INTRODUCTION

The provision of an efficient intelligent transport systems (ITS) communications infrastructure requires the deployment of multiple devices across the urban area at fixed locations such as bus stations, intersections, or along the roads, but also within the transportation vehicles such as buses, taxis, bikes, or even users’ vehicles [1–4]. From a transportation service provider’s perspective, such dense network is used for different ITS applications such as providing transport information (bus schedule, bikes’ availability, incidents, etc.). The same infrastructure augmented with the appropriate sensors can be used by a governmental organization for applications such as (1) congestion map computation/forecast [5,6], (2) vehicles classifications for statistics purposes [7], or (3) monitoring (air pollution, road quality, etc.) [8–10].

In today’s transportation sector, the traffic conditions are monitored by cameras and motion sensors set along significant road intersections and thoroughfares. On the other hand, with growing street activity and confined spaces for road expansion, these detecting innovations are coming as far as possible in giving ongoing traffic updates to ease traffic clogs and avoiding mishaps [11]. The developing pattern for figuring out the solution of such problems lies in the internet of things (IoT) empowered automotive industry to furnish vehicles with devoted Internet based short-range inter-communicative devices to give vehicle-to-vehicle correspondences and subsequently enhance traffic safety and give better traffic perceivability for its administration [12-14]. Case in point, when there is a congested driving condition, the first automobile might tell the other automobiles behind if there is a mischance, and this will in the end illuminate the astute route frameworks to recourse the way to another less swarmed street. These IoT-enabled automobiles or busses can make breakdown calls when suitable, gathering information about the encompassing infrastructures, for example, traffic lights and building structures, and about itself (for example, the broken parts in the vehicle and kind of load stock/cargo it is hauling) in the occasion of a crisis [15]. Streaming such real-time data to cloud servers and processing it for real-time analytics purposes where information is considered as information in movement and diagnostic handling is required to be completed progressively with goals such that that decision choices can be made in a matter of seconds [16]. For instance, this necessity is normal in the transportation sector where intercommunication between vehicles regarding the onward speeding vehicle shall be intimidated or in situations concerned with ongoing traffic data enable drivers to enhance their courses and voyaging times. Vehicles gradually get to be “smart things” which can respond to the situations, taking into account ongoing circumstances in traffic, enhances transport utilization, automated monitoring of carbon emissions, drop in rate of traffic accidents, oversee traffic load and add to a more secure traffic system. In this study, we present the cognitive architecture for IoT-based intelligent transportation system by availing solution for interoperability between devices for M2M communication and availing cloud services on streaming data.

METHODS

The proposed IoT architecture can be straightforwardly spoken to by three classes of interconnected systems: Sensing (infrastructure) layer, communication layer, and service layer where stream analysis is is done on cloud to encourage the service creation and solution layer to guarantee solid and secure bi-directional communication of data among these systems (Fig. 1). The proposed IoT solution for ITS obliges things to either be intelligent so they can channel and oversee information locally and give this usefulness. The communication infrastructure involves network and cloud through and through to encourage the control information movement stream associating cloud to IoT gadgets equipped vehicles. The Internet is a worldwide arrangement of interconnected IP networks that connects the computing system altogether. This system foundation, involving switches, aggregators, passageways, repeaters, and different gadgets that control information movement stream, additionally interfaces with telecom and link systems (e.g., 3G, 4G/LTE) worked by service suppliers. Server farm/cloud infrastructure: Data focuses and cloud base contain extensive pools of virtualized servers and capacity that are arranged together. Supporting IoT, this infrastructure runs applications that investigate information from gadgets and sensors keeping in mind the end goal to create noteworthy data utilized for services and choice making [17,18]. Along these lines, returning the last decisions back to the IoT-equipped vehicles.

The e number of M2M devices e is divided into three classes: Device initial readiness be ϕi, operating M2M devices denoted as u and loitered...
number of devices be \( v_e \). Similarly, the average packet arrival density per device \( S \) is divided into two classes: Initial \( i_s \) and operational denoted as \( u_s \). By considering the criss-cross interaction availability of devices and packet arrival density, the equations that describe the spread of the signals can be written as:

\[
\frac{di}{dt} = -\mu_s i_s + A k_{i_s} i_s - c(S) i_s u_s + \delta v_e
\]

\[
\frac{du}{dt} = c(S) i_s u_s - \gamma u_e - k_{i_s} u_e
\]

\[
\frac{dv}{dt} = k_{i_s} (u_e) k_{i_s} v_e - \delta v_e
\]

\[
\frac{de}{dt} = \mu_e + A k_{i_s} e
\]

\[
\frac{ds}{dt} = \mu_e - k_{i_s} e
\]

Where, \( e = i_s + u_s \) and \( S = i_s + u_s \).

In the system \( 1.1 \), \( \mu_e \) is priority index, \( A \) is the maximum delay threshold and \( k_{i_s} \) is forward reaction rate constant. \( c \) is the total concentration of the enzyme-substrate complex. \( \gamma \) is the recovery rate and \( \delta \) is the parameter denotes the flow rate such that the \( v_e \) will join the \( u_e \) class. \( \mu_e \) is probability that the preceding delay threshold is violated and \( k_{i_s} \) is its reverse flow rate of signals. \( \beta_1 \) and \( \beta_2 \) are the interaction rates of operational number of devices with the initial and recovered classes of the M2M devices, respectively (\( \beta_2 > \beta_1 \)).

The model gives following two cases to be analyzed:

a. The waiting time for a queued packet \( c \) of the operating M2M devices with the infective M2M devices is a constant \[19\], and

b. It depends on the initial values of operational M2M units \[20\]. For positive constants \( a_0 \) and \( a_1 \), thus \( c \) takes the form

\[
c = a_0 + a_1 S
\]

Case b is impractical at high numerical values such as ours. Therefore, we shall exempt rest of the calculation for this case.

Case A: When \( c = c_j \) is a constant.

Since \( i_s + u_s + v_e = e \) and \( i_s + u_s = S \), the system (1) can be reduced to the form:

\[
\begin{align*}
\frac{di}{dt} &= \mu_s A - k_{i_s} i - c(S) i u_s + \delta v_e \\
\frac{du}{dt} &= c(S) i u_s - \gamma u_e - k_{i_s} u_e \\
\frac{dv}{dt} &= k_{i_s} (u_e) k_{i_s} v_e - \delta v_e \\
\frac{de}{dt} &= \mu_e + A k_{i_s} e \\
\frac{ds}{dt} &= \mu_e - k_{i_s} e
\end{align*}
\]
The equilibrium $E_i$ exists if

$$R_i = \frac{c_0 k_{+1}}{(k_{+1} + s)} - 1$$

We state the local stability of the three equilibria $E_0$, $E_1$, $E_2$ in the following theorem.

The equilibrium $E_0$ is stable. The equilibrium $E_1$ is stable if $R_0 < 1$, otherwise if $R_0 > 1$, it is unstable and the equilibrium $E_2$ exists and is stable if $q_1 > q_2 > q_3 > 0$.

The general variational matrix $M$ corresponding to the system (2) is

$$M = \begin{pmatrix}
-c_0 u_x + & -c_0 u_x & -c_0 (v - w) & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
\end{pmatrix}
$$

At the equilibrium point $E_0(0,0), \frac{\mu_2 + A}{k_{+1}}, (0,0)$, the variational matrix $M_0$ is

$$M_0 = \begin{pmatrix}
-(v + k_{+1}) & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
\end{pmatrix}
$$

The characteristic polynomial corresponding to the above matrix is

$$(k_{+1} + \gamma) (k_{+1} + \delta) (k_{+1} + \gamma + \lambda) = 0$$

This gives all the negative roots of $\lambda$.

Thus, the equilibrium $E_0$ is stable.

At the equilibrium point $E_1(0,0, \frac{\mu_2 + A}{k_{+1}}, 0,0)$), the variational matrix is given by

$$M_1 = \begin{pmatrix}
-(v + k_{+1}) & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
\end{pmatrix}
$$

The characteristic polynomial corresponding to the above matrix is given by

$$(k_{+1} + \gamma)(k_{+1} + \delta) (k_{+1} + \gamma + \lambda) (k_{+1} + \delta + \lambda) = 0$$

Where,

$$p_2 = 2k_{+1} + k_{+1} + \delta + \lambda$$

$$p_3 = -c_0 (\beta \gamma + (v + k_{+1}) (k_{+1} + \gamma) + k_{-1} (2k_{+1} + \delta + \gamma))$$

We find that the Eigenvalues of (1.5) are $-k_{-1}, -k_{+1}$ and the roots of the polynomial $\lambda^3 + p_1 \lambda^2 + p_2 \lambda + p_3$

The above polynomial has roots with negative real part if $p_1, p_2, p_3 > 0$.

Hence,

$$p_2 p_3 - p_1 = (k_{+1} + \delta) (k_{+1} + \gamma) (k_{-1} + (2k_{+1} + \delta + \gamma)) (\gamma + k_{+1})$$

$$+ c_0 \beta \gamma \frac{\mu_2 + A}{k_{+1}}$$

Which is positive. Therefore, the stability of $E_1$ is given by the sign of $p_2$ which is positive if and only if $R_0 < 1$. For $R_0 > 1$, $E_1$ is unstable and $E_2$ exists.

At the equilibrium point $E_2(0,0,0,v,0)$, the variational matrix $M_2$ is given by

$$M_2 = \begin{pmatrix}
-(c_0 u_x + \gamma + k_{+1}) & -c_0 u_x & -c_0 (v - w) & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
\end{pmatrix}
$$

To give proper versatility at the most minimal expenses, the stage has been architected to keep running in an open/private cloud environment or server farms of M2M environment (Table 1). The framework tends to offer undertaking administrations crosswise over open, private and in addition crossover cloud situations. This shall helps meet necessities of information security, administrative prerequisites with reference to information stockpiling, offering undertakings control over their stockpiling and additionally network through secure passages or confined IP ranges. The administrations are provisioned and oversaw utilizing cloud APIs and are format driven, permitting administrations to be taken off rapidly and effectively. This model offers a genuinely shared methodology, and it permits our customers a "pay-as-you-develop" business model. It permits answers for be made from pilot to industrialized worldwide take off on an anticipated and controllable "develop" business model. It permits answers to be made from pilot to industrialized worldwide take off on an anticipated and controllable business model. It permits answers for be made from pilot to industrialized worldwide take off on an anticipated and controllable business model. It permits answers for be made from pilot to industrialized worldwide take off on an anticipated and controllable business model.

### Communication layer

The uses of IoT structures a broad configuration space with numerous measurements that incorporate a few issues and parameters some of which are said beneath as per the following:

A. Incremental and random deployment
B. Mobility infrequent or constant performed by either chose or all things in the select environment
C. Cost, size, assets, and vitality that all much asset compelled or bundless assets
D. Heterogeneity a solitary kind of thing or various arrangements of various properties and pecking orders
E. Communication methodology mainly multi-hop communication
F. Infrastructure unique applications bar, permit or require the utilization of altered base
G. Dynamic network topology: Single jump, star, multi-bounce, network or multi-level
H. Coverage-meager, thick or repetitive
I. Connectivity constant, infrequent or sporadic
J. Network size running from many hubs to thousands
K. Lifetime couple of hours, a while to numerous years
L. QoS necessities - ongoing imperatives, alter resistance, subtlety, and so on.
Table 1: Ted bed parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovenill LTE+M2M bandwidth</td>
<td>22 MHz</td>
</tr>
<tr>
<td>M2M bandwidth</td>
<td>3 MHz</td>
</tr>
<tr>
<td>LTE frame duration</td>
<td>1.3 m</td>
</tr>
<tr>
<td>Number of M2M devices</td>
<td>100, 500, 900, 1500</td>
</tr>
<tr>
<td>Average packet arrival rate</td>
<td>0.02/0.04 packets/TTI</td>
</tr>
<tr>
<td>Scheduling period</td>
<td>27-43/12-24 TTI</td>
</tr>
<tr>
<td>Network realizations</td>
<td>100</td>
</tr>
<tr>
<td>Realization length</td>
<td>1000 s</td>
</tr>
<tr>
<td>Average HP-class packet arrival rate</td>
<td>0.04/0.01 packets/TTI</td>
</tr>
<tr>
<td>HP-class scheduling period</td>
<td>35/55 TTI</td>
</tr>
<tr>
<td>Average LP-class packet arrival rate</td>
<td>0.06-0.075/0.026-0.037</td>
</tr>
<tr>
<td>LP-class scheduling period</td>
<td>17/25 TTI</td>
</tr>
<tr>
<td>Network realizations</td>
<td>15</td>
</tr>
<tr>
<td>Realization length</td>
<td>500 s</td>
</tr>
</tbody>
</table>

HP: High priority, LP: Low priority, LTE: Long-term evolution, M2M: Machine to machine, TTI: Transmission time interval

One of the difficulties in building IoT applications in the given context is the way to plan a common underlying software fabric for various situations and how to assemble a cognizant application out of a huge gathering of assorted software modules. A significant measure of innovative work effort is presently centered around service-oriented processing for creating disseminated and combined applications to support interoperable streaming data from cloud-to-cloud, machine-to-machine, and thing-to-thing interaction over a network. This is based on the internet protocols, and on top of that, one requires to characterize new protocols to portray and address the service examples. Service oriented processing freely organizes the web and cloud to cloud services and makes it a virtual network. This can be modeled as flows:

Let $p$ be the set of points for $(p_{1},p_{2},...,p_{n})$ where the contextual streaming data are embedded based on its geographical locality where a function $F$ is defined to gauge the closing distance between:

$$S = \{p_{1},p_{1}(u,v,z),p_{2}(u,v,z),p_{3}(u,v,z),...,p_{n}(u,v,z)\}$$

And a set of other points in $(u,v,z)$ coordinate system. Thus, the energy function or global distance of a surface is a weighted area where each element of this surfaces is weighted in correspondence with its distance to its closest point in the data set $S$.

$$F(s) = \left(\sum_{i=1}^{n}d(x^{i})^{p}/1 \leq p \leq 4\right)$$

Where $d(x)$ is the distance from $x\in\mathbb{R}^{3}$ to its closest point in $S$.

We can utilize this function for detailing the development of a variational formulation of an evolution equation to construct this minimal cloud to cloud routing in multiple streams to withstand the delay in data dissemination and processing for real-time applications such as traffic behavior modeling and traffic delay calculation. Therefore, at every iteration the evolution equation runs a gradient descent of the energy function to get it minimized. At each step, every point $x$ of the stream $S(t)$ at time $t$ multicast toward the other local clouds along the normal stream direction to $S(t)$ at point $x$, with a displacement speed that is relative to:

$$\frac{d(x)K}{T} - \nabla d(x)\bar{n}$$

Where $\bar{n}$ is the bid profile vector between local clouds to gain the streaming data at $x$ coordinate position and $K$ is a notation denoting the mean payoff at $x$. The aggregation of the bid profile is represented by first term $\frac{d(x)K}{T}$, which is non-linear, such that the evolution process requires a certain number of steps before reaching its equilibrium.

Therefore, taking in account of the effects of both bid profile and the concession for cloud negotiation through cloud agent can be put forth in the form of graph topology represented as a graph $G=(V,E)$, with vertices $V$ and edges $E$ are the aggregate conflict probability and counter bid proposal. Thus, the probability of cloud agent to reach out with counter proposal to gain streaming data can be globally represented as

$$TD(x) = \sum_{i=1}^{n}q_{i}(x)\psi_{i}$$

Where $TD$ is the complete topology, $q_{i}$ is the continuous piecewise basis function of the vertices (1 or 0 if $i = j$ or otherwise) for the $i$th vertex in which $x \in \mathbb{R}$. Given that we have external cloud negotiation vector $F^{ext} = [F_{1}^{ext}, F_{2}^{ext}, ..., F_{n}^{ext}]^{T}$, which tends to minimize the energy function for both external and internal cloud negotiation between cloud agents is given by:

$$S_{1}V = F^{ext}$$
The architecture defines the following functional components as part of an ITS station. Both M2M and ITS architectures may lead to understanding that each architecture is dedicated to specific scenarios. However, for the delivery of new and rich applications, interoperability between different platforms is needed. Such interoperability presented in this work will pave the way to a whole new business model with new actors’ roles such as communications provider, sensors provider, and data mules providers but also application providers. The innovation of this project consists on augmenting ETSI standardization works in the fields of M2M and ITS and proposing new functionalities.

CONCLUSION
The significance of combining M2M and cloud-to-cloud communication is twofold. First, it enables intelligent interactions between cloud-to-consumer for several IoT applications such as intelligent transportation system and the other is to model the economics of cloud services. Being this work first to model the coalition between multiple devices and multiple cloud based on the stream distribution with approximation to achieve perfect equilibrium has high payoff. This game-theoretic approach for modeling such a vast system will lay the foundation of IoT economics.

REFERENCES

$$S_{t_1}^{int} = \sum_{(v_i,v_j) \in E} a_{ij}(v_i - v_j)$$

Where the conflict matrix is represented by $S$, whose size is n x n, is the vector of control vertices of the streaming data and its division point. The control vertices can be precisely illustrated for the $i^{th}$ row and $j^{th}$ column streaming element of $S$, $a_{ij}$ as:

$$A_{ij} = \begin{cases} 1 & \text{if } (v_i - v_j) \in \text{E} \\ 0 & \text{otherwise} \end{cases}$$

Using finite differences in time, the multicast distribution of streaming data of the model can be iteratively represented as:

$$V^{(t)} = V^{(t-1)} + \sum_{t=1}^{T} V^{(t)} - V^{(t-1)}$$

Where $V^{(t)}$ is a piecewise linear in $t^{th}$ step, and $V^{(t)}$ is the vector of the model's vertices at the $t^{th}$ position, and $\theta$ is the time step size. Upon combining the effects of both external and internal cloud negotiation bid profiles, we get the final combined effects of conflict probability of cloud-to-cloud system:

$$V^{(t)} = \sum_{t=1}^{T} \sum_{(v_i,v_j) \in E} a_{ij}(v_i - v_j)$$

The above model is aimed to support an extensive variety of uses and address common necessities from an extensive variety of industry sectors and in addition the requirements of nature, society, and individual natives. Through accord forms including different partners, it will be conceivable to create standardized semantic information models and ontologies, common interfaces and protocols, at first characterized at a dynamic level, then with case bindings to particular cross-platform, cross-language technologies, for example, XML, ASN.1, web services and so forth. Instead of utilization of semantic ontologies, we used mathematically modeled machine-coherent codification which ought to overcome ambiguities because of human error or contrasts and confusion because of various programming languages and in addition assisting with cross-referencing to extra information accessible through different systems. Standards are required for bidirectional communication and information trade among things, their surroundings, their advanced partners in the cloud-to-cloud communication, stream distribution and substances that have an enthusiasm for monitoring, controlling or assisting the IoT.