-Physical System",International Journal of Applied Engineering Research (IJAER)Print ISSN 0973-4562 ,2014