

# IEEE TCSIM Newsletter

Quarterly Newsletter

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## Chair's Message

- Prof. Kaushik Chowdhury

*These are exciting times for TCSIM, thanks to the enthusiastic support of the current members and interest from emerging areas traditionally underserved by the TC. In this issue of the newsletter, we cover two exciting topics on electrical vehicular simulation as well as new tools for molecular communications. We hope readers will be as excited to read the latest developments on these fronts, as we were in learning and documenting them in this newsletter.*

*The new format of the newsletter was well received, and we got many emails with additional suggestions for improvement - please, do keep them coming! Also, the TC website is now fully operational. We plan to add a new permanent resource section that links to simulation tools that are available for the general community. If you would like your work to be featured, please drop an email to any of us. We plan to grow the website as a resource for the community over the next few months. Finally, we would like the newsletter to capture the latest and greatest happenings within the community. If you have news of interest that you would like to share or wish to contribute an article, by all means, get in touch with us!*

*The TC continues to support new events and provides endorsement for long-standing conferences. Additionally, we shall soon announce calls for a TCSIM organized journal special issue. We look forward to these new developments from our side.*

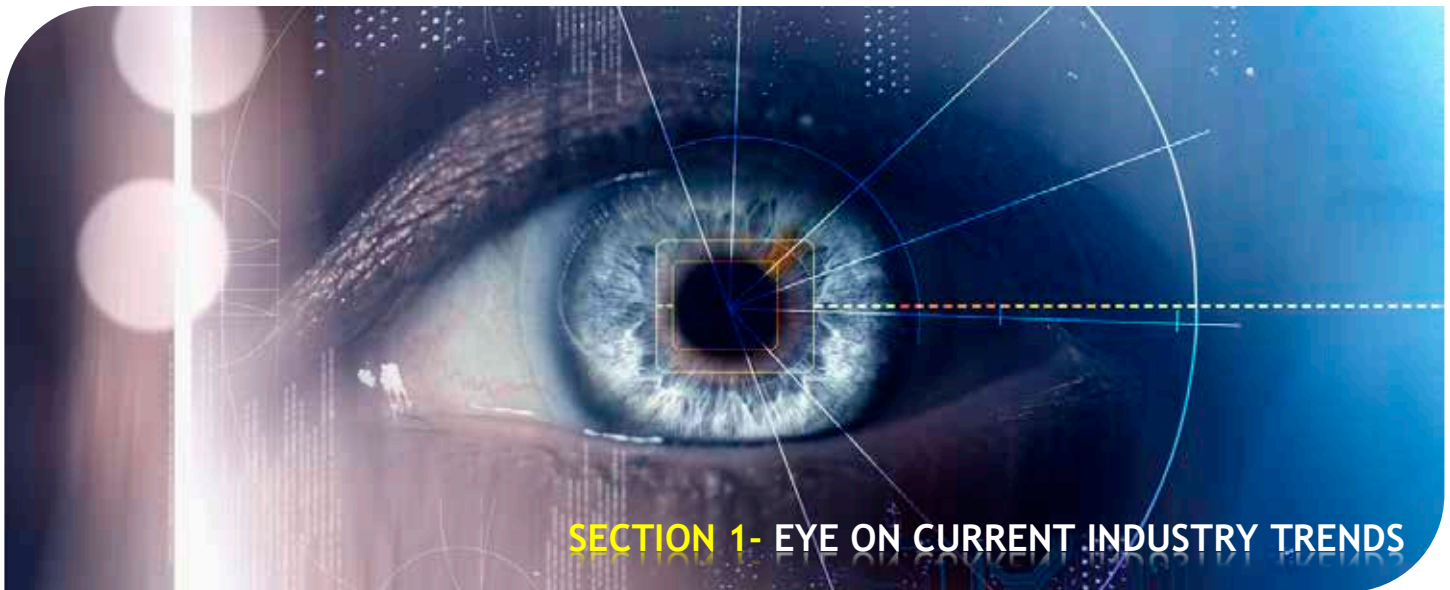
*Finally, I would like to extend my appreciation to Prof. Di Felice and his team for his work on the newsletter. It is a result of many a sleepless night, and a product that we at TCSIM leadership are very proud of.*

*Happy reading!*



## In this issue:

Chair's Message	page 1
Eye on Current Industry Trends	2
Meeting Simulation People	3
- Interview with Prof. Sekercioglu	
Electronic Notes on Simulation	5
<b>NETWORKED AND MOBILE SYSTEM</b>	
- An Integrated Simulation Framework for Electric Vehicular Scenarios	5
<b>MOLECULAR SYSTEMS</b>	
- Simulation Tools for Molecular Communications	8
Reports from Sponsored Events	13
Upcoming Sponsored Events	14
Call for papers	17



## SECTION 1- EYE ON CURRENT INDUSTRY TRENDS

Simulation has been increasingly used in difficult and challenging scenarios, in which real world data is hard to obtain, or experiments may not be safely conducted. In this containing series, we will place a spotlight on some of the ways and recent research through which computer simulations are aiding systems design and solving some of the practical problems facing the world today. This issue covers the following areas:

### **Wireless IoT devices in automation networks reached 14.3M in 2015.**

Berg Insight said its latest research into industrial automation networks found that the installed base of wireless Internet of Things (IoT) devices stood at 14.3 million by the end of 2015.

The company now forecasts that the number of wireless IoT devices in automation networks will grow at a compound annual growth rate (CAGR) of 27.7 per cent to reach 62 million by 2021.

It also found that Wi-Fi and Bluetooth are the most widespread technologies in factory automation while cellular connectivity typically is used for remote monitoring and backhaul communication between plants. [\[Link\]](#)

### **Conductive wireless charging might be the future.**

Fli Charge is a conductive wireless charging system that allows users to charge their devices by placing them anywhere on [Fli's charging pad](#). Users just have to have a special case for their phone or a cable wheel that plugs into their device and then sticks to the back of it. Users aren't tethered to a power cable, but will still have to keep their device stationary on a charging pad for it to power up. It's not wireless charging at a distance. Conduction is different from induction in that it requires direct contact between the device being charged and its

charging pad. Electrons flow directly between the devices; whereas with induction, the electrons in a device begin producing electricity only when activated by an inductive charging unit's electromagnetic field. [\[Link\]](#)

### **Visa Brings Secure Payments to Internet of Things IoT**

Visa Inc. (NYSE:V), announced that it is expanding its Visa Ready program to include Internet of Things (IoT) companies, such as manufacturers of wearables, automobiles, appliances, public transportation services, clothing and almost any other connected device. [\[Link\]](#)

### **[REPORT] Robots will soon have the power of life and death over human beings. Are they ready? Are we?**

In the not-so-distant future, we will begin entrusting to robotic systems such vital tasks as driving a car, performing surgery, and choosing when to apply lethal force in a war zone. As we describe in this report, ever more autonomous machines will present challenges spanning technical, regulatory, and even philosophical realms. They will force us to confront deep moral quandaries, and might even tweak our sense of who we are.. [\[Link\]](#)

## SECTION 2- MEETING SIMULATION PEOPLE

**Dear Ahmet, can you give us a little background about yourself?**

I studied electrical and electronics engineering at the Middle East Technical University in Ankara, Turkey. Since I laid my hands on a handheld calculator during my high school years, I always wanted to learn how they worked, and without a second's hesitation I chose electrical engineering as my career. After my graduation, I worked in the industry as a research and design engineer for a few years. Initially I was not thinking about an academic career although I always wanted to do a PhD. While I was at Ericsson, I saw an ad about part-time PhD study opportunities at a newly established parallel computing laboratory at Swinburne University. I talked to my manager, got their approval and enrolled. A year or so later I joined Swinburne as a member of the academic staff. In 2000 I moved to Monash University, and last year I joined Heudiasyc Laboratory of Université de

Technologie de Compiègne.

**One of your main research interests is networked mobile robots. Can you please tell us more about it?**

My PhD topic was related to the computer networks, and when I joined the faculty, I was given the computer networking units for teaching. So, networks have become my area of specialization. The laboratory activities were always related to writing networking programs or simulation type works. Being in an electrical engineering department, I observed that my students loved working directly with hardware. I started thinking about how I could merge networking experiments with some fun-to-do hardware and realized that networked mobile robotics had great potential. I was right! Students loved them and started coming up with great

[Continued...](#)

### INTERVIEW WITH Prof. AHMET SEKERCIOGLU

In this issue, we meet with Prof. Ahmet Sekercioglu, one of the most active researchers in the field of mobile sensor networks.

Prof. Ahmet Sekercioglu is with the Monash University, Australia. He is currently a visiting Professor fellow at the Heudiasyc Laboratory of Université de Technologie de Compiègne, France.



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We've launched our new WEBSITE that features new design and easy access to several resources and committee updates

ideas to create our unique flavour of mobile robot network testbed.

**In your opinion, what will be the most relevant applications in this field?**

There are so many to mention here. An example I love to give when I am asked is the following: Disaster response and infrastructure inspection. Think about the Fukushima nuclear reactor accident. You need to know what has happened inside, you need to know as quickly as possible, and you cannot send humans. A network of mobile robots would be given the task and they can coordinate the mapping, exploration, sensing tasks when they go into the area of interest to deliver us the results fast.

**Evaluating the performance of complex and dynamic systems like robot swarms can be challenging. In your research, how much do you rely on experimental testbeds? How much do you rely on simulation studies?**

I observe that experimental testbeds are great motivators for my students to get excited about learning more and choosing challenging projects. On the other hand, they can be very costly, time consuming and so many things can go wrong. Testing out ideas quickly on real experimental testbeds is not possible. In addition, scalability is another problem. Conducting a realistic swarming experiment involving a large number of mobile robots is extremely difficult. Simulation based studies do not suffer from these limitations. Of course, if I borrow the famous phrase “all models are wrong, but some are useful”, if we know the limitations of both approaches we can create great research.

“...Using a parallel discrete-event simulation system for modeling a robotic swarm consisting of hundreds or thousands of members would be great fun, and I believe it would allow us to uncover amazing behaviours...”

- Prof. Ahmet Sekercioglu

**In your opinion, what are the open challenges which has to be addressed in the modeling and evaluation of networked mobile robots?**

I would like to bring a more general issue into the discussion if you allow me: Parallel simulation. Supercomputing clusters and parallel processor architectures are becoming more and more accessible to the research community. Unfortunately, as far as I can see, parallel simulation tools are not yet mature enough. Coming back to the networked mobile robots and modeling topic, using a parallel discrete-event simulation system for modeling a robotic swarm consisting of hundreds or thousands of members would be great fun, and I believe it would allow us to uncover amazing behaviours.

**Thank you very much Ahmet.**



# An Integrated Simulation Framework for Electric Vehicular Scenarios

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*Abstract*— Simulation techniques play a fundamental role in Electric Vehicles (EVs) scenarios in order to support the planning of the charging infrastructure and of the software services assisting the operations of the EV drivers. In this paper, we present a novel and integrated simulation framework, deployed within the Internet of Energy (IoE) European project, which allows modeling most of the characteristics of an EV scenario, including: vehicular mobility, EV battery models, charging/discharging operations. Moreover, our tool provides facilities to embed EV-related mobile applications in simulated environments, so that it is possible to evaluate them over large-scale scenarios before their real-world deployments.

## I. INTRODUCTION

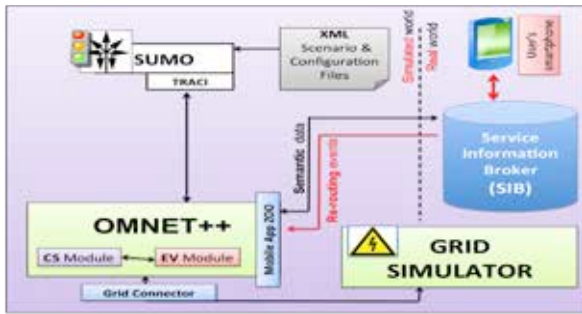
Electric Vehicles (EVs) are expected to become a key technology over the next few decades, in order to mitigate the carbon emissions as well as to open the way to more sustainable transportation systems. At the same time, current statistics about the sales of EVs worldwide demonstrate how far we are from these goals. Despite the well-known issues on EV autonomy and price, complexity and duration of charging operations are perceived as the main limitations by potential customers: this is confirmed, among others, by a recent survey from the U.S. National Energy Technology Lab according to which 70 percent of people would not purchase an EV due to doubts on the availability of Charging Stations (CSs) close to their needs [1]. Two actions are needed on the short-term to address this issue. On the one hand, more investments are required, since - even in most developed countries- the coverage of the existing CS infrastructure is mainly limited to urban areas. On the other hand, the pervasive penetration of mobile devices can be leveraged to assist the EV drivers with charging operations, for instance informing them about charging opportunities along their paths. Several mobile applications have been proposed for EV-related scenarios, providing CS mapping service, route planning or

advanced driving-style profiling functionalities [2][6]. However, how to evaluate the effectiveness of such services is a challenging task, due to the low penetration of EVs and the high costs of setting up large-scale test-beds.

In the transition phase from fossil fuel-based to EV-based mobility, simulation techniques play a fundamental role, since they can enable (i) the accurate planning of the RS infrastructure [3], by taking into account the characteristics of a target scenario, and (ii) the testing and evaluation of mobile services before their effective deployment. Nowadays, several vehicle simulators are available, and provide a fine-grained model characterization of the components of an EV (including the electric engine, the commutators, the mechanical transmissions, etc). However, none of these tools can be used to study complex dynamics of EV-related scenarios where it is required to model several interacting entities characterized by different time-scale behaviors (i.e. EVs, CSs, the smart grid, the communication network).

In this paper, we introduce a novel integrated simulation platform for EV related scenarios, deployed within the Internet of Energy (IOE) European project [4]. The proposed tool [5] relies on a co-simulation approach, which includes models deployed in SUMO [7], a microscopic traffic simulator, and OMNET++ [8], an event-based simulator, connected through the TRACI interface. Thanks to its integrated nature, the IoE simulation framework allows the modeling of EV operations (e.g. battery discharging), of CS operations (e.g. charging operations and policies), of vehicular traffic mobility, and of user driving profiles. Moreover, our platform provides facilities to connect to smart grid simulators, and to embed real-world software components, like mobile applications or services, within an EV simulated environment.

Figure 1: The IoE simulation



## II. ARCHITECTURE OF THE PROPOSED FRAMEWORK

The architecture of the IoE simulation framework is illustrated in Figure 1. Interested readers can refer to [5] for a detailed description of the tool.

The SUMO tool is used to model the vehicular traffic, by importing the characteristics of the scenario (e.g. altimetry, street map, buildings' positions) from OPENSTREETMAP. The OMNET++ tool is used to model the characteristics of the EVs and the CSs. The Battery Module models the discharging operations of the EVs, by taking into account the 3D cinematic of the vehicle, the forces applying on it, and the efficiency of the electric engine. In [5] we have demonstrated the accuracy of such model, comparing it against consumption traces from real EVs. The CS module is in charge of modeling (i) the charging operations based on the CS power profile and on the current State of Charge (SOC) of the EV, (ii) the current CS state (e.g. busy/idle) and the management policy (e.g. queuing or reservation-based). The TRACI interface is used to connect SUMO and OMNET++. Moreover, the IoE framework provides facilities to connect to external software components, i.e. the SIB and the Grid connector. The Semantic Information Broker (SIB) is a semantic data repository that guarantees the interoperability among different software agents and platforms on heterogeneous IoE electric mobility scenarios [2]. The SIB is populated with data from simulated entities, as in a real deployment. Through the SIB and the Mobile Application Zoo (MAZ) component, we are able to embed real mobile applications into the simulated environment, in order to test and evaluate them before their deployments. As a result, a person using the mobile application described in [6] can take control of a simulated EV, by monitoring the EV parameters (e.g. the SOC) as if he/she was driving it. At the same time, a user can reserve a charging slot at an available CS through the application described in [2]; such action will cause a re-routing event in SUMO for the controlled EV.

In both cases, no changes are required to the mobile applications; in other words, through this solution, we can test the EV-related applications on a simulated environment as they were used in a real-world scenario. The Grid component allows connecting our framework to an external grid simulator, so that the time dependent load characteristics of a CS can be used as input to study the impact on the grid in terms reactive power and harmonics propagation, as better detailed in [5].

## III. EVALUATION RESULTS

The IoE framework can be used for two purposes: (i) evaluation of mobile services and applications for EV scenarios, and (ii) quantitative analysis supporting the deployment of the charging infrastructure on a target scenario (pre-deployment analysis). Again, the readers can refer to [5] for an exhaustive illustration of the simulation studies conducted through our framework. We report here some preliminary results for the first case (service evaluation).

We consider the Bologna scenario, by importing the downtown street map from OPENSTREETMAP. Vehicular traffic is generated through the *ActivityGen* utility of SUMO, which takes as input some demographic information of the scenario, and produces in output a list of routes for each vehicle. Figure 2 shows two screenshots of the simulator: here, vehicles in red represent carbon-fossil cars, vehicles in green represent EVs, and vehicles in yellow are EVs which are re-charging at a CS. We consider the real locations and power profiles of CSs available in the downtown area of Bologna.

Figure 2. Screenshots of the IoE simulation framework

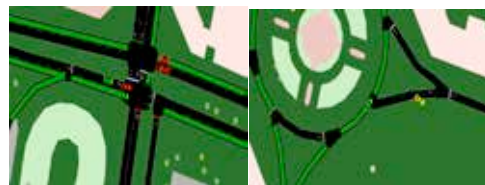


Table 1. CS Occupation with/without reservation service

	1 CS	4 CS	7 CS	10 CS	12 CS
Reservation ON	100%	99,5%	96,2%	94,5%	90%
Reservation OFF	100%	100%	99,4%	96,2%	89,9%

In Table 1, we compared two different charging management policies: (i) *reservation-enabled* or (ii) *without reservation*. In the first case, each EV needing to re-charge its battery must first reserve a temporal slot at an available CS, by using the reservation service described in [6].

Note that such service is a real-world software component, and it is embedded within the IoE simulated framework through the MAZ previously described. Vice versa, when the reservation service is not used, each EV needing to recharge will move to the closest CS; in case this is found busy, the EV will drive to another CS, till a free one is found. This models the typical behavior of an EV driver when no information about CS status is available.

Table 1 depicts the average occupation of a CS, when varying the number of CSs actively working in the Bologna scenario. From these results, it is possible to notice that:

- The reservation service provides -on average- a better scheduling of the charging requests, which translates into a more uniform utilization of the CSs, and into a lower utilization on average. The same trend can be shown whether we consider the number of unsatisfied requests, i.e. the number of EVs that are not able to recharge and run out of battery (the Figure can be found in [5]). Again, a higher number of requests can be accommodated when the reservation service is used.
- With or without the reservation service, the utilization is always higher than 90%, even when all the CSs of the Bologna scenario are active.

As a further confirmation of the twofold nature of the IoE framework, we note that these results can provide important hints in two ways: (i) for the pre-deployment of the charging infrastructure, they can help identifying the areas of the scenarios where there are more unsatisfied charging requests; (ii) for the service evaluation, they allow quantifying the benefit of the reservation service on a realistic large-scale scenario, also under different traffic loads, and considering different characteristics of EV battery models and CS power profiles.

#### IV. CONCLUSIONS

Simulation tools can play a fundamental role to favor the large scale uptake of EV mobility. In this paper, we have briefly summarized the characteristics of a novel and integrated simulation framework through which it is possible to model most of the components of a large-scale EV scenario, including the EVs, the charging stations, the vehicular mobility. We have used our tool to perform large-scale simulations of realistic urban scenarios, and also to evaluate the performance of EV-related services and applications, like charging reservation applications and EV route planners. Current and future works include the integration with smart-grid simulators, and the refinement of the EV battery model.

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## Simulation Tools for Molecular Communications

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**Abstract**— The field of molecular communications aims to utilize biological systems to create communication systems. This new paradigm shift, that has been developed and embraced by the computing and communication engineering researchers is highly multi-disciplinary, embodied with numerous challenges. One of these challenges is in developing a suitable simulation environment that can be used as a platform for researchers to embark into this new area of research. This paper is a survey of the most recent and versatile simulators for molecular communication systems. We highlight the peculiarities of these simulators in relation to the specific biological environment to be investigated.

### I. INTRODUCTION

As the field of nanotechnology continues to unravel and solve numerous challenges that are found in the world today, new paradigms are continually being developed and support this area of science. One particular functionality that has been recently proposed is the “communication” at the nanoscale, which has led to the birth of molecular communication. This paper illustrates, evaluates, and compares a set of existing simulators of Molecular Communications (MolCom).

MolCom is an emerging area which promises significant breakthroughs in some strategic socio-economic fields [1][2]. As shown in Fig. 1,

it encompasses multi-disciplinary research that brings together information and communication technologies, molecular biology, physics, chemistry, biotechnology, as well as technologies that will realize the vision of transferring information within biological environments at extremely small scales, down to a size comparable to that of molecules.

The physical mechanisms that allow transferring information have been inspired by the biological mechanisms that exist in living bodies to exchange many types of signaling and particles, such as proteins, pheromones, and immune system activation signals. This multidisciplinary nature characterizes also the tools that are used to design and analyze such systems.

Figure 1. The multi-disciplinary nature of Molecular Communications.





Besides the analytical tools that have been developed [1], the complexity of MolCom usually requires the use of simulators tailored to the specific biological environment. In fact, for a simulator to be useful for investigating the detailed interactions that occur at extremely small scales, it must implement the elementary interaction mechanisms that characterize the analyzed environment, in terms of particle size, shape, interaction with the surrounding environment, and timescales. For this reason, different research groups have been developing various simulation tools tailored to their research needs. Developing a realistic simulation toolset and framework can be beneficial not only for communication engineering and networking researchers to further progress this new field of research, but also to provide opportunities for other disciplines (biotechnologists, medical doctors) to solve specific health care problems using communication functionalities. For example, virtual human organs can now predict drug effects that occur in the tissues and cells, while the simulator can play a supporting role in designing the process of delivering the molecules to the intended target, as well as investigate how the molecular structure of the drug will influence the motion within the environment. Simulators can also be used as partial substitute for experiments conducted in animals too, which will reduce cost as well as minimize any need for ethical approvals. In addition, simulators can exploit their best features in the field of personalized medicine. In fact, the ability to analyze immense data sets and extract all possible useful information is fundamental for the development of personal medicine.

## II. REVIEW OF THE EXISTING SIMULATORS

In this section, some of the main simulators that have been developed to characterize the broad set of MolCom systems are revised. Table 1 reports the main features of some of the existing simulators. This set has been selected according to their adaptability to different types of molecular communication systems.

### A. BiNS - Biological and Nano-Scale communication simulator

BiNS is a simulation package for MolCom systems developed at the University of Perugia [3]. Its customizable design provides a set of tools that allow creating objects modeling the behavior of biological entities, such as nodes (transmitters, receivers), carriers, or surrounding objects (e.g., vessel walls). In addition, BiNS permits to shape the simulated communication channel (e.g., the blood stream

or in vitro experiment) with the desired accuracy. The simulator has been implemented in Java, and includes a generic type of software object, named Nano Object. Nodes and carriers are specific implementations of the Nano Object, and, although they share its general features, they can exhibit very different functions. The simulation is organized in discrete time steps. Each step consists of a number of phases, in which software objects are triggered in order to execute the operations associated with their specific behavior. The main phases are: transmission phase, reception phase, information processing phase, motion phase, object destruction phase (during which objects are removed due to lifetime expiration or because they exited from the area of interest), and collision management phase, which implements the elementary interaction between particles. BiNS has been validated through wet-lab experiments related to cardiovascular medicine. The list of simulated nano-objects are split into smaller lists, which can be handled in parallel by a thread pool. The simulated environment can be either unbounded or bounded by a surface of custom shape, referred to as simulation domain. Within a domain, the octree paradigm allows distributing the workload associate to the management of the objects in the domain volume to different threads.

### B. CalComSim - Calcium Signaling-based Molecular Communication System Simulator

CalComSim is a calcium signaling-based molecular communication simulator, designed for both synthetic and natural communications found inside a 3D human tissues [4].

An integration of the biological models for the signaling process governed by stochastic solvers is used to handle multiple and parallel reactions in each cell of the tissue. Also, it implements three different types of tissues. They can be classified as: non-excitabile (tissues which cannot propagate electric current), excitable (tissues which can propagate electric current) and hybrid (tissues capable of communicating with both excitable and non-excitabile tissues). Each type of cell simulated are as follows: epithelial (non-excitabile), smooth muscle cells (excitable) and astrocytes (hybrid). The biological models that are incorporated into the simulator are based on real experimental data. The simulator also includes the stochastic closing and opening behavior of the gap junction for each type of cell. The simulator can be used not only by telecommunication engineers and biological scientists, but also by pharmaceutical researcher that can design new drugs and treatments for diseases that emerge from impaired calcium signaling.

TABLE 1. Comparison of the most popular simulators for molecular communications systems

Simulator Name	BINS	CalComSim	N3Sim	COMSOL Multiphysics	NS-3 based Simulators	NanoNS	BNSim	NCSim
Customization	Customizable simulation domains	Through Python programming	Via configuration file.	Very flexible model adaptation. Script-based module integration.	Through C++/Python programming	Through C++/OTcl programming	Through Java programming; selection of the simulation method	Through C++/Python programming
Licence	Open	Open	Open	Commercial	Open	Open	Open	Open
Purpose	Diffusion based MolCom	Calcium-signalling based molecular communications inside cellular tissues	Diffusion based MolCom	multipurpose platform designed for simulating physics-based problems.	Designed as a network simulator	Diffusion based MolCom	Bacteria-Based Nanonetworks	Flagellated bacteria-based MolCom
User Interface	Command line based with possible visualization of propagating particles	Command line based only	Command line based	Graphical user interface	Command line preferable. Animation tools available	Command line preferable. Animation tools available	Command line based	Command line based
Implementation techniques	Java, multi thread.	Python	Java	N/A	C++/Python	C++	Java	C++ multithread + Python
Deployment	Both single machine and cluster-based	Single machine	Single machine	Both single machine and cluster-based	Single machine	Single machine	Single machine	Any, point-to-point, by default

CalComSim has been implemented in Python, and requires the following dependencies: Numpy, Scipy, Pypy, Cpython. Numpy and scipy. They are used to access mathematical and scientific functions, while the Pypy is an alternative interpreter for the simulator. The Cpython is used to run C libraries that can be used in python codes. The Gillespie stochastic algorithm [5], was used to solve partial differential equation that model intracellular and intercellular calcium signaling. The simulator is controlled by a command line interface.

### C. N3Sim

N3Sim [6] is a simulation framework for diffusion-based molecular communications. Transmitters encode the information by releasing particles into the medium, thus varying the concentration rate in their vicinity. The diffusion of particles through the medium is modeled as Brownian motion, taking into account particle inertia and collisions among particles. Receivers decode the information by sensing the local concentration in their neighborhood. The benefits of such a simulator are multiple: the validation of existing channel models for molecular communications and the evaluation of novel modulation schemes are just two examples. It implements a three-layer architecture. The user interface layer interacts with the user to read the input data for the simulation, while the data layer writes the simulation results to files. The domain layer contains the "intelligence" of the system, the molecular communication model. N3Sim is a Java-based simulator. The simulation parameters are determined by means of a text configuration file editable by the user.

The scalability of the simulator can be improved by selecting a higher simulation time step (at the expense of accuracy) or by deactivating the collisions among molecules in scenarios with a low molecular concentration. The time granularity of a simulation is defined by the user by selecting the simulation time step (typically a few ms).

### D. COMSOL Multiphysics

COMSOL Multiphysics® is a commercial multipurpose platform designed for simulating physics-based problems through a unified workflow for electrical, mechanical, fluid, and chemical applications. It implements finite element analysis, for different physics and engineering applications. It is available for different operating systems. An example of the use of COMSOL Multiphysics for simulating a MolCom drug delivery system is presented in [7]. Nevertheless, this platform is tailored to macroscopic phenomena, such as flows. Modeling the interactions of biologic particles at molecular level requires the implementation of specific models. For example, the ligand-reception formation is not supported by specific libraries and has to be implemented by users. MATLAB® scripts can be used to implement new modules. The learning time for a fruitful use of the simulator is in the order of several months. The COMSOL package supports cluster computing. Thus, any simulation job can be deployed to any number of clustered computers.

### E. NS-3 Based Simulators

NS-3 is a discrete-event network simulator for Internet systems, which was not developed

for MolCom simulators. Nevertheless, its flexible structure has allowed implementing some basic elements of MolCom, in particular a simulation tool has been developed in the framework of the IEEE P1906.1 working group [8]. NS-3 is organized in different software libraries that can work together. User programs, written in C++ or Python programming languages, can adapt these libraries or be linked with them. External animators and data analysis and visualization tools are available. Nevertheless, in order to exploit the full potentials of the NS-3 the command line interface is preferable. The simulator is designed to be executed on a single machine. The minimal requirements to execute basic simulations are a gcc or clang compiler and Python interpreter. The simulation granularity is defined by users.

#### F. NanoNS

NanoNS is a molecular communication tool developed on top of NS-2 [9], which is an object-oriented simulator written in C++ with an object-Tcl (OTcl) interpreter. The main objective of the framework is to provide a simulation tool to create a better understanding of nanonetworks and facilitate the development of new communication techniques as well as provide a platform for validation of theoretical results. It incorporates the simulation modules for various nanoscale communication paradigms using a diffusive molecular communication channel. This is based on Brownian motion in aqueous medium, and is a consequence of the constant thermal motion of atoms, molecules, and their chemical reactions. An OTcl library, called ns-mol.tcl, is developed for a new node structure called NanoNode, which is based on the OTcl standalone class of Node. The library along with new nanonetwork components, parameters and methods for molecular communication provides the scheduling of the simulation, settings of the network topology and configuration of nanonetwork parameters.

#### F. BNSim

BNSim [10] is a multithread java simulator for bacteria networks. These networks interconnect engineered bacteria that communicate at nanoscales. BNSim integrates three simulation methods: (i) the Gillespie's stochastic simulation algorithm (SSA), which solves the chemical master equation in order to determine the time evolution of a chemical system; the extremely small granularity of events makes this approach unpractical for population-level problems; (ii) stochastic differential equations, used to model large-scale chemical system with a controlled level of approximation; (iii) a hybrid algorithm which integrates both the SSA and the methods

based on differential equations. The approximated methods based on stochastic differential equations are used to model the behavior of species that are present in large quantities and generate scalability issues. It was estimated to have a speed increase of 5-7 orders of magnitude over the SSA approach [10].

#### G. NCSim

NCSim is a simulation framework for molecular communications, utilizing flagellated bacteria for information delivery [11]. The major focus of the framework is on different message encoding techniques. NCSim supports typical deployment policies, such as grid and random, as well as custom deployment policies. It can simulate several simultaneous links between the nanomachines. NCSim incorporates the stochastic model for bacteria mobility by Wang et al. [12], and the plasmid/chromosome transfer between bacteria through the conjugation process. Currently, only the 2-dimensional configuration is supported. The accuracy of the produced metrics in major scenarios has been confirmed via comparison with analytical results in simplified scenarios. NCSim consists of three modules: (i) physical (PHY) layer of bacterial nanonetworks, including deployment, bacteria mobility and conjugation, plus messages encoding/decoding; (ii) scenarios generator and simulation monitor; and (iii) plotting tool, intended to post-processing of raw simulation data and plots generation. The PHY module, as the most computational intensive, is implemented in C++. The two latter modules are written in Python for maintenance and extension simplicity. The user interacts with NCSim by writing small scripts on Python to define scenarios.

#### H. Other Related Simulators.

In [10] and in the references therein it is possible to find details of the following simulators: (i) Smoldyn, which simulates molecular-level biological interactions and particle diffusion; (ii) NFSim, which is a single-cell level simulators; (iii) Stochsim, developed for studying bacterial chemotaxis and the stochastic features of this signalling pathway; (iv) Agentcell, which is a population-level simulators working in conjunction with Stochsim; (v) RapidCell, which models the chemotaxis pathway through stochastic differential equations in a 2D environments, and (vi) BSim, which models the physicochemical interactions among bacteria in a 3D environment. In [13], the authors introduce a simulator design focusing on scalability, and adopting the high level architecture model, which is standardized under IEEE 1516. It is used to design a distributed simulation tool for molecular communication, so that different

scalability options can be used to include additional processing power to shorten the execution time. Additionally, in the Project MINERVA, a Nervous NaNoNetwork Simulator, N4Sim, covering the electrical and molecular communications in the synaptic channels and neurons, is being developed. The simulator will be used to capture communication theoretical insights of neural diseases related to communication failures, e.g., multiple sclerosis, paralysis, Alzheimer's disease.

Diffusion based molecular communication have been also simulated by using general purpose scripting and programming languages, such as MATLAB. In this regard, it is worth to mention a MATLAB script shown in [14] that emulates droplet circulation in microfluidic circuits by leveraging the formal equivalence between droplet propagation and current propagation in electronic circuits. Finally, it is important to consider BioModels, which is a reference repository of pathway models.

### III. Lesson Learned

The simulators shown above are characterized by both significant limitations and strengths. The main limitations consists of the lack of interworking functions between simulators. The main strength consists of the coverage of a large set of case studies and functions on which it is strategic to leverage for taking advantage of the capabilities of each other. In fact, the research challenges in the area are emerging frequently, and the cross-fertilization of the ongoing simulation activities will allow achieving research results much faster. For example, the ability of bacteria to communicate is significantly influenced by the physical features and flow of fluid in the environments they are invading. This phenomenon can be investigated by combining the capabilities of the mentioned simulators, handling both bacteria and fluid flow components in blood vessels. As a further example, combining the different facets of MolCom with microfluidics can open a wide range of research perspectives. For these reasons, the project CIRCLE pursues the realization of a combined simulation toolbox, to be used as a design tool for MolCom systems. The aim is to combine the behavior in complex MolCom systems, which are affected by a number of interdependent factors that make the fluid flow at any location depending on the properties of the entire system.

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## SECTION 4. REPORTS FROM TCSIM SPONSORED EVENTS



REPORTS FROM TCSIM SPONSORED EVENTS  
IEEE CORAL 2016, Coimbra, Portugal, June 21 2016



### Fourth IEEE International Workshop on Emerging COgnitive Radio Applications and aLgorithms (IEEE CORAL 2016)

IEEE CORAL is a young yet successful workshop that holds in conjunction with the World of Wireless and Mobile conference (WOWMOM). The objective of this workshop is to bring together practitioners and researchers from both academia and industry to discuss the recent advances in both the methodological, simulative and algorithmic aspects of **cognitive radio technologies**.

The **Fourth CORAL workshop** edition was held in the beautiful Coimbra, Portugal, on 22 June 2016, and it repeated the success of previous two events, with a good number of paper submissions, and of international attendees. Based on the reviews performed by the PC members, **five papers** were selected to be included in the final program. The workshop was opened by a speech held by **Prof. Frank Gao** and **Prof. Marco Di Felice** on the topic of TV White Space and applications for indoor communications.

**CORAL WEBSITE:** <http://www.cs.unibo.it/coral2016/coral2016.html>

## SECTION 5. UPCOMING TCSIM SPONSORED EVENTS



### IEEE 2nd International Forum on Research and Technologies for Society and Industry (IEEE RTSI 2016)

#### Track on Smart Grids and Smart Mobility for Smart Cities

**Chairs:** Prof. Luciano Bononi (University of Bologna), Prof. Alberto Borghetti (University of Bologna), Prof. Carlo Alberto Nucci (University of Bologna, GUSEE)

Recently several smart grid techniques have been proposed and demonstrated in pilot project in order to increase the hosting capability of the power distribution network with respect to the integration of embedded generation particularly from renewables. The forecasted increase of the use of electric vehicles provides another motivation for the design and application of new procedures for the planning, operation and protection of distribution networks in urban areas. The session aims at providing an occasion for the presentation of the results of the most recent research activities in the field.

**RTSI WEBSITE:** <https://apice.unibo.it/xwiki/bin/view/RTSI2016>

## SECTION 5. UPCOMING TCSIM SPONSORED EVENTS



UPCOMING TCSIM SPONSORED EVENTS  
IEEE MASS 2016, Brasilia, Brazil, October 10-13 2016



### *The 13th IEEE International Conference on Mobile Ad hoc and Sensor Systems (IEEE MASS 2016)*

**General Chairs:** Jiannong Cao (Hong Kong Polytechnic University), Marcelo M. Carvalho (University of Brasilia, Brazil)

The 13th IEEE International Conference on Mobile Ad hoc and Sensor Systems (IEEE MASS 2016) will be held in Brasilia, Brazil, October 10-13, 2016.

Wireless ad hoc communication has applications in a variety of environments, such as conferences, hospitals, battlefields, and disaster-recovery/rescue operations, and is also being actively investigated as an alternative paradigm for Internet connectivity in both urban and rural areas. Wireless sensor and actuator networks are also being deployed for enhancing industrial control processes and supply-chains, and for various forms of environmental monitoring. IEEE MASS 2016 aims at addressing advances in research on multihop ad hoc and sensor networks, covering topics ranging from technology issues to applications and test-bed development.

**MASS WEBSITE:** <http://www.ene.unb.br/mass2016/>



## SECTION 5. UPCOMING TCSIM SPONSORED EVENTS



### *The International Telecommunication Networks and Applications Conference (IEEE ITNAC 2016)*

**General Chairs:** Martin Purvis (University of Otago, New Zealand), Mark Gregory (RMIT University, Melbourne, AU)

With the increasing number of emerging robust networks, the challenges to design new networking protocols, techniques, and applications are never ending. ITNAC (formerly known as ATNAC) has been a leading forum in Australasia for researchers and engineers to present and discuss topics related to advanced telecommunication network technologies, services and applications.

ITNAC 2016 seeks to address and capture highly innovative and state-of-the-art research from academia, communications industry and standardization bodies that covers distributed, mobile, cognitive and cloud computing, computer and data communications, local and metropolitan networks, optical, wired and wireless telecommunication networks and applications.

**ITNAC WEBSITE:** <http://www.itnac.org.au/2016>

UPCOMING TCSIM SPONSORED EVENTS  
IEEE ITNAC 2016, Dunedin, New Zealand, December 7-9 2016



## SECTION 6. CALL FOR PAPERS ELECTRONIC NOTES on SIMULATION

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The IEEE TCSIM Newsletters will publish short technical papers. The submissions should emphasize modeling, design, and analysis of computational methods for simulations and its applications in various areas, including, but not limited to, computer science, engineering, communications, and simulation applications. The submissions are invited covering, but not limited to, the following topics:

- Simulation algorithm design, implementation, and analysis
- Simulation complexity in computing
- Parallel and distributed simulation
- Design and usage of simulation tools
- Real-time simulation monitoring
- Simulation tools for communications and networks
- Simulation of computer systems and applications
- Agent-based simulation tools focus on the use of agents in engineering, human and social dynamics, military applications
- Systems and process simulation
- Simulation of ubiquitous networking and computing
- Simulation of transportation systems
- Automotive simulation applications
- Building and energy management simulations
- Machine learning
- Virtual reality systems
- Knowledge and data systems
- Systems optimization
- Web-based simulation and applications
- Simulation of molecular systems
- DoDAF-based vulnerability assessment

### Submission

All papers must be submitted to [marco.difelice3@unibo.it](mailto:marco.difelice3@unibo.it) in five pages or fewer, including all figures, tables, and references. A manuscript submitted for publication should be original work that should not have been previously published and should not be under consideration for publication elsewhere. If an author uses charts, photographs, or other graphics from previously printed material, he/she is responsible for obtaining written permission from the publisher to use the material in his/her manuscript. Papers should use 7.875in x 10.75 in (20cm x 27.30cm) trim size and the IEEE transactions two-column format in 10-pt. font. All papers will be fully refereed for accuracy, technical content, and relevance. Contact Dr. Marco Di Felice at [marco.difelice3@unibo.it](mailto:marco.difelice3@unibo.it) with any questions concerning the paper submission and review process.

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