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PERFORMANCE ANALYSIS OF IoT- ENABLED INTELLIGENT CONTROL SYSTEMS FOR SMART CITIES

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***Abstract*—**Increasing population density in urban centers demands adequate provision of services and infrastructure to meet the needs of city inhabitants, encompassing residents, workers and visitorsThis research paper presents a novel intelligent smart city administration system, based on Internet of Things, which is featured by low cost, high scalability, high compatibility, easy to upgrade, to replace traditional traffic management system and the proposed system can improve efficiency. The paper suggests an architecture that incorporates internet of things with agent technology into a single platform where the agent technology handles effective communication and interfaces among a large number of heterogeneous highly distributed, and decentralized devices within the IoT. The architecture leads the use of an active radio-frequency identification (RFID), wireless sensor technologies, object ad-hoc networking, and Internet-based information systems in which tagged smart city objects can be spontaneously represented, traced, and interrogated over a network. This research presents an overview of a framework distributed smart city traffic simulation model within Net Logo, an agent based environment, for IoTsmart city monitoring system using mobile agent technology.

***Keywords*—**Intelligent Smart city; Internet-of-Things; RFID; Wireless Sensor Networks; Net Logo

I.INTRODUCTION

It is predictable that 75% of the world's population, over 8 billion people, will live in cities and nearby regions by 2030. So, the major cities needed to be smart, if only to survive as boards that permit economic, social and environmental wellbeing. Smart city is the one that uses information and communications technologies to make the city services and monitoring more aware, shared and efficient [1]. Smartness of a city is driven and enabled technologically by the growing Internet of Things (IoT) [2] - a radical evolution of the current Internet into a ubiquitous network of consistent objects that not only harvests information from the surroundings (sensing) and networks with the physical world (actuation/command/control), but also uses existing Internet standards to provide services for information transfer, analytics, and applications [3]. Fuelled by the adaptation of a variety of enabling devices such as embedded sensor and actuator nodes, the IoT has stepped out of its infancy and is on the verge of revolutionizing current fixed and mobile networking infrastructures into a fully integrated Future Internet. Wireless sensor networks (WSN), as the sensing-actuation arm of the IoT, seamlessly integrates into urban infrastructure forming a digital skin over it.

The information generated will be shared across diverse platforms and applications to develop a common operating picture (COP) of the city. With development breaking the 60% hurdle, it is of paramount importance to understand the demand for service profiles to increase the efficiency of city management. Currently, few municipalities have platforms or systems for live monitoring, and inferring of urban process parameters. The commonly employed strategy is: data collection; offline analysis; action; followed by system adjustments and repetition of the whole process. Data collection exercises are often costly and difficult to replicate. There is thus an increased demand on municipalities to incorporate smart technologies that collect the required data and analyze them for action, all in real time. Clearly, a large-scale, platform-independent, diverse-application IoT infrastructure can aid this process by including data processing and management, actuation and analytics. With advanced sensing and computation capabilities, data are gathered and evaluated in real time to extract the information, which is further converted to usable knowledge. This will enhance the decision-making of city management and citizens to turn the city smart.

The structure of this paper is as follows: Section II describes the vision and scope of iot with the huge energy impact that buildings represent at city level. Section III reviews related architecture of iotworks tackling the problem of energy building management systems. Section IV presents our proposal for an intelligent control system of cities infrastructures aimed at achieving energy sustainability, while ensuring the quality of life of its occupants and Section V the analysis of simulation resultsand evaluation tests. Finally, SectionVI concludes the paper with conclusions.

II.VISION AND IOT SCOPE

The increasing trend for people to move to urban areas [4] and the associated urbanization process have resulted in an

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urgent need to confront to challenges related with the ability of city infrastructures to cover every citizen's needs in terms of water supply, transportation, healthcare, education, safety, and, most importantly, energy. In this context, the integration and development of systems based on Information and Communication Technologies (ICT) [5] and, more specifically, the Internet of Things (IoT) [6], are important enablers of a broad range of applications, both for industries and the general population, helping make smart cities a reality. In [7] is researched the emergence of new business process management and of novel service-oriented architectures focused on the development of electronic services available to customers.

Many people [11],in my opinion[13], hold the view that cities and the world itself will be overlaid with sensing and actuation, many embedded in "things" creating what is referred to as a smart world. But it is important to note that one key issue is the degree of the density of sensing and actuation coverage. For example, today many buildings already have sensors for attempting to save energy [14]; home automation is occurring [10]; people have smartphones with sensors for running many useful apps [9]; industrial plants are connecting to the Internet [8]; and healthcare services are relying on increased home sensing to support remote medicine and wellness [12]. However, all of these are just the tip of the iceberg. They are all still at early stages of development. The steady increasing density of sensing and the sophistication of the associated processing will make for a significant qualitative change in how we work and live. We will truly have systems-of-systems that synergistically interact to form totally new and unpredictable services.

What will be the platform or platforms that support such a vision? One possibility is a global sensing and actuation utility connected to the Internet. Electricity and water are two utilities that can be used for a myriad of purposes. Sensing and actuation in the form of an IoT platform will become a utility. IoT will not be seen as individual systems, but as a critical, integrated infrastructure upon which many applications and services can run. Some applications will be personalized such as digitizing daily life activities, others will be city-wide such as efficient, delay-free transportation, and others will be worldwide such as global delivery systems.

In fact, smart watches, phones, body nodes, and clothes will act as personalized input to optimize city-wide services benefiting both the individual and society. Consequently, we will often (perhaps 24/7) be implicitly linked into the new utility. Some examples of new services include immediate and continuous access to the right information for the task at hand, be it, traveling to work or a meeting, exercising, shopping, socializing, or visiting a doctor. Sometimes these activities will be virtual activities, or even include the use of avatars or robots. Many outputs and displays for users may be holographic. Credit cards should disappear and biometrics like voice or retinas will provide safe access to buildings, ATMs, and transportation systems.

Humans will often be integral parts of the IoT system. The Industrial Internet is also a form of IoT where the devices (things) are objects in manufacturing plants, dispatch centers, process control industries, etc. Consequently, in the future the scope of IoT is enormous and will affect every aspect of all our lives.

III.PROPOSED ARCHITECTURESYSTEM OF IoT

The major tasks of the proposed system are detecting mobile objects and their location, identifying mobile objects and transmitting acquired data to the monitoring and controlling center for processing.More than 25 Billion things are expected to be connected by 2020 [17]whichisahugenumbersotheexistingarchitectureofInternet with TCP/IP protocols, adopted in 1980 [18], cannot handle a networkasbigasIoTwhichcausedaneedforanewopenarchitecture that could address various security and Quality of Service (QoS) issues as well as it could support the existing network applications usingopenprotocols[19].Withoutaproperprivacyassurance,IoT is not likely to be adopted by many [20]. Therefore, protection of data and privacy of users are key challenges for IoT [21]. Forfurtherdevelopmentofloт,anumberofmulti-layeredsecurity architectures are proposed. [22] described a three key level architecture of IoT while [17] described a four key level architecture. [23] proposed a five layered architecture using the best features of the architectures of Internet and Telecommunication management networks based on TCP/IP and TMN models respectively.Similarly,asix-layeredarchitecturewasalsoproposedbasedonthenetwork hierarchical structure [24]. So generally it's divided into seven layers as shown in the Fig. 1. The seven layers of IoT are described below:

3.1 CodingLayer

CodinglayeristhefoundationofIoTwhichprovidesidentification to the objects of interest. In this layer, each object is assigned a unique ID which makes it easy to discern the objects [25].

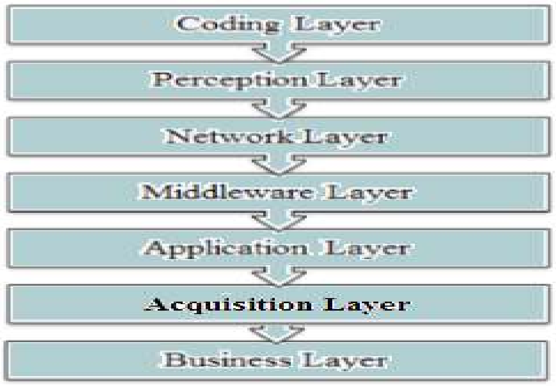


Fig. 1. Seven-Layered Architecture of IoT

3.2 PerceptionLayer

This is the device layer of IoT which gives a physical meaning to eachobject.Itconsistsofdatasensorsindifferentformslike RFID tags, IR sensors or other sensor networks [26] which could sense the temperature, humidity, speed and location etc of the objects. This layer gathers the useful information of the objects from the sensor devices linked with them and converts the information into digital signals which is then passed onto the Network Layer for further action.

3.3 NetworkLayer

The purpose of this layer is receive the useful information in the form of digital signals from the Perception Layer and transmit it to the processing systems in the Middleware Layer through the transmissionmediumslikeWiFiBluetooth, WiMaX, Zigbee, GSM,3G etc with protocols like IPv4, IPv6, MQTT, DDS etc [29].

3.4 MiddlewareLayer

This layer processes the information received from the sensor devices [16]. It includes the technologies like Cloud computing, Ubiquitous computing which ensures a direct access to the database to storeallthenecessaryinformationinit.UsingsomeIntelligentProcessing Equipment, the information is processed and a fully automated action is taken based on the processed results of the information.

3.5 ApplicationLayer

This layer realizes the applications of IoT for all kinds of industry, based on the processed data. Because applications promote the development of IoT so this layer is very helpful in the large scale development of IoT network [24].

3.6 Acquisition layer

This layer constituted by all kinds of sensors and sensor gateways such as RFID, WSN, cameras, intelligent terminals to transmit data of mobile objects and other sensors used to collect real-time traffic and object identification information.

3.7BusinessLayer

This layer manages the applications and services of IoT and is responsible for all the research related to IoT. It generates different business models for effective business strategies [15].

IVENLARGEMENT OF AN IoT-ENABLED INTELLIGENT CONTROL SYSTEM

The major issue in IoT is the interoperability between different standards, data formats, heterogeneous hardware, protocols, resources types, software and database systems [28]. Another issue is necessity of an intelligent interface and access to various services and applications. It seems that mobile agents are a convenient tool to handle these issues, provide means for communication among such devices and handle the IoT interoperability. Adding to that mobile agent is a perfect choice in cases of disconnection or low bandwidth, passing messages across networks to undefined destination and to handle the interoperability of IoT. All messaging exchanges among agents are established via the TCP/IP Protocol. A software agent is an autonomous executable entity that observes and acts upon an environment and acts to achieve predefined goals. Agents can travel among networked devices carrying their data and execution states, and must be able to communicate with other agents or human users.

A multi-agent system is a collection of such entities, collaborating among themselves with some degree of independence or autonomy. Applying agent technology in the process of monitoring and control traffic is new approach. Such technology perfectly fits for distributed and dislocated systems like traffic monitoring and controlling due to its autonomy, flexibility, configurability and scalability thus reducing the network load and overcoming network latency. Agents can also be used to pass messages across networks where the address of destination traffic device is unidentified. Each traffic object is represented as a software agent (an intelligent object agent). In this infrastructure the extremely large variety of devices will get interconnected, and will be represented by its own intelligent agent that collects information and responds to others 'requests. Agents will provide their functionality as a service. Autonomous intelligent agents are deployed to provide services necessary for the execution of functional tasks in each layer of the proposed architecture.

Main IoT Traffic agents are:

Traffic Mobile Agent: Transmits/receives different types of information to/from other objects the Internet; interprets the data coming from other objects (RFID, sensors, users), and provides a unified view of the context; communicates with other agents in the network to accomplish a specific task.

User Agent: provides users with real-time information of entities residing in the system. The user agent is a static agent that interacts with the user. It is expected to coordinate with mobile agents.

Monitor Agent: monitors the system to detect contingency situations and triggers some actions to react to some tag reading events on behalf of a smart traffic object, for example in emergency cases.

RFID Agent: responsible for reading or writing RFID tags. When reading a tag, according to the data retrieved from it, this agent performs appropriate operations in handling a single task on behalf of a smart object of the associated RFID and to migrate to different platforms at run time.

Sensor Agent: receives, processes data that have been read from the associated sensor and saves (or send it somewhere).

Traffic Light Agent: detects irregular traffic conditions and changes the traffic control instructions right away.

Camera Agent: is responsible for image collecting. All communications between camera agent and video Web server are conducted via the network layer.

The traditional traffic monitoring system based on imageprocessing technology has many limitations. One of them is the impact of the weather. In case of thick dust, heavy rain, etc., the license plate cannot be seen clearly, so its image cannot be captured. The development of e-plate based on RFID provides a good opportunity for intelligent traffic monitoring and vehicle ‘s identification and tracking [29]. If no agents are associated with the RFID tags (identification-centric RFID systems), then they may function as an independent set of programs for tag processing and communicate using standardized software agent protocols.

The author suggests utilizing the agent technology within the e-plate based on RFID and other traffic objects to fully realize the combined potential of RFID and software agent technology. An RFID-based smart traffic object (code-centric RFID systems) requires a substantial amount of memory space to store traffic object logics and data. The code-centric RFID systems can be used to store a mobile agent into the RFID tags that will enable integration with other parts of the traffic system. Using such technology in the Traffic Information System will eliminate the need for searching of the associated RFID-code information from a database and reduce overall system response time by retrieving service information from the tags [30], thus achieve faster service responses and perform on-demand actions for different objects in different situations.

Each smart vehicle's RFID object consists of two components, namely, object processing logics and object data [31]. The object data contains a global unique Electronic Product Code (EPC) code as its unique identifier. Each RFID-tagged traffic object may be assigned an IPv6 Mapped EPC address [32]. The IoT networks are expected to include billions of devices, and each shall be uniquely identified. A solution to this problem is offered by the IPv6, which provides a larger address space of 128-bit address field to accommodate the increasing number of devices in IoT, thus making it possible to assign a unique IPv6 address to any possible device in the IoT network. RFID can be used as a transponder in vehicle registration plate equipped with a RFID tag and sensors so that each car can get data it needs from the spot and deliver to assigned destination. The vehicle RFID tag stores information on the vehicle and its owner, such as plate number, vehicle type, speed, time when the car reaches the monitoring point, driver ‘s name and license number. It can be used to estimate the number of vehicles in the road, average speed of vehicles, vehicle density, etc.

When a vehicle with an RFID tag passes through each monitoring station along the road, the RFID reader at those points will automatically read the tag data related to the vehicle and its owner and transmit to the wireless sensor active nodes. These nodes send accumulated data to the cluster head node. At the same time, a GPS receiver installed at the monitoring station can communicate with GPS satellites to obtain its position information that is taken as a position parameter of the vehicle. Then the data is transmitted using GPRS scheme to the real-time central database where the data is constantly updated to ensure data reliability.

V. SMART CITY TRAFFIC SIMULATION FRAMEWORK

Simulation allows us to observe the properties, characteristics and behaviors of the traffic system. Based on detailed real-time data collected from the distributed online simulations, the IoT traffic system can provide accurate information necessary for near real-time traffic decisions. The whole traffic IoT network is partitioned into dynamic overlapped sections, and a simulation processor is mapped to each section. Each simulation will be supplied with real-time data from nearby RFIDs and sensors and enabled to run continuously. The overall distributed simulation consists of a collection of such segment simulations where each small segment of the overall traffic IoT network is modeled based on local criteria. Each simulation segment is operating in an asynchronous mode, meaning each simulator executes independently of other simulators and the simulation server.

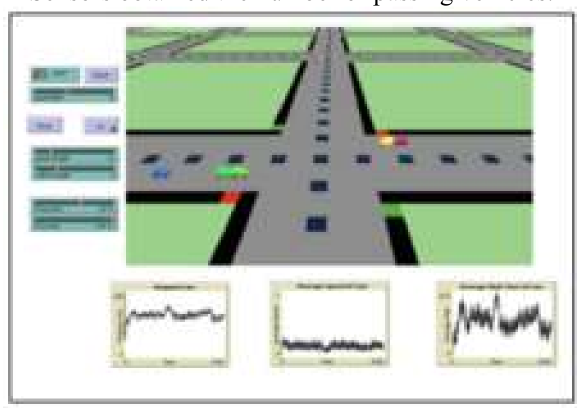
These simulation segments are allowed to exchange information on vehicles moving from one simulation segment to another. Each simulator's segment locally models current traffic conditions and concentrating only on its area of concern. A simulator's segment, for example, might model some set of roads and intersections of that segment, and predict the rates of vehicle flow on links carrying vehicles out of that segment. Each segment shares its predictions with other simulation segments to create an aggregated view of both the individual segment 's area of interest and the overall of traffic system. Simulators' segments publish their current traffic state information (speed, travel time, flow rate, etc.) and their predictions to the simulation server. An aggregation of all simulation segments provides an accurate estimation of a future state of the system.

The simulation server disseminates information among the simulator segments, coordinates all simulators' segments and provides a predictive model of traffic conditions in specified traffic areas by analyzing and integrating the results of distributed simulators of those areas. The simulation server maintains state information of current and future operations of the traffic network such as flow rates, average speed, and the time when that information was generated. Running online simulations are integrated with traffic information system infrastructure to receive real-time traffic data and this overall simulation provides detailed information required for prediction of the system future states of the system. Detailed traffic information (such as speed, location, average acceleration of vehicles on the network segment and the current state of traffic control devices) generated during simulation is saved and managed on the simulation server.

Online distributed traffic simulation is a powerful approach for analyzing the characteristics and behavior of the traffic system and determining traffic conditions and help to reduce vehicle delay time of on the road, traffic congestion without the need of making costly changes in real world; prevent dangerous situations and delays by broadcasting messages informing drivers in the area to avoid congested roads [33]. It will be beneficial to transportation management as well as urban planning and architecture working on enhancement of the roads capacity, building new roads or to improve the existing roads and improvement of public transportation systems. The current large-scale distributed simulation methodologies require tremendous network bandwidth and huge amount of computation by each simulator host. Mobile agents are used to reduce the communications loads placed in the network.

Agents communicate with a specific simulation segment, providing all of the state information that was sent to the simulator server. NetLogo simulator has been used for modeling a collection of adjacent intersections. Static and mobile agents represent different features of the network. Motor vehicles have been modeled individually within NetLogo using mobile agents. Simulation can be run on several computers. NetLogo allows giving instructions to large number of independent agents which could all operate at the same time. In this cause the NetLogo model runs in a single machine computing environment, but it can be extended to run on cluster of computers.

Four types of agents used in NetLogo: patches are used to represent static agent, turtles for mobile agent; links are used to make connections between turtles; and the observer for observing everything going on in the simulated environment [34]. The environment of the NetLogo is written entirely in Java, therefore patches and turtles are programmable by the user of NetLogo in Java language. In this simulation, the agent entities are vehicle, traffic lights, and sensors of intersections and lanes. Agents are created and randomly distributed over the network of intersections. A random number of vehicles were generated according to limits defined in the model. Sensors obtained the number of passing vehicles.



The interface and performance evaluation of the simulation results are shown in fig. 2.

In most cases the driver's behavior is unpredictable. Modeling of drivers 'behavior using agent-based has been performed based on techniques proposed by [35]. The simulation has setup 'andgo'buttons. The setup'button calls a procedure to reset the model to the initialization state, and the _go' button calls a procedure that carries out all actions for each simulation run. All visual aspects are managed by the NetLogo simulation, and after every run visualization are automatically updated.

VI. CONCLUSIONS

The proposed architecture employs key technologies: Internet of Things, RFID, wireless sensor network (WSN), GPS, cloud computing, agent and other advanced technologies to collect, store, manage and supervise smart city information. Fig. 2. Interface and performance evaluation of the simulation results Agents provide an effective mechanism for communication amongst networked heterogeneous devices within the traffic information system. The proposed system can provide a new way of monitoring smart city traffic flow that helps to improve traffic conditions and resource utilization. In addition, transport administration department, using real-time traffic monitoring information, can in time detect potentially dangerous situations and take necessary actions to prevent traffic congestion and minimize number of accidents thus ensuring safety of road traffic

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