THE SOCIETY FOR
MODELING & SIMULATION
INTERNATIONAL

SUMMERSIM

Summer Simulation Multi-Conference 2015

JULY 26-29, 2015

Palmer House Hilton; Chicago, IL, USA

2015 SummerSim

PROGRAM BOOK

July 26-29, 2015
Chicago, IL, USA

General Chair
Saurabh Mittal

Vice-General Chair
Floriano De Rango

Program Chair
José Luis Risco Martín

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Welcome to SummerSim '15

Welcome from the General Chair

Dear Colleagues and Friends,

On behalf of the Organizing Committee, I am delighted and honored to welcome you to the Summer Simulation Multi-Conference 2015 (SummerSim'15) in Chicago, Illinois.

The Society for Modeling & Simulation International (SCS) which organizes SummerSim is one of the oldest Modeling and Simulation organizations in the world. It endeavors to promote the advancement of Modeling and Simulation and connect Modeling and Simulation professionals worldwide. **The SummerSim'15 program** includes a world-class selection of peer-reviewed paper, presentations, distinguished keynote speeches and tutorials. In addition, SummerSim'15 offers a Ph.D. colloquium where students and established professionals can meet and exchange ideas. This year SummerSim'15 is additionally sponsored by IBM, MapleSoft, Link Fourndation, and International Simulation Alliance. Great thanks to the organizations that have donated money, licenses and books to recognize the best submissions at this conference.

I would also like to thank our keynote speakers **Prof. C. Donald Combs**, **Prof. Thomas Talbot**, **Prof. Alexander H. Levis**, **Paul Martin**, **Dr. Barclay Brown** and **Greg Gorman** for graciously accepting to share their vast knowledge and experiences with us. My thanks also go to all members of the Organization Committee for their tireless efforts especially in working through the introduction of a new format and editing process. It was truly a team effort. The committee consists of:

Vice-General Chair	Floriano De Rango, University of Calabria, Italy
Program Chair	Jose Luis Risco Martin, Complutense University of Madrid, Spain
Proceedings Chair	Deniz Cetinkaya, Univ. of Turkish Aeronautical Association, Turkey
Awards Chair	Andreas Tolk, SimIS Inc., USA
Tutorial Chair	Jose Luis Risco Martin, Complutense University of Madrid, Spain
Publicity Chair	Justyna Zander, Humanoid Way, USA
Sponsorship Chair	Umut Durak, German Aerospace Center, Germany
PhD Colloquium Chair	Miroslav Velev, Aries Design Automation, USA

As a Multi-Conference, our success depends heavily on the track organizers, reviewers and committee members. I am very grateful for the efforts of all of the volunteers that dedicated their time and effort to review and edit all of the submissions and thus make this gathering possible. I also express my gratitude to authors and tutorial presenters for their important contributions.

My sincere appreciation goes to the Conference chairs, whose invaluable efforts in their respective sections were key to the success of the overall multi-Conference. This year's Conference chairs are:

- International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015), chaired by Franco Davoli and Jose Marzo.

Welcome to SummerSim '15

- 47th Summer Computer Simulation Conference (SCSC'15), chaired by me and Il-Chul Moon.

This year SCSC brings back the track on Grand Challenges in M&S (GCMS) and introduces a new Track on M&S for Environmental Systems (MSES). SCSC 2015 continues the tracks debuted in SCSC 2014:

- M&S for intelligent, adaptive and autonomous systems (MSIAAS)
- M&S and Test for Cyber Physical Systems (MST4CPS)
- M&S for Medicine

I would also like to express my thanks to the respective Program Chairs:

- SPECTS 2015: Joel Rodrigues, Malamati Louta and Imadeldin Mahgoub
- SCSC 2015: Eugene Syriani

Special thanks go to the SCS officers, **Oletha Darensburg**, **Aleah Hockridge** and the team for their high level of professionalism, and for the smooth running of all the events. Last but not the least, thanks to **Prof. Gabriel Wainer**, outgoing Vice President for SCS Conferences, for his outstanding support in shaping various things for SummerSim over the last few years.

Chicago is one of the iconic cities in the United States and Palmer House Hilton's central location in downtown Chicago offers visitors the chance to walk to famous attractions such as the Art Institute of Chicago, Millennium Park, and State Street Shopping. In addition, you are invited to enjoy the hotel's History is Hot Tour and join Palmer House Hilton historian Ken Price for lunch and an exclusive guided tour through this legendary Chicago landmark.

Welcome to SummerSim'15.

Saurabh Mittal, Ph.D.
General Chair SummerSim 2015
Dunip Technologies, LLC, Colorado, USA

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GENERAL INFORMATION

General Information

SummerSim'15 Organizing Committee

General Chair: Dr. Saurabh Mittal, Dunip Technologies, LLC, Colorado USA
General Co-Chair: Floriano De Rango, University of Calabria, Italy
Awards Chair: Andreas Tolk, SimIS Inc., Virginia, USA
Program Chair: José Luis Risco Martin, Universidad Complutense de Madrid, Spain
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Tutorial Chair: José Luis Risco Martin, Universidad Complutense de Madrid, Spain
Poster Session and Student Colloquium: Miroslav Velev, Aries Design Automation, USA
Awards Committee:
Prof. Helen Karatza, Aristotle University of Thessaloniki, Greece
Prof. Helena Szczerbicka, Leibniz Universität Hannover, Germany
Prof. Drew Hamilton, Mississippi State University, USA

2015 Summer Computer Simulation Conference (SCSC 2015)

General Chair: Dr. Saurabh Mittal, Dunip Technologies, LLC, USA
General Co-Chair: Il-Chul Moon, KAIST, Korea
Program Chair: Eugene Syriani, University of Montreal, Canada

Symposia

- **Modeling, Simulation, and Test For Cyber Physical Systems**

  Chair: Miroslav Velev

- **M&S For Intelligent, Adaptive and Autonomous Systems**

  Chair: Saurabh Mittal and Marco Lutzenburger

- **M&S In Medicine**

  Chair: Jacob Barhak

- **M&S for Sustainability**

  Chair: Bjoern Johansson

- **Agent-Directed Simulation**

  Chairs: Levent Yilmaz and Tuncer Oren

- **Emergency Management Simulation**

  Chair: Francesco Longo

General Information

2015 Summer Computer Simulation Conference (SCSC 2015) Continued

- **Work in Progress**

  Chair: Mohammad Raunak

- **Computer Graphics for Simulation**

  Chair: John F. Richardson

- **Grand Challenges in Modeling and Simulation**

  Chair: Ali Elkamel, Chandramouli R. Madhuranthakam, Hedia Fgaler

- **Modeling and Simulation in Energy Systems Integration and Smart Grid**

  Chair: Vladimir Koritarov, Saurabh Mittal and Prakash R. Thimmapuram

SCSC 2015 features varied tutorials, tracks, and workshops. The conference focuses on modeling and simulation, tools, theory, methodologies and applications, providing the latest R&D results in academia and industry.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)

General Chairs: Franco Davoli, University of Genoa, Italy and Jose Marzo, University of Girona, Spain

This annual international conference is a scientific forum for professionals and scientists involved in performance evaluation of computer and telecommunication systems. Performance evaluation of computer systems and networks has progressed rapidly in the past decade and has begun to approach maturity. Significant progress has been made in analytic modeling, simulation, and measurement approaches for performance evaluation of computer and telecommunication systems.

General Information

Registration

Your registration for SCS's 2015 Summer Simulation Multi-conference (SummerSim'15) includes AM and PM breaks, lunch for Tuesday's IBM Lunch Presentations, the Monday evening reception and all mixers, and access to all sessions, tutorials and special presentations (unless otherwise noted). Please visit the SCS Registration Desk in the 7th Floor Foyer for any questions you have during the conference.

Registration Hours (7th Floor Foyer):

Sunday, July 26th – 8:00-9:00* and 16:00-18:00

Monday, July 27th – 7:00–17:00

Tuesday, July 28th – 7:00–17:00

Wednesday, July 29th – 7:30–15:00

Please note that the Registration Desk will be closed for lunch Mon-Wed

Breaks and Lunches

Coffee Breaks & Lunch (Breaks in Clark 5 unless otherwise noted):

Monday, July 27th :

Breaks: 10:00–10:30 | 15:30-16:00 Lunch: 12:00-13:00 (on your own)

Tuesday, July 28th:

Breaks: 9:30–10:00 | 15:00-15:30 IBM Sponsored Lunch: 11:30-12:30 (Wabash Room, third floor)

Wednesday, July 29th:

Break: 10:00-10:30

Speakers' Breakfasts

Speakers' breakfasts will be held Monday – Wednesday from 7:15 – 8:00, located in the Crest Hill room on the third floor. The presenters for each day are invited to join their session chairs at a breakfast on the morning of their presentation. If you are not sure which day to attend the breakfast, please check the list outside the door.

Meetings

SCS Board of Directors Meeting—Sunday, July 26 at 9:00 in Clark 1.

* Badge pickup for pre-registered attendees only

General Information

Sunday Welcome Mixer

Attendees who are in town on Sunday are invited to mix and mingle with other attendees at our Welcome Mixer on Sunday, July 26 from 17:00-18:00 in the 7th Floor Foyer. Snacks and sodas will be provided.

Monday Evening Social

There will be a welcome social with drinks and light appetizers in the Crystal Room (third floor) on Monday, July 27 from 17:30-19:00. All attendees and their guests are invited to attend.

Tuesday Evening Awards Ceremony/Networking Social

Best Paper and other awards will be announced at this event on Tuesday, July 28 at 18:00 in Clark 5. Appetizers, drinks, and live music will be provided. Mix and mingle with other attendees at this social event...it's a great way to network! Open to all attendees.

Plenary/Keynotes

Plenary Session and Keynotes (*Wabash Room—third floor)*

- **Monday Plenary:** 8:00-8:15: Welcome

  8:15-10:00: Keynotes Dr. C Donald Combs and Paul Martin

  13:00-14:00: Keynote Dr. Thomas Talbot

- **Tuesday Plenary:** 8:30-9:30: Keynote Dr. Alexander Levis

  11:30-12:30: Lunch sponsored by IBM (including SummerSim'16 Planning Meeting)

  12:30-13:20: IBM Presentation by Greg Gorman & Barclay Brown

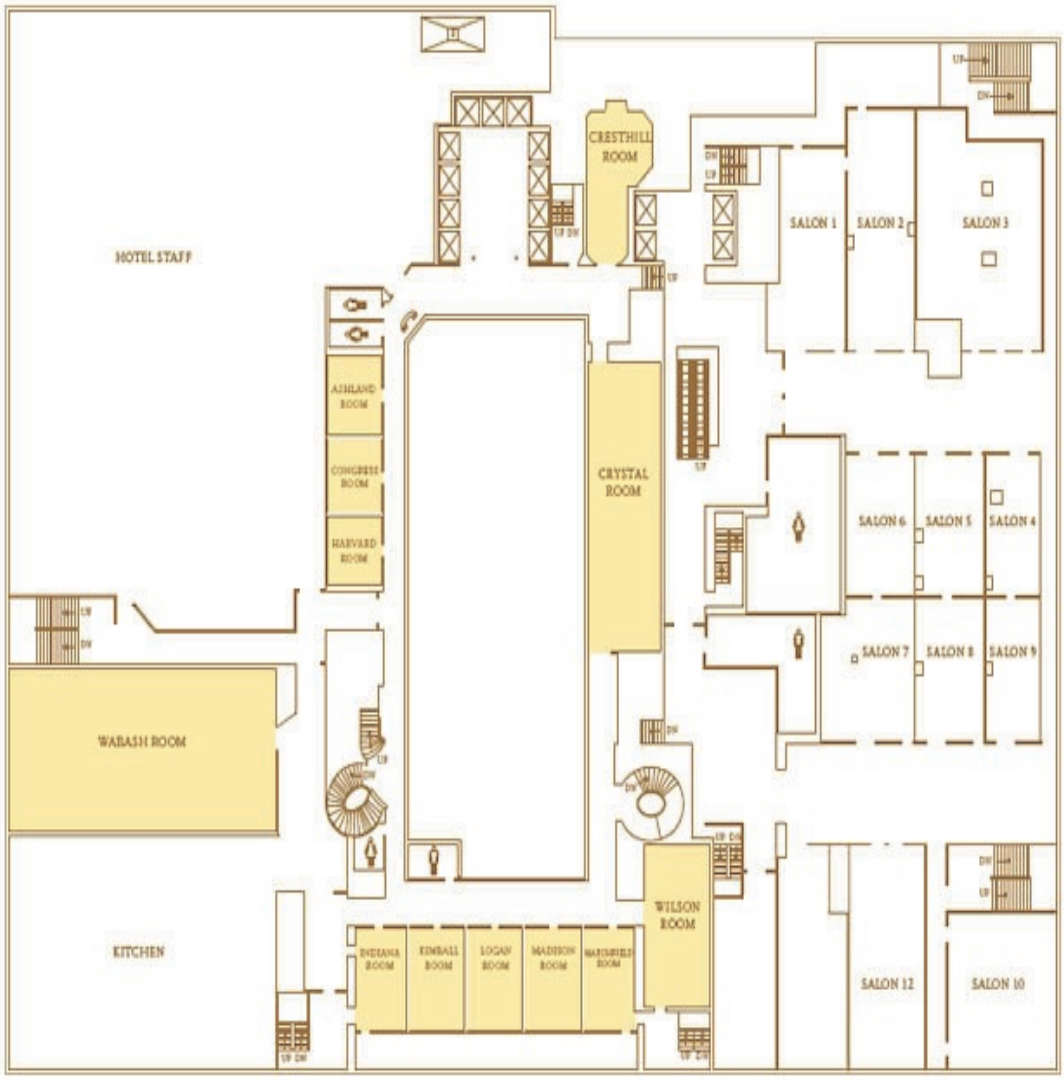
SCS Fellows Award Dinner

The Fellows Award dinner, honoring recent inductee Dr. John A. Hamilton, Jr., Ph.D, will be held on Tuesday, July 26 at 18:00 in the Indiana Room (third floor). This dinner is by invitation only.

General Information

Plenary, Breakfast and Reception Floor Plan

Third Floor



General Information

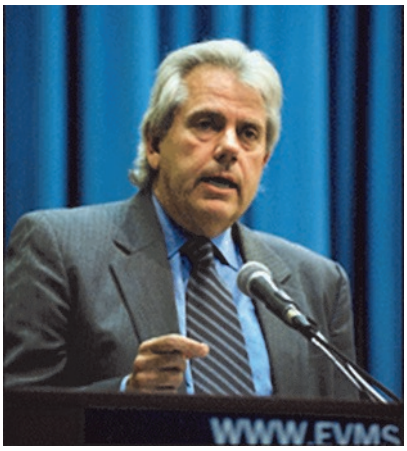
Meeting Space Floor Plan

Seventh Floor

KEYNOTES

Keynote Speaker

TITLE: Personalized Medicine, Complexity and the Evolving Importance of Simulation



AUTHOR: C. Donald Combs, PhD, Vice President and Dean of the School of Health Professions at Eastern Virginia Medical School

DATE/TIME: Monday, 8:15 to 9:00, Wabash Room

ABSTRACT: President Barack Obama said in his 2015 State of the Union speech that his administration wants to increase the use of personalized genetic information to help treat diseases like cancer and diabetes. Obama urged Congress to boost research funding to support new investments in precision medicine. "I want the country that eliminated polio and mapped the human genome to lead a new era of medicine – one that delivers the right treatment at the right time," Obama said.

Understanding in detail and with certainty what is going on within one's own body has been an elusive quest throughout history. Partial glimpses and general understanding are the best we have been able to do with the data we have at our disposal and with the limitations of population-normed theories of what the data mean for diagnosis and treatment for individuals. In the not-too-distant future, however, that will change as the Digital Patient platform is developed. The capacity to sense one's personal physiological and social metrics, compare those metrics with the metrics of millions of other humans, personalize needed therapeutic interventions and measure the resulting changes will realize the vision of personalized medicine. Incorporating all of that rich data in simulations will also have significant impacts on medical research, education and healthcare systems around the world as more interventions are simulated and assessed in silico prior to their use in therapy. A substantial challenge, however, is the data integration and analysis required to model the complex data and relationships and to build the simulations that integrate systems from the molecular to the social. That is the grand challenge of healthcare simulation in the next decade.

SHORT BIO: C. Donald Combs, PhD, serves as Vice President and Dean of the School of Health Professions at EVMS. His responsibilities include direction of all EVMS health professions programs, academic planning, oversight of medical modeling and simulation, program development, accreditation liaison, and directing educational outreach programs.

Dr. Combs holds senior faculty appointments with the EVMS School of Health Professions and the Department of Modeling, Simulation and Visualization Engineering at Old Dominion University. He has long-standing research interests in health and human services management, emergency response, health workforce research, health professions regulation, organizational development, strategic planning, and medical modeling and simulation. These interests are reflected in his professional publications and conference presentations; many consultancies with federal, state and local agencies, non-profit services organizations and businesses; and $115 million in external funding.

He currently serves on several regional, state and national boards and task forces that address national and international health policy. Dr. Combs is active in the Society for Simulation in Healthcare, the Association of American Medical Colleges (AAMC) and the Association of Academic Health Centers (AHC) and in national policy discussions addressing health workforce planning, applied information systems and medical modeling and simulation.

In the international arena, Dr. Combs has worked with colleagues at the Naval Postgraduate School to develop and implement the International Health Resource Management executive education program that has served some 20 nations, including Moldova, Bulgaria, Macedonia, Nepal, Botswana and El Salvador. He holds degrees received with distinction from South Plains College, Texas Tech University and the University of North Carolina - Chapel Hill. He was awarded an honorary doctoral degree from Moldova's State Medical and Pharmaceutical University in 2002 for his service in reforming its primary-care health system.

Keynote Speaker

TITLE: Serving Humans with Virtual Intelligent Characters
AUTHOR: Thomas "Brett" Talbot, USC Institute for Creative Technologies

DATE/TIME: Monday, 13:00 to 14:00, Wabash Room

ABSTRACT: Virtual human characters are now seeing effective use for a variety of purposes. They are serving as virtual patients, job interviewers, and crime witnesses for training purposes. Additional use cases include information guides, psychological therapy screeners and even emotionally responsive conversation partners. Virtual humans are treated by users as people, with more user disclosure and comfort than with in-vivo human interactions. Additionally, intelligent virtual humans can transform empty Virtual Reality (VR) spaces into socially interactive environments that increase the utility of VR tremendously. This presentation will demonstrate and review examples of these applications and provide insight to the underlying technologies that enable rich high-fidelity virtual human appearance, expression and interaction.

SHORT BIO:
Dr. Talbot is the Principal Medical Expert at the USC Institute for Creative Technologies and adjunct associate research professor at Keck School of Medicine of USC. Dr. Talbot was the founder of the Armed Forces Simulation Institute for Medicine at the Telemedicine and Advanced Technology Research Center and established, at the Department of Defense, the nation's largest medical education focused research and development program, encompassing more than $275 million and 150 projects under his leadership. He has been at the center of many of the nation's major medical simulation R&D efforts. At ICT, he is designing the next generation of virtual standardized patients.

Dr. Talbot is a veteran of the US Army with combat experience and has more than 18 years' experience as a medical education developer. As a pediatrician and scientist, Dr. Talbot endeavors to create meaningful improvements that will advance the state of the art in medical education and patient care. Work interests include serious games, natural user interfaces, virtual and augmented reality, virtual interactive humans and microcontrollers.

Keynote Speaker

TITLE: Modeling, Multi-formalism Modeling, and Meta-modeling…Dreams and Realities

AUTHOR: Alexander H. Levis, Volgenau School of Engineering, George Mason University, Fairfax, VA

DATE/TIME: Tuesday, 8:30 to 9:30, Wabash Room

ABSTRACT: Technology has enabled us to interconnect models at the physical and syntactic levels, but this has raised a number of challenges at the semantic and workflow levels. Many of the challenging applications require development and interoperation of a set of several models. Each model, developed using different modeling languages but the same data, offers unique insights and makes specific assumptions about the organization being modeled. Interoperation of such models can produce a more robust modeling and simulation capability to support analysis and evaluation. Meta-modeling analysis based on Concept Maps and ontologies indicates what types of interoperation are valid between models expressed in different modeling languages. Domain specific multi-formalism workflow languages show promise for enabling the interconnection of models so that they can interoperate in a valid manner. However, when the models range from social networks, to agent based models, to Bayesian nets, to colored Petri nets, to differential equations, etc. many challenges remain unexplored. The issues are illustrated through various applications.

SHORT BIO:

Dr. Alexander H. Levis is University Professor of Electrical, Computer, and Systems Engineering and heads the System Architectures Laboratory in the Volgenau School of Engineering, George Mason University, Fairfax, VA. From 2001 to 2004 he served as the Chief Scientist of the U.S. Air Force at the Pentagon. He was educated at Ripon College where he received the AB degree (1963) in Mathematics and Physics and then at MIT where he received the BS (1963), MS (1965), ME (1967), and Sc.D. (1968) degrees in Mechanical Engineering with control systems as his area of specialization. Dr. Levis is a Life Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and past president of the IEEE Control Systems Society; a Fellow of the American Association for the Advancement of Science (AAAS), a Fellow of the International Council on Systems Engineering (INCOSE), and an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA). For the last fifteen years, his areas of research have been system architecture design and evaluation, resilient architectures for command and control, and evaluation of cyber exploits on system behavior through modeling and simulation.

Keynote Speaker

TITLE: M&S and the Future of Systems Engineering

AUTHOR: Paul Martin, Systems Engineering Technical Adviser (SETA) and President of SE Scholar, LLC

DATE/TIME: Monday, 9:05-10:00, Wabash Room

ABSTRACT:

It's not hard to see that our society is being overrun by technology. And yet there is an expectation that we will solve our biggest problems by using technology. But these world spanning societal problems are becoming increasing complex and more difficult to solve because of the very technology that is embedded in the world already. Systems Engineering is a profession dedicated to finding holistic solutions that takes into account every eventuality. But trying to understand the emergent properties of the complex systems needed to solve complex problems is especially difficult. The future of Systems Engineering must address these issues in a compressive manner so that the next generation of Systems Engineers can face these challenges and find successful solutions. Paul Martin will be reviewing the 2014 INCOSE Systems Engineering Vision 2025 document in light of our present day dilemmas. Speciality focusing on the ever increasing importance of modeling and simulation to ensure the emergent behaviours of future complex systems don't lead to unintended consequences.

SHORT BIO:

Paul Martin, ESEP, is a practicing Systems Engineer with over 35 years of experience. He has been everything from a Product Engineer for General Electric Products Division to a Software Systems Engineer for a multi-million dollar Navy program. Presently he's a Systems Engineering Technical Adviser (SETA) supporting a Government Agency.

Paul is also the owner and President of SE Scholar, LLC , located at www.se-scholar.com, where he teaches an on-line INCOSE ASEP/CSEP Exam Preparation Course. He's been teaching this course since 2009 and has taught several hundred students. Paul also serves as an Adjunct Professor for the University of Maryland, Baltimore County College of Engineering and Information Technology, Systems Engineering Graduate Programs where he teaches ENEE 663: System Implementation, Integration, and Test and ENEE 667: Advanced Systems Engineering Processes. Paul has been involved with INCOSE since 2000 and has served on the local INCOSE Chesapeake Chapter Board of Directors as Programs Director and Communications Officer. He's also a Senior Member of IEEE.

Tutorials &
Student Colloquium

Tutorial

Tutorial I (Sunday, 10:00-11:30, Clark 7 Room)
The Role of Simulation in Model Based Systems Engineering for complex cyber physical systems

G. Bleakley Ph.D.	I. Badr	B.P. Douglass Ph.D.
IBM UK Ltd.	IBM US	IBM US
London, UK	Chicago, USA	Reston, USA
graham.blekaley@uk.ibm.com	ibadr@us.ibm.com	bruce.douglass@us.ibm.com

Abstract

The International Council Of Systems Engineering (INCOSE) is advocating the use of Model Based Systems Engineering (MBSE) as part of its Systems Engineering 2020 vision. Part of what MBSE offers to Systems Engineering is the ability to simulate and execute models so that systems engineers and designers can analyze the models to gain an understanding of the nature of the things that they are developing. MBSE is now becoming the standard way forward to implement Systems Engineering within companies, especially those developing complex cyber physical systems such as Aerospace and Defense.

The nature of the simulations carried out in MBSE are wide and varied. The objective of this tutorial is to describe the benefits of using simulation in MBSE, some of the uses of MBSE simulations, and the various methods available to use. The methods described, range from the simulation of behavioral models captured as State charts or Activity diagrams in the Systems Modeling Language (SysML), through to the use of multi-domain modeling. In this approach several modeling tools can be integrated together to get a complete understanding of the systems behavior.

The tutorial will use a common SysML tool as the basis for the discussion. It will show how it can be used as a modeling and simulation environment. Then integrated with other tools like Simulink, combining discrete and continuous simulation. This will lead to how the Functional Mockup Interface (FMI) Standard can be used to integrate a variety of modeling tools together, enabling multi-domain simulation.

Tutorial

Tutorial II (Sunday, 13:30-15:00, Clark 7 Room)

DEVS Modeling using the DEVSML Editor and Foundations of DEVS M&S Environments Performance Evaluation Using the DEVStone Benchmark

José L. Risco-Martín
ArTeCS Research Group
Complutense University of Madrid
jlrisco@ucm.es

Saurabh Mittal
Dunip Technologies, LLC
Colorado, USA
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Abstract

In the last four decades, various Modeling and Simulation (M&S) methodologies have provided excellent approaches to solve problems. Among them, one of the M&S techniques that has gained popularity is the Discrete Event System Specification (DEVS): a sound, formal definition, based on generic dynamic systems theoretical concepts, which supports efficient event based simulation, verification and validation.

DEVS divides the system into basic models, called atomic models, and composite models called coupled models. Atomic models define the behavior of the system, whereas coupled models specify the structure. This formalism, which supports hierarchical and modular model composition, has been widely used to understand, analyze and develop a variety of systems. DEVS has been implemented in various languages and platforms over the years, e.g. C++, Java, Python, Scheme, etc. Developing a Model-driven Engineering (MDE) solution to DEVS model editing is currently being pursued by development of DEVS Domain Specific Language (DSL) called as DEVS Modeling Language (DEVSML).

In the first part of the tutorial, we will illustrate the installation and capabilities of DEVSML editor described in our book “Netcentric System of Systems Engineering with DEVS Unified Process”, CRC Press, published in 2013. We will then showcase a full example using our latest DEVS Simulation engine: xDEVS 1.0.

In the second part, we will highlight the current methodology to benchmark various DEVS simulation engines. DEVStone is a set of benchmarks that was conceived to generate a collection of models with varied structure and behavior, and to automate the evaluation of the performance of DEVS-based simulators. We will elaborate on DEVStone introducing new equations to compute the number of events triggered and introduce a new benchmark, called HOmem, designed to exploit memory footprint more than CPU usage. Finally, we compare both the performance and memory footprint of different DEVS simulators.

Student Colloquium

Sunday, 15:30-17:00, Clark 7 Room

The colloquium is intended to bring together students in both early and advanced stages of their careers who are working on any modeling and simulation topics, to provide them a friendly forum and an opportunity to present, discuss and illustrate their ongoing research in a constructive and enjoyable atmosphere. Each student will have 15 minutes to present. All conference registrants are welcome to attend.

Student Colloquium Schedule

1. **"The Kidney Transplant Process Model"**
By Christine Harvey (advisor Robert Weigel)
George Mason University and MITRE Corporation

2. **"An Optimization Model for Assessing Multi-products Productions from Biomass: A Case of Renewable Malaysian Oil Palm Empty Fruit Bunch"**
By Abdul Halim Abdul Razik (advisors Ali Elkamel and Leonardo Simon)
University of Waterloo, Canada

3. **"The Interplay Between Numerical Methods Within the Numerical Solution of a Three-Dimensional Model of Calcium Waves in a Heart Cell"**
By Jonathan Graf (advisor Matthias Gobbert)
University of Maryland, Baltimore County (UMBC)

4. **"Innovation Process Simulation on the Base Predator and Prey"**
By Nikita S. Mullen (advisor Victor P. Romanov)
Russian Plekhanov University of Economics, Moscow, Russian Federation

5. **"Exploring the Limits of Autonomy and Adaptation in Cognitive Radio"**
By Jacek Dzikowski (advisor Cynthia Hood)
Illinois Institute of Technology, Chicago, IL

6. **"An Agent-Based Model of Supplier Management in Regional Food Systems"**
By Hardik Bora (advisor Caroline C. Krejci)
IMSE—Iowa State University

Notes

IBM Lunch Presentation

IBM Lunch Speakers

IBM Speaker Bios

Greg Gorman

At IBM Greg leads the IoT Engineering Team, including Rhapsody, RELM, DOORS and all related components and industry solutions. Greg joined IBM through the Telelogic acquisition in 2008, where he served in several positions ranging from field engineer to sales executive to Vice President of Product Management over his 20 year history. Prior to joining Telelogic, Greg was with McDonnell-Douglas and then Honeywell Air Transport, where he led a software and systems team creating crew station displays for fighter aircraft and commercial jetliners. Greg graduated from the University of Missouri and is a Certified Product Manager, AIPMM and INCOSE Expert Systems Engineering Professional. Greg also serves as one of IBM Rational's thought leaders in the areas of complex systems development and is IBM's Corporate Advisory Board Representative to the International Council on Systems Engineering (INCOSE). He is also active in Scouting (and is an Eagle Scout), mentors a FIRST Robotics team and volunteers as INCOSE's Associate Director of K-12 Youth Outreach.

Dr. Barclay Brown

Dr. Brown is the Global Solution Executive for the Aerospace and Defense industry for IBM Continuous Engineering Solutions. A former Chief Engineer for IBM Global Business Services, he was the lead systems engineer for some of IBM's largest development projects. He is co-author of the book *Model Driven Systems Engineering with Rational Tools.*

Dr. Brown holds a bachelor's degree in Electrical Engineering with master's degrees in Psychology and Business and a PhD in Industrial and Systems Engineering. He is a certified Expert Systems Engineering Professional (ESEP), the INCOSE Director for the Americas and adjunct faculty at Worcester Polytechnic Institute.

IBM Lunch Presentation

Lunch Presentation with IBM (Tuesday, Wabash Room)

Lunch Served 11:30-12:30, talks from 12:30-13:20

- New role of Model Based Engineering for the Internet of Things

- A New Paradigm for Complex Behavior

Greg Gorman, ESEP
Director, Product Management and Design,
IBM Internet of Things Engineering Solutions
greg.gorman@us.ibm.com

Barclay Brown, PhD, ESEP
Global Solution Executive
IBM Internet of Things Engineering Solutions
barclayb@us.ibm.com

This session presents two visionary aspects of the future of modeling. First, Greg Gorman will discuss how Model Based Engineering is becoming fundamental to product design through the transformation of engineering from document-based specification and team communication to a dynamic model-based development lifecycle. Models will increasingly become the way that defining, implementing, verifying and analyzing systems is done—from product concept to monitoring of operational equipment. Today Model Based thinking is changing the way engineers work. It allows them not just to define concepts, but also to verify them by creating virtual integration between different modeling domains.

IBM has been investing into improving products and solutions in the space of modeling and simulation for decades. The session will also highlight the IBM vision for Model Based Engineering, which is to extend the use of models to the overall life cycle, including requirements, design, simulation, verification, implementation, data analysis and testing.

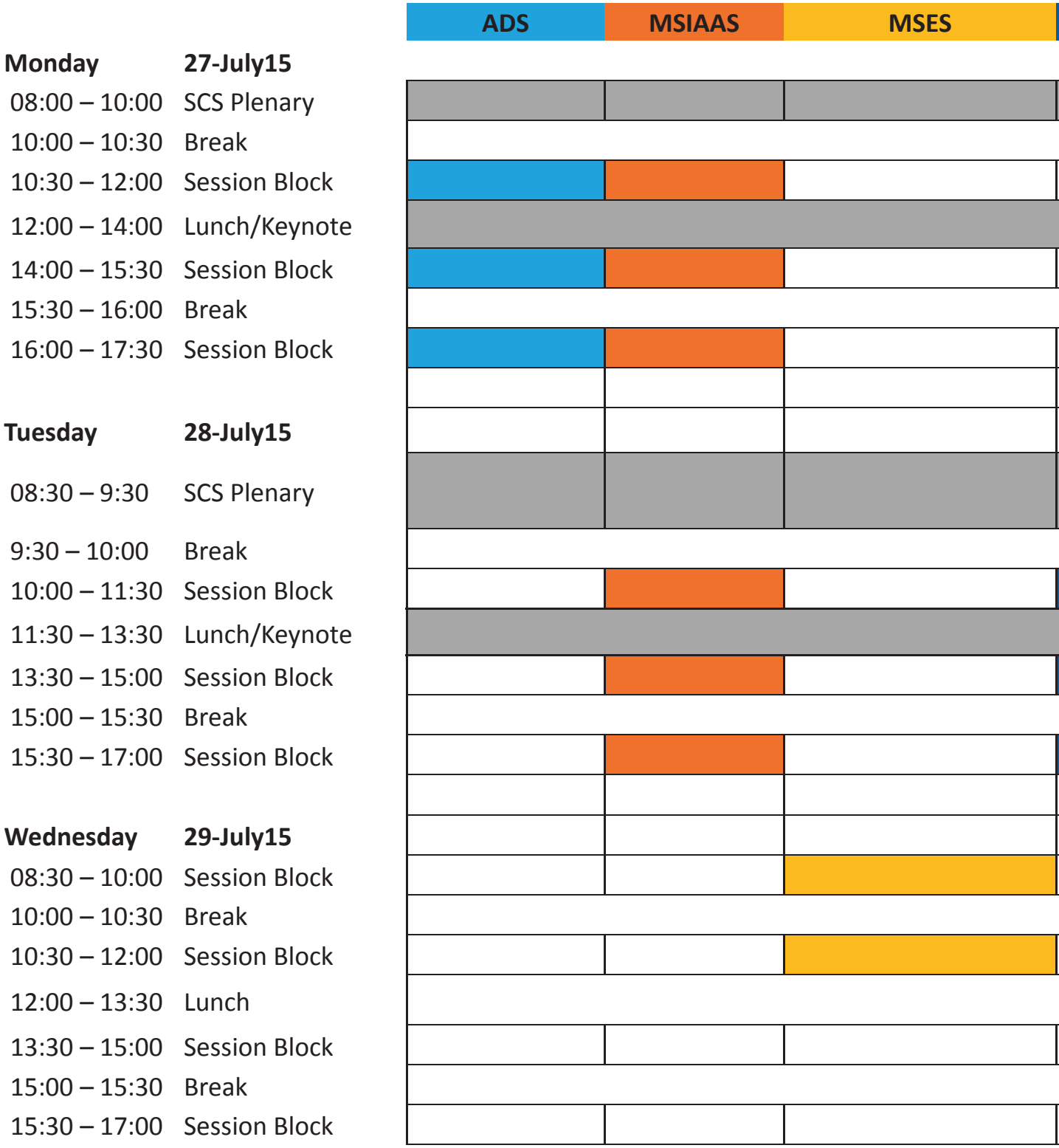
In the second half, Barclay Brown will present 'A New Paradigm for Complex Behavior'. Describing and modeling complex behavior involving systems has traditionally been accomplished using one of two main approaches—business or mission process modeling and system use case modeling. These two modeling approaches describe the behavior of organizations and systems, and their interactions, but rest on different paradigms and serve different needs. In many cases, business process modeling is employed as a precursor to system use case modeling, leading to potential redundancy of effort. An integrated approach would have advantages in efficiency, consistency and completeness of the overall behavioral model.

This part of the session describes recent research to develop a new paradigm for behavior modeling, integrating business process modeling and use case modeling into one model that can be created early in the development process.

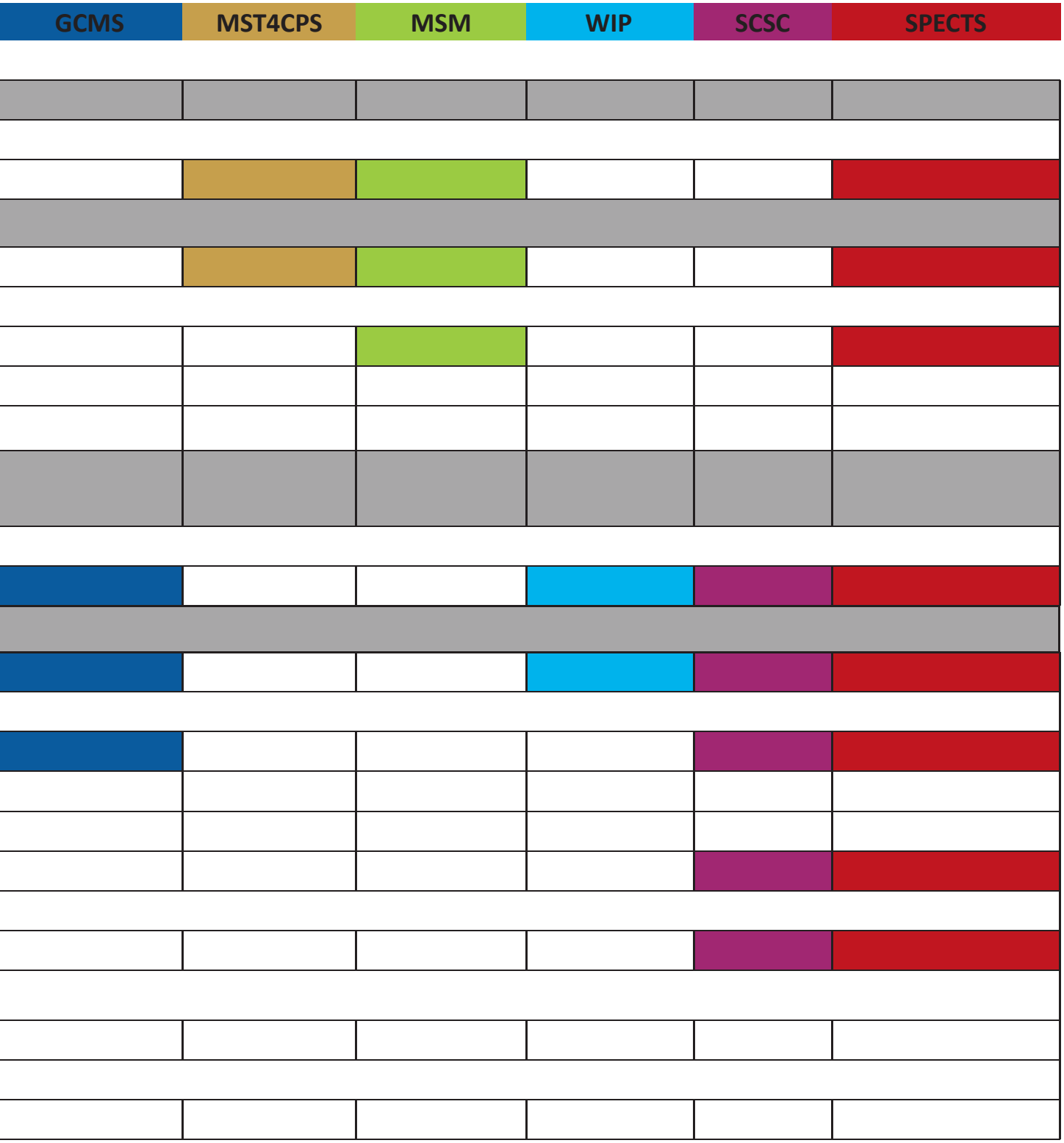
The two main innovations developed for the new paradigm are the *usage process* and the *timebox*. Usage processes allow system usages (use cases) to be identified as the business process model is developed, and the two shown in a combined process flow. Timeboxes allow processes to be positioned in time-relation to each other without the need to combine processes into higher level processes implying causal relations that may not exist. The combination of usage processes and timeboxes allows any level of complex behavior to be modeled in one pass, without the redundancy and waste of separate business process and use case modeling work.

Agendas

SummerSim'15 At A Glance Sessions



SummerSim'15 At A Glance Sessions



ADS 2015 Agenda

Monday, 27 July 2015

8:00-10:00 **Wabash Room: Opening Session and Keynote Speech (Plenary)**

Session 1

10:30-12:00 **Clark 1** **Chair: Gregory Madey**

- *An Approach to Address the Intrinsic Complexity in Multi-Modelling of Enterprises for Decision Making* by Vinay Kulkarni, Souvik Barat, Tony Clark and Balbir Barn
- *Agent-based Modeling and Simulation of the Emotional Experiences of Employees Within Organizations* by Hanen Lejmi Riahi, Fahem Kebair and Lamjed Ben Said
- *Including Public Transportation into a Large-scale Agent-based Model for Epidemic Prediction and Control* by Mingxin Zhang, Rongqing Meng and Alexander Verbraeck

13:00-14:00 **Wabash: Keynote Speech**

Session 2

14:00-15:30 **Clark 1** **Chair: Gregory Madey**

- *A Generic Simulation Model for Strategic Level Driver Behavior* by Marco Lützenberger
- *OpenMalaria and EMOD: A Case Study on Model Alignment* by Casey Ferris, Benoit Raybaud and Gregory Madey
- *Computational Complexity of Agent-based Multi-scale Cancer Modeling* by Fei Xing and Dieter Heermann

Session 3

16:00-17:30 **Clark 1** **Chair: Gregory Madey**

- *An Agent Based Exploration of a Relationship Between Daily Routines and Convenience Store Footfalls* by Vivek Balaraman, Deepa Athle and Meghendra Singh

MSIAAS 2015 Agenda

Monday, 27 July 2015

8:00-10:00 **Wabash Room: Opening Session and Keynote Speech (Plenary)**

13:00-14:00 **Wabash: Keynote Speech**

Session 1

14:00-15:30 **Clark 3** **Chair: Saurabh Mittal**

- *A Driving Simulator for Discovering Requirements in Complex Systems* by Andreas Gregoriades, Maria Pampaka, Iacovos Headjicosti and Christos Florides
- *Development and Application of System Complexity Measures for Use in Modeling and Simulation* by Jennifer Deaton
- *Modeling Cognitive Radio Networks in NetLogo* by Jacek Dzikowski and Cynthia Hood

Session 2

16:00– 17:30 **Clark 3** **Chair: Marco Lutzenberger**

- *Agent-based Modeling and Simulation of Pooled Warehouse Intelligent Management* by Wided Mathlouthi, Narjès Bellamine Ben Saoud and Sami Sboui
- *Analysis of Simulation Modeling Systems Illustrated with the Problem of Model Design for the Subject of Technological Logistics (WIP)* by Konstantin Aksyonov, Eugene Bykov, Olga Aksyonova, Natalia Goncharova and Alena Nevolina
- *Perspectives of Modeling in Metallurgical Production (WIP)* by Konstantin Aksyonov, Eugene Bykov, Olga Aksyonova, Natalia Gonharova and Alena Nevolina

MSIAAS 2015 Agenda

Tuesday, 28 July 2015

8:30-9:30 **Wabash Room: Keynote Speech (Plenary)**

Session 3

10:00-11:30 **Clark 3** **Chair: Saurabh Mittal**

- *Advanced Systems Engineering and Model Philosophy (WIP)* by Barclay Brown
- *Cyber Modeling & Simulation for Cyber-Range Events (invited)* by Suresh K. Damodaran and Jerry Couretas
- BEST PAPER NOMINEE: *Harnessing Emergence: The Control and Design and Emergent Behavior in System of Systems Engineering* by Saurabh Mittal and Larry Rainey

11:30-13:30 **Wabash: Lunch and IBM Keynote Speech**

Session 4

13:30-15:00 **Clark 3** **Chair: Andreas Tolk**

- *The Next Generation of Modeling & Simulation: Integrating Big Data and Deep Learning* by Andreas Tolk
- *Panel: Building the Virtual Product with Big Models* by Barclay Brown, Saurabh Mittal, Andreas Tolk, Greg Gorman and Sayyidul Arafat

Session 5

15:30-17:00 **Clark 3** **Chair: Saurabh Mittal**

- *Intelligent Simulation Models based on Business Rules Approach in Banking Sector (WIP)* by Roman R. Veynberg, Aleksandra O. Varfolomeeva and Kseniya Grigoryeva
- *Virtual enterprise synthesis by web services composition with HTN-like parsing algorithm (WIP)* by Victor Romanov, Svetlana Efimova, Katerina Youdakova and Aleksandra Varfolomeeva
- *An Analysis on the Metrics for Dynamic Process Scheduling on Distributed Simulation Using Optimistic Protocols* by Emerson Carvalho, Mateus Junqueira, Edmilson Moreira and Otavio Carpinteiro

MSES 2015 Agenda

Wednesday, 29 July 2015

Session 1

8:30-10:00 **Clark 3** **Chair: Suad Al-Adwani**

- *Energy Optimization of the Canadian Oil Sands* by Mohamed Elsholkami, Alberto Betancourt-Torcat, Ali Elkamel, Ali Almansoori, Suad Al-Adwani and Chandra Madhuranthakam
- *Adaptive Particle Filtering in Data Assimilation of Wildfire Spread Simulation* by Feng Gu, Mohammad Butt, Chunyu Ai, Xiaoke Shen and Jiehao Xiao
- *Evaluation of Industrial Biofilter Emissions on Health Effects through Dispersion Model Predictions* by Nada Azlah, Zarook Shareefdeen, Ali Elkamel and ChandraMouli Madhuranthakam

Session 2

10:30-12:00 **Clark 3** **Chair: Chandra Mouli Madhuranthakam**

- *An Optimization Model for Assessing Multi-Products Productions from Biomass: a Case of Renewable Malaysian Oil Palm Empty Fruit Bunch (EFB)* by Abdul Halim Abdul Razik, Mohamed Elsholkami, Ali Elkamel and Leonardo Simon
- *Effect of Thermal Sintering and Poisoning on Light-Off Performance of Zoned Pt-Pd/Al2O3 Diesel Oxidation Catalysts* by Suad Al-Adwani, William Epling and João Soare
- *The Impact of Climate Condition on the Optimal Size of Direct Coupled Photovoltaic-Electrolyzer Systems* by Farid Sayedin, Azadeh Maroufmashat, Sourena Sattari, Ali Elkamel and Suad Al-Adwani

GCMS 2015 Agenda

Tuesday, 28 July 2015

8:30-9:30 **Wabash Room: Keynote Speech (Plenary)**

Session 1

10:00-11:30 **Clark 1** **Chair: Mohammad Zubair**

- *Simulation-based Bayesian Analysis of Complex Data* by Paul Marjoram, Steven Hamblin and Brad Foley
- BEST PAPER NOMINEE: *High-Fidelity Simulation of Collective Effects in Electron Beams Using an Innovative Parallel Method* by Kamesh Arumugam, Mohammad Zubair, Desh Ranjan, Alexander Godunov and Balsa Terzic
- *Vertical Scalability Benchmarking in Three-Dimensional Virtual World Simulation* by Sean Mondesire, Jonathan Stevens and Douglas Maxwell

11:30-13:30 **Wabash: Lunch and IBM Keynote Speech**

Session 2

13:30-15:00 **Clark 1** **Chair: Paul Marjoram**

- *Modeling and Simulation as a Service (MSaaS) for Education: Learning STEM Concepts through Simulation Use and Building* by Jose J. Padilla, Enilda Romero-Hall, Saikou Y. Diallo, Anthony Barraco, Hamdi Kavak, Ross J. Gore, Christopher J. Lynch and Manasi Sheth-Chandra
- *Linguistic Geometry for Intelligent Analysis of Courses of Action for Training* by Oleg Umanskiy, Boris Stilman, Vlad Yakhnis, Latika Eifert and Jonathan Stevens
- *Variable Intensity RCPSP Approach to a Case Study Flow Shop* by Oladipupo Olaitan, Paul Young and John Geraghty

Session 3

15:30-17:00 **Clark 1** **Chair: ChandraMouli Madhuranthakam**

- *Approach to Examine Efficacy of Game-Based and Virtual Simulation Training* by Jonathan Stevens, Douglas Maxwell, Eric Ortiz and Lauren Reinerman-Jones
- *Dynamic Load Balance for Approximate Parallel Simulations with Consistent Hashing* by Roberto Solar, Veronica Gil-Costa and Mauricio Marin
- *Development of the Energy Hub Networks Based on Distributed Energy Technologies* by Azadeh Maroufmashat, Ali Elkamel, Sourena Sattari Khavas, Michael Folwer, Mohamed Elsholkami and Ramin Roshandel

MST4CPS 2015 Agenda

Monday, 27 July 2015

8:00-10:00 **Wabash Room: Opening Session and Keynote Speech (Plenary)**

Session 1

10:00-11:30 **Clark 8** **Chair: Seda Ogrenci Memik**

- *Executable Models of Fissile Reactor Systems for Hardware Simulation and Design* by John Determan, Christy Day, Steven Klein and Marsha Roybal
- *Efficient Analysis for Emergency Management Using Simulation Metamodeling: A Case Study for a Medical Trauma Center* by Scott Rosen, Jim Ramsey, Christine Harvey and Samar Guharay
- *MOKA: An Object-Oriented Framework for FMI Co*-Simulation by Memduha Aslan, Halit Oğuztüzün, Umut Durak and Koray Taylan

13:00-14:00 **Wabash: Keynote Speech**

Session 2

14:00-15:30 **Clark 8** **Chair: Jie Gu**

- *On Estimation of Optical Properties in Near Infrared Spectroscopy with Use of Cumulative Distributions of Times of Flight of Photons* by Norbert Zolek, Marcin Botwicz, Daniel Milej and Anna Gerega
- *Development of a Wake Simulator for Wind Energy Analysis* by Tyamo Okosun, Xiang Liu, Yihong Liu, Jerry Dekker, John Moreland and Chenn Zhou
- *A Low-Cost Multi-Modal Simulator for Ultrasonography Training* by John Sokolowski, Hector Garcia, Richards William and Catherine Banks

MSM 2015 Agenda

Monday, 27 July 2015

8:00-10:00 **Wabash Room: Opening Session and Keynote Speech (Plenary)**

Session 1

10:30-12:00 **Clark 9** **Chair: Iwona Jasiuk**

- *The Reference Model uses Object Oriented Population Generation* by Jacob Barhak
- *The SILAS model: Sexual Infections as Large-scale Agent-based Simulation* by Stefan Scholz, Manuel Batram and Wolfgang Greiner
- BEST PAPER NOMINEE: *PACT: a PArticipant-centered Clinical Trial Framework* by Ross Gore and Manasi Sheth-Chandra

13:00-14:00 **Wabash: Keynote Speech**

Session 2

14:00-15:30 **Clark 9** **Chair: Jacob Barhak**

- *Multiscale Analysis of Bone* by Iwona Jasiuk
- *An Architecture to Support Integrated Manikin-Based Simulations* by James Leathrum, Roland Mielke, Michel Audette, Frederick McKenzie, Robert Armstrong, Geoff Miller, Mark Scerbo and Andrew Cross
- *Lightning talks*

Session 3

16:00-17:30 **Clark 9** **Chair: Jacob Barhak**

- *Fiber tractography for finite-element modeling of transversely isotropic biological tissues of arbitrary shape using computational fluid dynamics* by Joshua Inouye, Geoffrey Handsfield and Silvia Blemker
- *Calcium Induced Calcium Release with Stochastic Uniform Flux Density in a Heart Cell* by Matthew Brewster, Jonathan Graf, Xuan Huang, Zana Coulibaly, Matthias Gobbert and Bradford Peercy
- *Lightning talks*

WIP 2015 Agenda

Tuesday, 28 July 2015

8:30-9:30 **Wabash Room: Keynote Speech (Plenary)**

Session 1

10:00-11:30 **Clark 8** **Chair: Megan Olsen**

- *Shared-Files Parallel Simulation Framework for Dynamic Multi-Domains Networks using OMNeT++ (WIP)* by Abdelhakim Hamzi and Saud Albarrak
- *An Agent-Based Model of Supplier Management in Regional Food Systems (WIP)* by Hardik Bora and Caroline Krejci
- *Efficient Parallel Cell List Algorithms for Monte Carlo Simulations (WIP)* by Kamel Rushaidat, Loren Schwiebert, Brock Jackman, Jason Mick and Jeffrey Potoff

11:30-13:30 **Wabash: Lunch and IBM Keynote Speech**

Session 2

13:30-15:00 **Clark 8** **Chair: Caroline Krejci**

- *Towards Sonic Urban Morphologies: A Modeling Nexus (WIP)* by Merate Barakat
- *Appending Variable-Structure to Modelica Models (WIP)* by Daniel Gomez Esperon, Alexandra Mehlhase and Thomas Karbe
- *Simulation Validation Using Metamorphic Testing (WIP)* by Mohammad Raunak and Megan Olsen

SCSC General 2015 Agenda

Tuesday, 28 July 2015

8:30-9:30 Wabash Room: Keynote Speech (Plenary)

Session 1: Modeling and Simulation for Sustainability

10:00-11:30 Clark 9 Chair: Bjoern Johansson

- *Simulation for Higher Education Sustainability* by Anatoly Kurkovsky
- *Modeling a Regional Emission Trade Market via Computer Simulation* by Ming Zhou, Yanchun Pan, Zhimin Chen, Meirong Zhou and Jun Zeng
- *Supply Chain Simulation and Environmental Performance in Decision Making: Are Order Pattern Changes Important Enough to Affect Transport Cost and CO2 Emissions?* by Theodora Trachana, Angeliki Karagiannaki and Katerina Pramatari

11:30-13:30 Wabash: Lunch and IBM Keynote Speech

Session 2: Emergency Management Simulation

13:30-15:00 Clark 9 Chair: Francesco Longo

- *Discrete Event Modelling for Operational Planning of Urban Public Transport Services—Towards Minimizing the Bunching of an Urban Bus Service* by Nam Huynh, Johan Barthelemy, Pascal Perez and Amal Kumarage
- *Multi-Disciplinary Approach to Disasters Management in Industrial Plants* by Agostino Bruzzone, Laura Cirillo, Francesco Longo and Letizia Nicoletti
- *Simulation of a Runoff Model Running with Multi-Criteria in a Cluster System* by Antoni Portero, Radim Vavrik, Stepan Kuchar, Martin Golasowski, Simone Libutti, Giuseppe Massari, William Fornaciari and Vit Vondrak

Session 3: Computer Graphics for Simulation

15:30-17:30 Clark 9 Chair: John F. Richardson

- *Healthcare System Process Improvement: A Systems Engineering Approach* by Hesham Maghrabie and Arman Sadreddin
- *Simulation and Visualization of Industrial Processes in Unity* by Jichao Wang, Lucas Phillips, John Moreland, Bin Wu, and Chenn Zhou
- *Towards Visulations of Astrophysical Accretion Disk on HPC Clusters with AccretionSim* by Amit Goel, Oddny Brun, Michele M. Montgomery and Peter J. Kincaid
- *Risk Modeling in the Global Sustainable Supply Chain: A Research Trend* by M. Hajian-Heidary and A. Aghaie

SCSC General 2015 Agenda

Wednesday, 29 July 2015

Session 4: Modeling and Simulation for Energy Systems Integration and Smart Grid

8:30-10:00 **Clark 9** **Chair: Vladimir Koritarov**

- *A System-of-Systems Approach for Integrated Energy Systems Modeling and Simulation* by Saurabh Mittal, Mark Ruth, Annabelle Pratt, Monte Lunacek, Dheepak Krishnamurthy and Wesley Jones
- *Robust Fault Tolerant Control of Wind Turbine Benchmark Model* by Young-Man Kim
- *Optimal Porosity for Gas Diffusion Layers of Hydrogen Fuel Cells* by Jamal Hussain Al-Smail

Session 5

10:30-11:00 **Clark 9**

- *A Second Look at Oblivious Simulation* by Peter Maurer

SPECTS 2015 Agenda

Monday, 27 July 2015

8:00-10:00 **Wabash Room: Opening Session and Keynote Speech (Plenary)**

Session 1: Modeling, Analysis, Simulation and Performance Evaluation (I)

10:30-12:00 **Clark 7** **Session Chair: Nezer Zaidenberg**

- *Approximate Mean Value Analysis for Multi-core Systems* by Lei Zhang and Douglas Dow
- *Scalability Evaluation of an Energy-Aware Resource Management System for Clusters of Web Servers* by Simon Kiertscher and Bettina Schnor
- *New Caching Algorithms Performance Evaluation* by N.J. Zaidenberg, Limor Gavish and Yuval Meir

13:00-14:00 **Wabash: Keynote Speech**

Session 2: Packet Processing Systems

14:00-15:30 **Clark 7** **Session Chair: Torsten M. Runge**

- *Low Latency Network Traffic Processing with Commodity Hardware* by Torsten M. Runge, Alexander Beifuß and B. E. Wolfinger
- *Optimizing Latency and CPU Load in Packet Processing Systems* by Paul Emmerich, Daniel Raumer, Alexander Beifuß, Lukas Erlacher, Florian Wohlfart, Torsten M. Runge, S. Gallenmüller and Georg Carle

Session 3: Wireless Communications and Networking (I)

16:00-18:00 **Clark 7** **Session Chair: Majed Jarrar**

- *Load Balancing Probabilistic Spectrum Handoff for Cognitive Radio Networks* by Ahmed Tayel and Sherif Rabia
- *Novel Channel Estimation Scheme in Fast Fading Channel Applied to Sidehaul SystemTitle* by Sangmi Moon, Hun Choe, Myeonghun Chu and Intae Hwang
- *Multi-layer Sociality in Opportunistic Networks: an Extensive Analysis of Online and Offline Social Behaviors* by Annalisa Socievole, Antonio Caputo and S. Marano
- *Analytical Model of Two-Level Scheduling Algorithm for WiMAX Networks* by Zeeshan Ahmed and Salima Hamma

SPECTS 2015 Agenda

Tuesday, 28 July 2015

8:30-9:30 **Wabash Room: Keynote Speech (Plenary)**

Session 4: Optical, Optical-Wireless Networks and Systems

10:00-11:30 **Clark 7** **Session Chair: Jingyan Wang**

- *Linear Dynamic Adaptation of the BW Granularity Allocation for Elastic Optical OFDM Networks* by Luae Al-Tarawneh and Sareh Taebi
- *An Enhancement to the Novel RoF-PON as an Optical-Wireless Services Enabling Technology* by Majed Jarrar, Khaled Maamoun and H. T. Mouftah
- BEST PAPER NOMINEE*: Energy-efficient Optical HPC and Datacenter Networks using Optimized Wavelength Channel Allocation* by Jingyan Wang, Conor McArdle and Liam Barry

11:30-13:30 **Wabash: Lunch and IBM Keynote Speech**

Session 5: Modeling, Analysis, Simulation and Performance Evaluation (II)

13:30-15:00 **Clark 7** **Session Chair: Floriano De Rango**

- *User inactivity modeling and simulation for power management of PC fleets* by Ramón Medrano, Daniel F. García, Joaquín Entrialgo and Javier García
- *Bio-inspired Exploring and Recruiting Tasks in a Team of Distributed Robots over Mined Regions* by Floriano De Rango, Nunzia Palmieri, Xin She Yang and S. Marano
- *Self-Learning Adaptive Algorithm for Maritime Traffic Abnormal Movement Detection based on Virtual Pheromone Method* by Julius Venskus, Mindaugas Kurmis, Arūnas Andziulis, Žydrūnas Lukošius, Miroslav Voznak and D. Bykovas

Session 6: Network Virtualization and Services

15:30-17:30 **Clark 7** **Session Chair: Christian Callegari**

- *OpenCounter:Counting Unknown Flows inSoftware Defined Networks* by Christian Callegari, Stefano Giordano, Michele Pagano and G. Procissi
- *pfs: Parallelized, Flow-based Network Simulation* by Mukta Gupta, R. Durairajan, M. Syamkumar, Paul Barford and Joel Sommers
- *Management of Non-Conformant Traffic in OpenFlow Environments* by Luca Boero, Marco Cello, Chiara Garibotto, Mario Marchese and M. Mongelli
- *Cloud and Network Service Orchestration in Software Defined Data Centers* by Davide Adami, Christian Callegari, Pietro Castoldi, Lisa Donatini, Molka Gharbaoui, Stefano Giordano, Barbara Martini and A. Sgambelluri

SPECTS 2015 Agenda

Wednesday, 29 July 2015

Session 7: Security Protocols and Techniques

8:30-10:00 **Clark 7** **Session Chair: Christian Callegari**

- *Histogram Cloning and CuSum: An Experimental Comparison Between Different Approaches to Anomaly Detection* by Christian Callegari, Stefano Giordano and M. Pagano
- *Multi-class SVMs Analysis of Side-Channel Information of Elliptic Curve Cryptosystem* by Ehsan Saeedi, MD. Selim Hossain and Yinan Kong

Session 8: Wireless Communications and Networking (II)

10:30-12:00 **Clark 7** **Session Chair: Bassel Arafeh**

- *Efficient Network Level Beamforming Training for IEEE 802.11ad WLANs* by Anique Akhtar and S. Coleri Ergen
- *Efficient Broadcasting for Route Discovery in Mobile Ad-hoc Networks* by Haitham Adarbah, Shakeel Ahmad, Bassel Arafeh and Alistair Duffy
- *Memory and Memoryless Optimal Time-Window Controllers for Secondary Users in Vehicular Networks* by Nicola Cordeschi, Danilo Amendola, M. Shojafar, P.G.V. Naranjo and Enzo Baccarelli

Notes

Abstracts

Executable Models of Fissile Reactor Systems for Hardware Simulation and Design
John Determan, Christy Day, Steven Klein and Marsha Roybal
(Submission #1)

Summary
Dynamic system simulation (DSS) of fissile solution systems (FSS) is used at Los Alamos National Laboratory (LANL) with the ultimate goal of aiding the medical isotopes industry, which employs FSS in manufacturing, to develop a method for producing specific urgently needed medical isotopes, including Mo-99 and Tc-99. The DESIRE (Direct Executing Simulation in Real Time) system has been used to perform DSS of FSS for several years. A benchmark FSS, SUPO, operated for several decades at LANL, has been modeled, and the SUPO model validated against historical data. Models of proposed isotope production systems have also been modeled. DESIRE simulation models, while useful to laboratory researchers, are not easily shared with industry partners more interested in such topics as system design and operator training. To support these needs a system for producing computer executable versions of specific system models has been developed. The executable models can be run on Windows-based computers, are designed for use by design engineers, and are capable of serving as the back-end of hardware simulators, for use in training scenarios. A DESIRE model converter code automatically converts DESIRE model input to C++ subclass plug-in input modules. A C++ DLL receives the plug-in input modules and provides the numerical engine for execution of the modules. A C interface to a LabView graphical model of an FSS provides the back-end support for a real time simulator. A C# design tool interface to the C++ numerical engine presents a design engineer graphical user interface. This paper focuses on the development of the system for producing and using the executable models described above. LA-UR-14-29512
Track: Modeling, Simulation, and Test for Cyber Physical Systems

Efficient Analysis for Emergency Management Using Simulation Metamodeling: A Case Study for a Medical Trauma Center
Scott Rosen, Jim Ramsey, Christine Harvey and Samar Guharay
(Submission #5)

Summary
This paper presents a rapid, quantitative simulation-based approach for Systems Engineering applicable to the emergency management domain. The motivation behind this approach is to provide improved decision -support for emergencies. A case study is performed on a problem in the healthcare domain concerning the effect of worker capacities in a trauma center. The application of simulation to healthcare systems analysis is a growing area, but analysis with large-scale simulations can be inefficient due to their long run times. This problem can be overcome by simulation metamodeling that provides the ability to expedite system evaluations and enable complex systems analysis. This paper demonstrates the effectiveness of simulation metamodeling for healthcare systems analysis. The methodology developed for this case study has the potential to be transferred or applied to other scenarios for emergency management
Track: Modeling, Simulation, and Test for Cyber Physical Systems

Abstract

A Driving Simulator for Discovering Requirements in Complex Systems
Andreas Gregoriades, Maria Pampaka, Iacovos Hadjicosti, Christos Florides and Harris Michail
(Submission #7)

Summary
One of the most critical phases in complex systems design is the requirements engineering process. During this phase, system designers need to accurately elicit, model and validate the desired system based on user requirements. Smart Driver Assistive Technologies (SDAT) belong to a class of complex systems that are used to alleviate accident risk by either improving situation awareness, reducing driver workload or enhancing driver attentiveness. Such systems aim to draw drivers' attention on critical information cues that improve decision making. Discovering the requirements for such systems necessitates a holistic approach that addresses not only functional and non-functional aspects but also the human requirements such as drivers' situation awareness and workload. This work describes a simulation-based user requirements discovery method. It utilizes the benefits of a modular virtual reality simulator to model driving conditions to discover user needs, which subsequently inform the design of prototype SDATs that exploit the augmented reality method. Herein, we illustrate the development of the simulator, the elicitation of user needs through an experiment and the prototype SDAT designs using UNITY game engine.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

MOKA: An Object-Oriented Framework for FMI Co-Simulation
Memduha Aslan, Halit Oğuztüzün, Umut Durak and Koray Taylan
(Submission #12)

Summary
An Functional Mockup Unit (FMU) is defined as a model that realizes the Functional Mock-up Interface (FMI) which provides a standard interface for dynamic system models to run in both model-exchange and co-simulation settings. While the standard provides a solid model interface specification, it does not provide its user with any guidelines on how to develop FMUs and how to integrate them for co-simulation. In this paper, MOKA, an object-oriented co-simulation framework for FMUs, is introduced. Based on FMI, MOKA is designed to serve as an overall simulation framework that provides a C++ API for developing FMUs and co-simulation capabilities for integrating and executing multiple FMUs to carry out a scenario. FMI specification is mapped to an object oriented framework that leads to a modular structure for FMUs. This approach has the potential to ease the process of developing FMUs with a view towards maintenance and extendibility. Co-simulation capabilities enable scenarios to be modeled as finite state machines. Thus particular set of FMUs can be co-simulated at system's overall discrete state and overall system state transitions can be defined over the FMU states.
Track: Modeling, Simulation, and Test for Cyber Physical Systems

Modeling a Regional Emission Trade Market via Computer Simulation
Ming Zhou, Yanchun Pan, Zhimin Chen, Meirong Zhou and Jun Zeng
(Submission #14)

Summary
To control air pollution and promote green economy, China started establishing regional emission trade markets (RETM). These systems operate under the conditions of "Cap and Trade", i.e. participating companies are restricted in total CO2e emission via initial allocation of emission quotes (EQ); but allowed to purchase EQ for additional needs via the market. They can also conduct self-purification to reduce emission level or sell surplus EQ to gain revenue. The decisions are individually made and together influence the market's overall performance. The interaction between many participants and market performance is quite complex and heavily influenced by policy design and regulation. Modeling a RETM system must capture critical functions that ensure the control and operations, such as EQ allocation, transaction, and regulation. In addition to planning traditional resource (labor, equipment and raw material), the companies must now consider acquiring/disposing environmental resource and balance between production economy and CO2e reduction. They must also deal with the risks associated with the decisions (i.e. market fluctuation of EQ and increasing abatement cost) and make best trade-offs. The collective impact due to the emerging behavior of participating companies is very difficult to predict due to great uncertainties. This has raised important issues for policy-design and evaluation of such complex systems. It remains a great challenge to build a model that adequately represents and effectively simulates the dynamics of a RETM to allow researchers conduct experiments to analyze market performance under various conditions and risk profiles. This study applies multi-agents modeling paradigm to develop a simulation model that focuses on participating companies' decisions in planning environmental resource via interactions with RETM under various risk conditions and evaluates the collective impacts of decentralized actions of the individual companies on system's performance. The implementation through ANYLOGIC© is disseminated and the results for verification.
Track: Modeling and Simulation for Sustainability

Towards Minimizing the Bunching of an Urban Bus Service
Nam Huynh, Johan Barthelemy, Pascal Perez, Amal Kumarage and Peter Campbell
(Submission #15)

Summary
This paper demonstrates the application of Simulink to building a discrete event model that simulates the operation of urban public transport services. An important feature of the model is the explicit tracking of change of passenger demands at a transport station along a given route, including the passengers coming to the station to board (and alighting) a transit vehicle (e.g. a bus or a train), the passengers boarding the vehicle, and the passengers remaining at the station for next services. This feature enables the formulation of average waiting time of passengers at a station, which differs from many of its type found in the literature by accounting for the fact that passengers may miss a number of vehicles (due to high demand) before successfully boarding one. To demonstrate the potential of the model in assisting operational planning for urban public transport services, the paper presents simulation results from a parametric study that uses the model to investigate the correlation between operation parameters (e.g. cycle time) and key performance indicators of a shuttle bus route in Wollongong City (New South Wales, Australia). The discrete event model together with sample input datasets and post-processing codes of simulation results are available at https://github.com/jojo-/PTSim.
Track: Emergency Management Simulation

Simulation for Higher Education Sustainability
Anatoly Kurkovsky
(Submission #17)

Summary
We consider the paradigm of sustainability in higher education as a computational problem to analyze the numerical values of institutional goal dynamics and the possibility to reach their rational balance. We suggest using a simulation approach to tie up the institutional goals, a set of traditional institutional internal subsystems (faculty, students, educational technology, and administrative structure) and a set of external requests. We propose using a united approach for formalization of sustainability components/systems and their relationships that will be independent from the specificity of a particular system. This approach can be represented as a hierarchy of the system models and includes several levels with various details of granularity/complexity. We created several simulation models to demonstrate how the simulation approach can be applied for educational studies of sustainability at an actual fast-growing US higher education institution.
Track: Modeling and Simulation for Sustainability

On Estimation of Optical Properties in Near Infrared Spectroscopy with use of Cumulative Distributions of Times of Flight of Photons
Norbert Zolek, Marcin Botwicz, Daniel Milej and Anna Gerega
(Submission #21)

Summary
Visible and near infrared light propagation in turbid media has been extensively studied for recent years. A several different models have been derived to efficiently describe different aspects of light propagation and simulate various measurement approaches. Different attempts have been proposed to use these models for estimation of macroscopic parameters characterizing internal measured structure using time resolved near infrared light radiation. Because the scattering and absorption can influence the detected signal in similar way, the reconstruction and estimation of the macroscopic optical properties with the satisfying accuracy is possible after detailed analysis of measured signal.

In this work, we propose and analyze the method of estimation of absorption and scattering coefficients based on analysis of inverse cumulative distributions of times of flight of photons. This approach allows for detailed analysis of small variations in characteristics of times of flight of photons influenced by non-homogeneous media. The presented method as a variation of statistical minimum distance estimation is compared to a method that uses statistical moments as well as to standard curve fitting methods. The method is analyzed by fitting theoretical models as Monte-Carlo simulations of light propagation to the data from simulated measurements and allows to estimate optical parameters despite the noise in the measured signal. The method is implemented using Open Computing Language framework for efficient calculations on heterogeneous computers. The theoretical results are verified on the data from measurements of times of flight of photons on optically turbid physical phantoms mimicking tissues.
Track: Modeling, Simulation, and Test for Cyber Physical Systems

An Approach to Address the Intrinsic Complexity in Multi-Modelling of Enterprises for Decision Making
Vinay Kulkarni, Souvik Barat, Tony Clark and Balbir Barn
(Submission #23)

Summary
Modern enterprises are complex systems operating in increasingly dynamic environment and are thus subject to multiple inter-dependent change drivers. The size and complexity of modern enterprises ensures that the understanding of all aspects: why, what and how, is available only for highly localized parts distributed amongst multiple stakeholders. Existing enterprise modelling tools cater principally to only one of the three aspects. Consequently, the problems under consideration need to be decomposed into aspect-specific sub-problems, to be solved independently, and part-solutions integrated into a consistent whole: the intrinsic complexity in multi-modelling for decision making. Current practice relies extensively on human expertise to overcome the intrinsic complexity – a time-, cost- and effort-intensive endeavor. This paper proposes an approach supported by a language that enables specification of the why, what and how aspects in a localized integrated manner for each stakeholder of interest. The simulation-capable nature of the language leads to informed data-driven decision-making thus significantly reducing dependence on human expertise. Moreover, the approach enables less experienced users to function at the level of experts. A real-life case study illustrating the proposed approach is presented.
Track: Agent-Directed Simulation

Agent-based Modeling and Simulation of the Emotional Experiences of Employees within Organizations
Hanen Lejmi Riahi, Fahem Kebair and Lamjed Ben Said
(Submission #25)

Summary
Agent-Based Modelling and Simulation (ABMS) have been used to study a wide range of complex systems and several emergent behaviors across a variety of disciplines. However, very limited works have adopted these paradigms to provide insights to organizational psychology in general and to researches dealing with emotions at work in particular. The current research uses ABMS to study the emotions experienced in the organizational context; it focuses specifically on their impact on the quality of decisions made as a key factor of organizations success. In this paper, the emphasis is set on the emotion generation process. The proposed work introduces an agent-based model of the emotional experiences of employees within organizations. It adopts a cross-disciplinary approach and it brings another theoretical perspective to agent-based modelling of emotions at work. In fact, this model is based on the OCC appraisal theory to generate artificial emotions, but it also takes advantage of theoretical foundations from organization behavior and organization psychology. Simulation results can bring new insights to organizational researches. Moreover, the simulated system can serve as a human resources development tool used by employees at work to enhance their emotional awareness.
Track: Agent-Directed Simulation

Healthcare System Process Improvement: A Systems Engineering Approach
Hesham Maghrabie, Arman Sadreddin and Andrea Schiffauerova
(Submission #27)

Summary
The goal of this study is to minimize patients' length of stay and total waiting times for the Emergency Department (ED) at a given Health institution in North America. To accomplish this goal, the current process of the ED has been analyzed and a proposed model has been evaluated. In order to assess the added value of the proposed model, the results of the two models have been compared and the proposed model reflected a better performance. A simulation software has been utilized to imitate the real system and to illustrate the proposed concept for determining the best process.
Track: Emergency Management Simulation

Development of a Wake Simulator for Wind Energy Analysis
Tyamo Okosun, Xiang Liu, Yihong Liu, Jerry Dekker, John Moreland and Chenn Zhou
(Submission #28)

Summary
Wind turbine and, by extension, wind farm performance is significantly impacted by the interaction between turbine generated wakes. These regions of lower wind speed created by the extraction of kinetic energy from the free stream flow by upstream turbines can lead to large losses in potential energy production for wind farms. In order to design a wind farm to take full advantage of the available wind resource, an understanding of wake phenomena must first be established. To address this, a wind turbine wake simulator was developed as part of the Mixed Reality Simulators for Wind Energy Education project, sponsored through the U.S. Department of Education's FIPSE program.
The simulator software accesses a database of simulated wind turbine and wind farm wakes for a large variety of wind conditions. To generate wakes for single turbine cases, a 3D model of a utility-scale Horizontal Axis Wind Turbine (HAWT) was created and simulations were conducted at varying wind speeds. Additional simulations of 2D models at multi-kilometer scale were conducted using simplified arrays of 64 to 72 turbines, in order to examine the scale and intensity of wakes generated by a full wind farm. The first version of the simulator is available for download at www.windenergyeducation.org.
Track: Modeling, Simulation, and Test for Cyber Physical Systems

Simulation and Visualization of Industrial Processes in Unity
Jichao Wang, Lucas Phillips, John Moreland, Bin Wu and Chenn Zhou
(Submission #32)

Summary
Computational Fluid Dynamics and Finite Element Analysis have been combined with 3D visualization and used for optimization, troubleshooting, and training with a variety of industrial processes. The Unity 3D game engine has been used to create interactive and immersive 3D environments to visualize and communicate simulation results between users of varying experience and expertise. Simulation results are integrated with photorealistic 3D models of equipment and facility environments, and combined with a game-like interface to review of equipment failures and provide interactive training scenarios. The development and functionality of several projects from the steel and power industries are discussed.
Track: Computer Graphics for Simulation

Supply Chain Simulation and Environmental Performance in Decision Making: Are Order Pattern Changes Important Enough to Affect Transport Cost and CO2 Emissions?
Theodora Trachana, Angeliki Karagiannaki and Katerina Pramatari
(Submission #33)

Summary
Due to the increasing importance of the sustainability issues on the supply chain management sector, firms tend to pay more attention to the incorporation of environmental concerns and corresponding policies. As a consequence, they tend to take actions including the adoption of green practices and the compliance to corporate laws and regulations. In addition, their attempts emphasize on the adoption of a combination of different types of indicators, namely operational (e.g. product output, availability, costs), and environmental (e.g. energy consumption, carbon footprint). Within this context, this paper tries to assess the impact of alternative order frequency patterns and pallet height policies on both transport costs and CO2 emissions in the Fast Moving Consumer Goods (FMCG) sector using simulation software and Supply Chain modeling techniques. The results indicate that rarer order frequency and adoption of certain pallet height policies can both decrease performance indicators and keep the inbound service level stable.
Track: Modeling and Simulation for Sustainability

Modeling Cognitive Radio Networks in Net Logo
Jacek Dzikowski and Cynthia Hood
(Submission #37)

Summary
Cognitive radio networks exhibit (and are defined by) many features typical to complex adaptive systems. With systems of that nature, research progress relies on expertise from different domains and interdisciplinary work. The latter can prove difficult without a “common language” and practical understanding of the subject. Simple and accessible experimentation platform, a “playground”, could help bridge that gap quicker. It could also serve as a rapid experiment design and educational tool. Unfortunately, commonly used network simulation tools are too esoteric for people with no sufficient background and in reality offer very little in support of cognitive radio studies to justify the complexity and steep learning curve. Agent-based modeling, a primary simulation tool in complex system research, provides a logical alternative. Previous work with Repast-based platform has shown that it could be successfully applied in cognitive radio research context. To satisfy the goals outlined earlier, we have used our expertise to build an “entry-level” model using NetLogo multi-agent programming environment. Simplicity of NetLogo enables creating models that help people with no or little exposure to understand agent-based approach and quickly gain practical insight into the problem. Its popularity and extensive library of models makes it a common language used by many specialists. Our NetLogo model is stripped down to essentials, but still flexible enough to conduct a wide range of experiments. It has been presented to varied audiences in classroom and research group settings. Its usefulness was confirmed as we were able to explain basics of agent-based modeling demonstrate complexity concepts (emergence, self-organization) in practice and conduct interactive cognitive radio experiments in a single session without extensive training.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Production Control and Optimization
William Conley
(Submission #38)

Summary
The Simulation Technique Multi Stage Monte Carlo Optimization Is Used To Optimize Production in Large Scale Manufacturing Settings.
Track: Grand Challenges in Modeling and Simulation

A Low-Cost Multi-Modal Simulator for Ultrasonography Training
John Sokolowski, Hector Garcia, Richards William and Catherine Banks
(Submission #39)

Summary
Ultrasonography (US) is an ultrasound-based diagnostic imaging technique used for visualizing subcutaneous body structures and internal organs. US are user-dependent technology. Pathology-specific training to facilitate cognitive and mechanical proficiency is needed for clinicians to derive full use of the technology. The purpose of this project is to design and evaluate a low-cost, multi-modal simulator for student training and educator assessment of those students in the use of US. Experts in US education served as consultants in the development of this multi-modal, easy-to-use, high-fidelity simulator trainer. Simulation engineers adhered closely to requirements set out by these consultants making incremental adjustments and refinements to the simulator. The simulator was evaluated for functionality and ease of use. The simulator promises to be effective as a training and assessment platform with excellent fidelity and feedback mechanisms. It is extendable for additional anatomical images and teaching modules. This paper outlines the final steps in the ongoing development of a prototype simulator trainer focusing on the coming together of user requirements and developer specifications.
Track: Modeling, Simulation, and Test for Cyber Physical Systems

Dynamic Load Balance for Approximate Parallel Simulations with Consistent Hashing
Roberto Solar, Veronica Gil-Costa and Mauricio Marin
(Submission #41)

Summary
Parallel simulation is a powerful tool to evaluate the performance of large-scale systems. However when it comes to simulating large scale Web search engines, the parallel simulation execution can introduce imbalance among processors because event occurrence is driven by user behavior which is unpredictable, making events take place in different parts of the system in an irregular manner. In this paper, we study the impact of load balance strategies on the performance of a parallel simulation strategy. In particular, we present a consistent hashing load-balance algorithm aimed to reduce queuing waiting times, evenly distribute the costs of executing events among processors, and more importantly migrations of LPs only occur between neighbor processors. We use a Web search engine composed by services as the application case study. Our simulations are driven by actual query log traces. Results show that the proposed load balance strategy is capable of reducing the execution times of simulations and the total amount of communication.
Track: Grand Challenges in Modeling and Simulation

Multi-Disciplinary Approach to Disasters Management in Industrial Plants
Agostino Bruzzone, Laura Cirillo, Francesco Longo and Letizia Nicoletti
(Submission #43)

Summary
Safety plan is one of the main strengths of strategic risk management for any industrial plant. The several incidents over the past decade have led a strong scientific attention and many advances in the current state of knowledge. This paper deals with the phase of design of two interoperable simulators based on the IEEE 1516 High Level Architecture (HLA) for the disaster management in industrial plants. The simulators will be able to reproduce the step of accident diffusion and the stage of rescue operations/ hospitalization processes, covering with the entire multiple and interdependent aspects of the emergency. In order to achieve these aims principles of human reliability and error analysis, facility location and network design, information flow modelling, alternative and multiple disaster scenarios recreations were considered. The aim of the project is to provide an innovative tool in order to support management decision-making and operators/medical equips training activities, overcoming the deficiency in integrated risk management and improving the capability in the emergency response operations.
Track: Emergency Management Simulation

Shared-Files Parallel Simulation Framework for Dynamic Multi-Domains Networks using OMNeT++
Abdelhakim Hamzi and Saud Albarrak
(Submission #44)

Summary
Parallel discrete event simulation (PDES) has been recognized as a challenging research field bridging between modeling and simulation and high-performance computing. It tackles the problem of executing discrete event simulations on parallel processors. OMNeT++ is a powerful and open-source simulation tool which is basically intended to model discrete-event systems. According to its authors, the OMNeT++ PDES implementation has a modular and extensible architecture, allowing new synchronization protocols and new communication mechanisms to be added easily, which makes it a particularly attractive platform for PDES research. Unfortunately, some constraints should be verified first in order that parallel simulation under OMNeT++ works properly. The most important one is that the topology of the network should be static. In this paper, we propose a new parallel simulation approach for OMNeT++ based on socket communication and shared files that allows dynamic models to work without any of the existing problems.
Track: Work in Progress Session

Energy optimization of the Canadian Oil Sands
Mohamed Elsholkami, Alberto Betancourt-Torcat, Ali Elkamel, Ali Almansoori, Suad Al-Adwani and Chandra Madhuranthakam
(Submission #46)

Summary
The paper presents an energy optimization model applied for the Canadian Oil Sands industry. The model quantifies the energy requirements for oil sands operations and determines the optimal energy infrastructure required. The model is applied to several case studies reflecting Oil Sands operations for different operational years. Variability in key techno-economic parameters is investigated.
Track: Modeling and Simulation for Environmental Systems

Adaptive Particle Filtering in Data Assimilation of Wildfire Spread Simulation
Feng Gu, Mohammad Butt, Chunyu Ai, Xiaoke Shen and Jiehao Xiao
(Submission #47)

Summary
Data assimilation techniques can be used to improve the estimation of the wildfire spread simulation by assimilating the real time data into the simulation models, such as sequential Monte Carlo (SMC) methods. The standard SMC methods employ the same number of particles and don't utilize the run-time state inference particle convergence characterization information during the execution of the algorithm. Therefore, a large number of particles are required to ensure that the particles can converge to the true posterior of the system state. For such large-scale spatial temporal systems as wildfire spread simulation, the system's state is large and its behaviors are heterogeneous in various areas. This heterogeneous and dynamic behavior makes the uncertainty of state inference dynamically change. In this paper, we design the adaptive particle filtering algorithm to dynamically adjust the number of particles based on the quantified uncertainty of state inference, thus to achieve more efficient simulation results.
Track: Modeling and Simulation for Environmental Systems

An Optimization Model for Assessing Multi-Products Productions from Biomass: A Case of Renewable Malaysian Oil Palm Empty Fruit Bunch (EFB)
Abdul Halim Abdul Razik, Mohamed Elsholkami, Ali Elkamel and Leonardo Simon
(Submission #48)

Summary
The economic potentials of Malaysian oil palm empty fruit bunch (EFB) are realized with its abundance resources in the country and the feasibility of this renewable feedstock to produce multi-products ranging from energy, chemicals and materials. Amid continuing supports from the government in terms of policies, strategies and funding, manufacturing planning in enterprising EFB's potential are still requiring a fundamental tool for decision making process. Biomass supply chain model in this context can present economic indications for maximizing profitability or/and minimizing investment risks. This paper has outlined important steps and developed biomass supply chain model of EFB for multi-products productions. Options are available in the model's superstructure to produce bio-products with high profitability as well as considerations for other economic decisions.
Track: Modeling and Simulation for Environmental Systems

Simulation-based Bayesian Analysis of Complex Data
Paul Marjoram, Steven Hamblin and Brad Foley
(Submission #50)

Summary
Our ability to collect large datasets has grown rapidly in recent years. Such richness of data offers great promise in terms of addressing detailed scientific questions in great depth. However, this benefit is not derived without scientific difficulty. Specifically, many traditional analysis methods become computationally intractable for very large datasets. For example, when modeling at the individual level, e.g., through agent-based models, the analysis of population-level behavior of a system can be highly complex. This often leads investigators to resort to approaches such as optimization to find "best fitting" parameter values. Such approaches work well, but do not address parameter uncertainty in a formal statistical way that easily allows for subsequent hypothesis testing.
However, one can frequently still simulate data from scientific models for which direct calculation is no longer possible. In this paper we propose a Bayesian perspective for such analyses, and argue for the advantage of a simulation-based approximate Bayesian method that remains tractable when tractability of other methods is lost. This method, which is known as "approximate Bayesian computation" [ABC], has now been used in a variety of contexts, such as the analysis of tumor data (a tumor being a complex population of cells), and the analysis of human genetic variation data (which arise from a population of individual people).
We review a number of ABC methods, with specific attention to the use of ABC in agent-based models, and give pointers to software that allows straightforward implementation of the ABC approach. In this way we demonstrate the utility of simulation-based analyses of large datasets within a rigorous statistical framework.
Track: Grand Challenges in Modeling and Simulation

Fiber Tractography for Finite-Element Modeling of Transversely Isotropic Biological Tissues of Arbitrary Shape Using Computational Fluid Dynamics
Joshua Inouye, Geoffrey Handsfield and Silvia Blemker
(Submission #51)

Summary
Fiber tractography is useful for studying a variety of biological phenomena associated with transversely isotropic tissues, in which fibers serve to provide functional strength along a specific axis. One useful application of fiber tractography is finite-element analysis (FEA) studies. Here, we present a method utilizing computational fluid dynamics (CFD) for efficiently determining fiber trajectories in a transversely isotropic material with arbitrary structures of any complexity (such as those determined from biomedical imaging). We demonstrate assignment of fiber directions to FEA mesh by registration with the CFD mesh. Sensitivity analysis on various solver settings, flow characteristics, and material parameters shows less than 2 degrees of average deviation from the nominal fiber vectors if the Reynolds number is <1 and the flow is laminar and incompressible with our nominal fluid properties (viscosity of 1Pa-s and density of 1g/cm^3). Flow guides can be used to help match fiber trajectories to experimental or anatomical observations, such as twisting in the Achilles tendon. This method also provides an elegant solution to determining fiber tracts in muscles that intertwine with each other, such as in the soft palate complex. For FEA studies, this method enables efficient determination and assignment of fiber directions to any finite-element mesh.
Track: Modeling and Simulation in Medicine

Evaluation of Industrial Biofilter Emissions on Health Effects through Dispersion Model Predictions
Nada Azlah, Zarook Shareefdeen, Ali Elkamel and ChandraMouli Madhuranthakam
(Submission #52)

Summary
This paper investigates the dispersion of air pollutants that are accidentally released from industrial biofilters. For this study, a commercial biofilter that is installed in an industrial plant located in Hickson, Ontario, Canada is considered as an example. The accidental releases could happen due to failure in biofilter performance. Dispersion model CALPUFF was used in this study at different biofilter removal efficiencies to predict pollutant concentrations, dispersion and health effects under various atmospheric conditions. The study shows geographical variations (i.e. flat surface versus elevated) of the location of a biofilter have effect on the wind nature, hence on the pollutant dispersion. The results confirmed that the wind direction has a direct impact on the pollutant plume path whereas atmospheric conditions have an influence on the pollutant dispersion. Also, the results elucidated that the high concentration of pollutants that obtained at a low removal efficiency of biofilter can cause serious health problems. The results of this investigation can be used as a basis to evaluate biofilter performance under different atmospheric and geographical conditions and to improve biofilter design.
Track: Modeling and Simulation for Environmental Systems

CAEDISI: A Cellular Automata Editor and Simulator for Network Decontamination
Livaniaina Rakotomalala and Nejib Zaguia
(Submission #56)

Summary
Hi there this is our paper for 2015 Summer Simulation Multi-Conference (SummerSim'15). With respect to the category under which the submission should be reviewed, we have not found the right category under the listing as our paper crosses network security and distributed systems. Thus, we have selected "Grand challenges in Modeling and Simulation" but please feel free to move it under the appropriate category if needed.
Track: Grand Challenges in Modeling and Simulation

Development of the energy hub networks based on distributed energy technologies
Azadeh Maroufmashat, Ali Elkamel, Sourena Sattari Khavas, Michael Folwer, Mohamed Elsholkami and Ramin Roshandel
(Submission #57)

Summary
In this paper the creation of multiple energy hubs that make up a complex energy network are modeled and optimized for a selection of six scenarios to examine both their financial viability and potential reduction of greenhouse gas emissions. As a proposed case study scenario for the model, three energy hubs are considered: a ‘residential complex (RC)’, a ‘commercial shopping plaza (CS)’, and a ‘school (S)’. The use of combined heat and power systems, solar photovoltaic, solar collectors and network interaction are also examined for their impact on efficiency and cost. The modeling is undertaken and carried out by General Algebraic Modeling System (GAMS). It is shown that cost can be reduced with the introduction of combined heat and power plant, but emissions reductions depend on the emission factor of the grid supplied electricity, and in the all-case energy hubs working as a network achieve economic advantages.
Track: Grand Challenges in Modeling and Simulation

The Impact of Climate Condition on the Optimal Size of Direct Coupled Photovoltaic-Electrolyzer Systems
Farid Sayedin, Azadeh Maroufmashat, Sourena Sattari, Ali Elkamel and Suad Al-Adwani
(Submission #58)

Summary
Solar energy exists extensively in all parts of the world. However the intermittency of solar energy presents critical challenges to PV system. The intermittency can be covered by storing solar energy in chemical bonds such as hydrogen. This process can be performed by photovoltaic powered electrolysis of water. The energy transfer efficiency between PV and electrolyzer is subject to the distance between maximum power points (MPP) of PV module and operating points. The operating points can be adjusted by optimizing the design parameters of the electrolyzer but the maximum power points are function of PV module characteristics, solar radiation and ambient temperature. Therefore the weather condition can significantly affect the MPP and consequently the optimal size of the PV-Electrolyzer (PV/EL) system. In this paper the impact of climate condition on the optimal size and operating condition of a direct coupled photovoltaic-electrolyzer system has been studied. For this purpose the optimal size of electrolyzer for six cities of Iran which have different climate condition is obtained and then the levelized costs of hydrogen production for these cities are compared. The results show that the climate condition can strongly affect the size of the electrolyzer, the annual hydrogen production and consequently the levelized costs of hydrogen production.
Track: Modeling and Simulation for Environmental Systems

The Reference Model uses Object Oriented Population Generation
Jacob Barhak
(Submission #59)

Summary
The Reference Model for disease progression is a league of models attempting to explain published study data. The model cross references simulation results with observed clinical results for multiple population cohorts. The model has grown to contain 47 different cohorts from 9 diabetic populations. Each population contains -40 rules and ~45 objectives. Since there are many repetitions and replications in the code, it becomes hard to maintain and expand further. To support future expansion, code reusability is needed. This is accomplished by an object oriented approach that allows inheriting population generation building blocks. The presentation will discuss the reorganization of population generation using the MIcro Simulation Tool - MIST. Examples demonstrating the benefit from the transformation towards the object oriented approach are presented. Results demonstrate model stability after code transformation.
Track: Modeling and Simulation in Medicine

High-Fidelity Simulation of Collective Effects in Electron Beams Using an Innovative Parallel Method
Kamesh Arumugam, Mohammad Zubair, Desh Ranjan, Alexander Godunov and Balsa Terzic
(Submission #60)

Summary
Among the most challenging and heretofore unsolved problems in accelerator physics is accurate simulation of the collective effects in electron beams. Electron beam dynamics is crucial in understanding and the design of: (i) high-brightness synchrotron light sources — powerful tools for cutting-edge research in physics, biology, medicine and other fields, and (ii) electron-ion particle colliders, which probe the nature of matter at unprecedented depths. Serial, or even naively parallel, implementation of the electron beams self-interaction is prohibitively costly in terms of efficiency and memory requirements, necessitating simulation times on the order of months or years. In this paper, we present an innovative, high-performance, high-fidelity, scalable model for simulation of collective effects in electron beams using state-of-the-art multicore systems (GPUs, multicore CPUs, and hybrid CPU-GPU platform). Our parallel simulation algorithm implemented on different multicore systems outperforms the sequential simulation, achieving a performance gain of up to 7.7X and over 50X on the Intel Xeon E5630 CPU and GTX 480 GPU, respectively. It scales nearly linearly with the cluster size. Our simulation code is the first scalable parallel implementation on GPUs, multicore CPUs, and on hybrid CPUGPU platform for simulating the collective .
Track: Grand Challenges in Modeling and Simulation

Including Public Transportation into a Large-scale Agent-based Model for Epidemic Prediction and Control
Mingxin Zhang, Rongqing Meng and Alexander Verbraeck
(Submission #61)

Summary
Large-scale agent-based modeling and simulation has recently become an effective analytical method for city/country/global level epidemic prediction and evaluation of potential disease control measures. However, the role of public transportation has not been widely investigated in this method, although it has been proven in historical observations and mathematical epidemic models that random contacts in dense areas (e.g., buses and metros) could be an influential factor for the transmission of most contagious diseases. This paper describes a large-scale agent-based model for epidemic prediction in the context of the metropolitan area of Beijing (with a population of 19.6 million people), where a microscopic public transport system (including metros and buses) is simulated and integrated with the agent-based model. This public transportation component is microscopic as we modeled all lines and stops for both the metro and the bus system in Beijing. Through this component, agents can realistically 'travel' to their destinations and the component will provide accurate travel routes and durations. To systematically investigate the role of this public transportation component and how interventions related to this component will impact the disease transmission, we implemented a pandemic influenza disease progression model, and we tested several interventions related to traveling behavior using public transport on a baseline model. The simulation results indicated that the inclusion of public transportation can offer more possibilities for public health policy makers to evaluate the interventions related to public transportation.
Track: Agent-Directed Simulation

Effect of Thermal Sintering and Poisoning on Light-Off Performance of Zoned Pt-Pd/Al2O3 Diesel Oxidation Catalysts

Suad Al-Adwani, William Epling and João Soares

(Submission #62)

Summary

The CO conversion performance over Pt−Pd/Al2O3 catalysts for a variety of distributed precious metal designs, while maintaining equivalent totals of precious metal, was evaluated as a function of exposure time to sulphur and the spatial accumulation profile of Sulphur along the monolith length were predicted. The results illustrate that the Sulphur accumulates near the catalyst inlet and decreases toward the outlet, resulting in shifting the reaction zones further toward the catalyst outlet. With sulfation, light-off temperatures (T50) increased and the time for back to front reaction propagation also increased. A back loaded catalyst resulted in the best light-off conversion compared to the other catalyst designs and a middle loaded catalyst maintained a higher overall conversion if Sulphur poisoning takes place. These catalyst designs were also tested under thermal aging conditions by using a second order sintering model integrated with the CO oxidation reaction model. The spatial normalized dispersion profiles along the monolith showed that the catalyst outlet experienced significant damage relative to the inlet due to sintering. A front loaded catalyst design had the highest catalytic activity due its resistance to sintering.

Track: Modeling and Simulation for Environmental Systems

Simulation of a Runoff Model Running with Multi-Criteria in a Cluster System

Antoni Portero

(Submission #63)

Summary

In this paper, we propose a safety-critical system with a run-time resource management. On the system, an application for disaster management is running. This application is simulated with different Quality of Services (QoS) depending on the situation. When studying the power consumption of existing systems running HPC workloads, we find power; energy and performance are closely related leading to the possibility to optimize energy without sacrificing performance. The system operation can follow two main scenarios - Standard and emergency operation. In both scenarios, the resource allocation can be used either for decreasing power consumption and minimizing needed resources in standard operation or increasing the precision and decreasing response times in emergency operation. This paper shows that it is possible to describe different optimal points at design time and use them to adapt to the current quality of service requirements during run-time. The proposed process can then be used to prepare an operational environment with high availability while saving energy at the cost of lower precisions of the results during non-critical situations.

Track: Emergency Management Simulation

A Generic Simulation Model for Strategic Level Driver Behavior
Marco Lützenberger
(Submission #64)

Summary
When it comes to road traffic, there seems to be no parameter more essential than the driver himself. Currently, there are many models available, which can be used to describe a driver's behavior for a traffic simulation. Nevertheless, despite the rich offer of available formalisms it is our opinion that existing approaches do not comply with psychological models. In this work we determine the differences between both domains and present a model which aims to bridge the gap between psychology and simulation.
Track: Agent-Directed Simulation

OpenMalaria and EMOD: a Case Study on Model Alignment
Casey Ferris, Benoit Raybaud and Gregory Madey
(Submission #65)

Summary
This paper presents a case study of model alignment involving two independently developed agent-based malaria models. Each of these models simulates malaria transmission and various malarial interventions, such as insecticides, drugs, and bednets. EMOD specifically models both humans and mosquitoes as agents while they interact with each other and interventions. However, OpenMalaria, only directly models humans as agents, while the mosquitoes interact based on results from several differential equations. This is the main difference between the two models, but there are several more, some which are not clearly noticeable without performing a complete comparison. In this docking exercise, we take a unique third-party perspective in order to determine equivalence between these two models. The successful alignment of OpenMalaria and EMOD further validates each model beyond their previous, individual validations. This case study also provides insight into the challenges and benefits of docking when none of the original model creators are fully involved in the exercise.
Track: Agent-Directed Simulation

Multiscale Analysis of Bone
Iwona Jasiuk
(Submission #67)

Summary
In this paper we present a review of our multi-scale analysis of bone. First, we characterize the bone organ experimentally at several structural levels: the macroscale (whole bone level), the mesoscale (trabecular bone represented as a porous network and cortical bone represented as a collection of osteons in interstitial bone), the microscale (single trabecula or single osteon), the sub-microscale (single lamella level) and the nanoscale (apatite crystals and collagen fibril level). More specifically, we study the hierarchical structure of bone using electron microscopy, Raman spectroscopy, and computed and micro-computed tomography, and measure its mechanical properties using compression and tension tests and micro indentation and nanoindentation techniques. Then, we model bone organ theoretically at each structural level in a hierarchical way. The modeling techniques include analytical micromechanics theories and numerical simulations involving finite element, spring network, and beam network approaches. We compare our theoretical results on elastic moduli and strengths at different scales with experimental measurements. Such experimentally-based multi-scale predictive computational model can be used to assess of bone quality in clinical settings, including the diagnosis of bone diseases such as osteoporosis. Secondly, it provides a more complete understanding of the complex phenomena taking place in bone such as bone fracture and bone adaptation, among others.
Track: Modeling and Simulation in Medicine

Virtual enterprise synthesis by web services composition with HTN-like parsing algorithm
Victor Romanov, Svetlana Efimova, Katerina Youdakova and Aleksandra Varfolomeeva
(Submission #70)

Summary
The fast changing world around dictates need for the same speed to change structure of the enterprise to save clients and compliance to world around. The virtual enterprises provide such opportunity. Existence of a large number of various services in the Cloud does potentially possible both fast changing of the enterprise, and assembly of the new enterprises of atomic services. It is known that algorithms of automated planning are important part of such synthesis. In this paper it is proposed to apply the theory of the formal grammar and the appropriate procedures as means of support of automated planning for composition of web services.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Robust Fault Tolerant Control of Wind Turbine Benchmark Model
Young-Man Kim
(Submission #71)

Summary
In this research, robust fault tolerant controller design using recursive predictor-based system identification algorithm is developed for wind turbine benchmark model. One of the characteristics of wind turbine is that system dynamics is close to stability boundary, thus recursive identification of wind turbine easily fails while covariance matrix is updated. Regarding the issue, array algorithm is known numerically stable; hence it is applied to this research. Imperfect system identification is usually resulted from a bias and a noise. In this research, those factors are considered to design fault tolerant controller in full wind speed range. With simulation, it is shown that the designed controller robustly controls the system to perform under any fault situations.
Track: Modeling and Simulation in Energy Systems Integration and Smart Grid

Vertical Scalability Benchmarking in Three-Dimensional Virtual World Simulation
Sean Mondesire, Jonathan Stevens and Douglas Maxwell
(Submission #72)

Summary
The United States military is investigating large-scale, realistic virtual world simulations to facilitate warfighter training. As the simulation community strives towards meeting these military training objectives, methods must be developed and validated that measure scalability performance in these virtual world simulators. With such methods, the simulation community will be able to quantifiably compare scalability performance between system changes. This work contributes to the development and validation prerequisite by evaluating the effectiveness of commonly used system metrics to measure scalability in a three-dimensional virtual trainer. Specifically, the metrics of CPU utilization and simulation frames per second are evaluated for their effectiveness in vertical scalability benchmarking.
Track: Grand Challenges in Modeling and Simulation

Advanced Systems Engineering and Model Philosophy
Barclay Brown
(Submission #73)

Summary
As systems grow more complex, development programs grow larger and more difficult to execute successfully. Challenges in meeting cost and schedule targets show up across all industries in complex systems development. Recent research shows that correctly applied systems engineering approaches can make a significant impact on cost and schedule risk. This led to the Advanced Systems Engineering initiative and the Continuous Engineering approach, a set of concepts and directions aiming at improving engineering and development program execution. Though many buy into the mantra, "models are the answer" in systems engineering, we must distinguish what makes a model, a model. Beyond particular modeling languages and diagram types, models exist for various purposes, and can have relationships with each other, forming a kind of "model of models." In Advanced Systems Engineering, the relationship between models and requirements is also changing and evolving to include both model-driven requirements and requirements-driven models. Outline - Continuous Engineering: A vision for the future of engineering - Review systems engineering research and show how it led to the development of the IBM Advanced Systems Engineering Initiative - Advanced Systems Engineering initiative: new approaches to for requirements engineering, model-based systems engineering, automated generation of work products, design model integration and measurement-based technical work management. By applying these approaches, tailored to specific program needs, programs can execute more effectively, meeting targets as well as customer needs.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

An Analysis on the Metrics for Dynamic Process Scheduling on Distributed Simulation Using Optimistic Protocols
Emerson Carvalho, Mateus Junqueira, Edmilson Moreira and Otavio Carpinteiro
(Submission #74)

Summary
This work presents an assessment about the metrics used by the well known load balancing algorithms for optimistic distributed simulations running over the Time Warp protocol. It also introduces a new metric for calculating the simulation load and implements a generic load balancing algorithm that is metric independent, allowing the metrics evaluation under the same execution environment, with the same simulation models, the same load imbalance factors and the same migration processes mechanism. The new metric proposed is based on the straggler messages factor, and the load balancing algorithm was designed to not benefiting anyone of the metrics. With the models evaluated, the proposal metric achieved a good performance, but the most efficient metric was that based on the variance among the processes Local Virtual Time.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Agent-based Modeling and Simulation of Pooled Warehouse Intelligent Management
Wided Mathlouthi, Narjès Bellamine Ben Saoud and Sami Sboui
(Submission #75)

Summary
Logistics, in its most basic definition, is the efficient flow and storage of goods from their creation to their consumption. It is the part of the supply chain process that plans, implements and controls the flow of goods. Increasing production rate and product distribution velocity of warehousing facilities play a vital role in the overall supply chain process and optimizing their storage spaces capacities is one of the major challenges for logistics companies, which aim to lower cost by reducing product storage cost and damage and to improve the environmental performance of their service. Logistics companies offer more and more solutions as multi-client warehouse and storage pools. Considering all the storage facilities as a single virtual space and pooling "optimally" capabilities between these storage spaces would be the right answer to solve these challenges. Through this paper, we are challenged to figure out new ways to make storage process more effective by optimizing storage space allocation in a pooled storage network. This pooled logistics management (e.g. resource allocation, scheduling of tasks), that provides economic benefits and add efficiency by consolidating and accumulating products and storage operations to both customers and warehouse managers, resembles closely to the pooled management of hosted computer servers in Cloud Computing (CC). Based on this similarity, the proposed model intends to adapt resource allocation methods and models, developed in CC environments, and their reuse for optimizing storage space allocation in a Pooled Warehouse (PW) in order to maximize the number of accepted storage requests with keeping the best quality of stored products. After an analytical study, an agent based model and simulator for an intelligent management of PW are presented, and the first simulation results are discussed. A comparison of the different allocation strategies show that the total number of storage requests rejections differ from one scenario to another.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Perspectives of modeling in metallurgical production
Konstantin Aksyonov, Eugene Bykov, Olga Aksyonova, Natalia Goncharova and Alena Nevolina
(Submission #76)

Summary
The paper introduces the architecture of the automated system for metallurgical production. We focus on the interaction of the sub-systems, dive into the principles that the simulation module is based on, analyze the alternatives and look at the perspectives of modeling for the problem domain. We compared the functionality of simulation module with various agent architectures. We may conclude that the simulation module is essentially an intelligent agent that builds the infrastructure for the execution of logistical, technological and business models.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Analysis of Simulation Modeling Systems Illustrated with the Problem of Model Design for the Subject of Technological Logistics

Konstantin Aksyonov, Eugene Bykov, Olga Aksyonova, Natalia Goncharova and Alena Nevolina

(Submission #77)

Summary

The paper presents definition of the models for technological logistics in various modeling systems: Plant Simulation, Simio, AnyLogic, as well as the software, which is currently run at an enterprise that operates metallurgical production with the purpose of quality assurance. Performance analysis of simulation systems identified the advantage of current software from the point of view of RAM and CPU load, and Simio with Plant Simulation from the experiment duration point. Main disadvantages of the systems under analysis include incomplete correspondence to the problem domain of the resource conversion processes, orientation towards users with programming skills and the corporate information system integration interfaces.

Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Computational Complexity of Agent-based Multi-scale Cancer Modeling

Fei Xing and Dieter Heermann

(Submission #78)

Summary

One of the main challenges of agent-based multi-scale cancer modeling and simulation is the explosive growth of the computational cost of model solving with increasing the system size as well as the model complexity. Current models have to comprise significantly between model complexity and model fidelity. We investigate this problem based on a specific tumor model developed by us. The model takes into account the discrete nature of tumors and continuous processes involved in tumor development by integrating discrete and continuum approaches. Each individual tumor cell is modeled as a single agent that interacts with its nearest neighbors as well as with the extracellular environment biochemically and biomechanically. Cells move in an overdamped manner, which is realized by Newton's second law. The transport and metabolism of nutrients are described by reaction-diffusion equations. Cell proliferation is performed according to the biochemical and biomechanical conditions of the cell environment. Optional methods are compared for solving parts of our models in term of the performance and the stability. After that, the computing bottleneck of our model is tested. In general, this work may provide important instructing information for people who intend to work on single-cell-oriented multi-scale cancer modeling.

Track: Agent-Directed Simulation

Variable Intensity RCPSP Approach to a Case Study Flow Shop
Oladipupo Olaitan, Paul Young and John Geraghty
(Submission #79)

Summary
Presented in this submission is the development of a simulation modelling and solution approach for the scheduling problem of a case study company which can be classified as a project based flow shop. The problem is formulated as a Resource Constrained Project Scheduling Problem (RCPSP) and solved with a variable intensity approach. Binary decision variables are used in determining the projects to be executed on a periodic basis at the operations involved, followed by the application of a capacity allocation algorithm for determining the proportion of operational capacity to dedicate to each project. Also, a feeding precedence relation is applied for modelling the overlap that exists between two of the operations involved in the system. The work is part of the development of the various modules of a simulation based decision support system. The simulation modelling and solution methodology developed here are for implementation in its simulation module, which is an open-source simulation modelling package.
Track: Grand Challenges in Modeling and Simulation

The Next Generation of Modeling & Simulation: Integrating Big Data and Deep Learning
Andreas Tolk
(Submission #80)

Summary
Big data allows users to cope with data that are huge in regards to volume, velocity, variety, and veracity. It provides methods and tools to extract aggregates and new information out of heterogeneously structured data or even completely unstructured data. Deep learning is a collection of algorithms that allows us to discover correlations and learn — supervised and unsupervised — from information provided. This contribution introduces the main ideas and methods of big data and deep learning and shows how they can be applied to various phases of the traditional modeling and simulation process. Big data supports obtaining data for the initialization as well as evaluating the results of the simulation experiment. Deep learning can help with the conceptual modeling phase as well as with the discovery of correlations in the results. Examples of existing applications will be given to prove the feasibility of such ideas. This leads to the observation that big data, deep learning, and modeling and simulation have the potential to lead to a new generation of modeling and simulation applications that provide computational scientific support on a new scale beyond the current capabilities.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Development and Application of System Complexity Measures for Use in Modeling and Simulation

Jennifer Deaton

(Submission #82)

Summary

A reliable method for categorizing and quantifying System Complexity has been successfully demonstrated. The technique is based on an ordinal scale applicable to programs and products in government and industry. It provides objective planning and analysis, supporting management and technical decisions. This paper describes how the scale has been developed and how it has been successfully used in modeling and simulating program outcomes. In the first section, we provide the motivation why a more reliable method to characterize System Complexity is needed. In the next section, we discuss our approach to measuring and modeling system complexity. Finally, we summarize our findings.

We have developed a scale which is useful for categorizing system complexity, which has been shown to be predictive of quantitative measures related to system development. The data collected from a large set (hundreds) of product and system developers were used to calibrate the scale which was implemented in a model/simulation constructed for program and product development efforts. When this modeling construct was connected to other ordinal and quantitative measures, such as TRL and design reuse, our scale becomes part of a rich model providing powerful insight.

Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Modeling and Simulation as a Service (MSaaS) for Education: Learning STEM Concepts through Simulation Use and Building

Jose J. Padilla, Enilda Romero-Hall, Saikou Y. Diallo, Anthony Barraco, Hamdi Kavak, Ross J. Gore, Christopher J. Lynch and Manasi Sheth-Chandra

(Submission #83)

Summary

Despite their proven advantages in science and engineering and their broad application in daily activities such as travel planning and financial planning, simulations are not widely utilized in education, particularly at the K -12 levels. One of the main reasons is that simulation use and simulation building is reserved for expert's use and remains out of the reach to a larger audience. One potential solution is Modeling and Simulation as a Service (MSaaS) for education in the form of a cloud-based simulation learning environments (CSLEs). CSLEs can provide worldwide access to many people for using and building simulations as well as exposing them to STEM concepts like data capture and probability. This paper presents a roadmap for CSLEs. The roadmap, six requirements for building CSLEs, draws on insights from 1) testing a cloud-based simulation environment for education purposes with students ranging from middle school to graduate school and 2) capturing longitudinal data of simulation-building activities. Insights from the students' testing of the environment suggest that using drawings as conceptual models facilitates the transition from a real-life system to abstraction into implementation of the model. Longitudinal data capture provides the potential for identifying simulation-building habits across levels of expertise and the development of metrics and models for simulation development.

Track: Grand Challenges in Modeling and Simulation

Towards Sonic Urban Morphologies: A Modeling Nexus
Merate Barakat
(Submission #84)

Summary
This paper is part of an ongoing research investigating the potential for creating a tool that integrates the theoretical spatial and soundscape design connections, to aid spatial designers when considering sound as a primary driver for urban design. The investigation is founded on establishing a relationship between aural architecture theories and the urban spatial experience and design. It also explores the merging of spatial and acoustical computational approaches, through integrating the physical/mathematical representation of sound to the mapping of the spatial envelopes and phenomena of human aural responses. The intent is the development and calibration of a computational design and decision-aiding tool that can predict qualitative patterns of aural spatial perception, and translate them into spatial attributes within a modelled urban space. The tool combines known urban modelling techniques with established acoustic simulation methods to produce qualitative aural spatial patterns that can aid architects (urban and event designer) to incorporate acoustic sensory manipulation during the preliminary design phase.
Track: Work in Progress Session

Intelligent Simulation Models based on Business Rules Approach in Banking Sector
Roman R. Veynberg, Aleksandra O. Varfolomeeva and Kseniya Grigoryeva
(Submission #86)

Summary
In this paper, we discuss business rules management systems (BRMS) and their use in bank scoring models. Business rules are considered as an effective tool in determination of trustworthiness and solvency of borrowers, taking into account their socio-demographic and personal characteristics. This article will be informative for scientists in applied IT field, finance, banking, as well as for practicing risk managers and insurers.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Risk Modeling in the Global Sustainable Supply Chain: a Research Trend
Mojtaba Hajian-Heidary and Abdollah Aghaie
(Submission #92)

Summary
In the last two decades, supply chain was an important area of the researches in the field of Industrial Engineering, Management etc. On the other hand, there are many publications about the supply chain management (SCM). However, a main question is: what are the future trends in supply chain management researches? There is some review papers in the literature tried to replay to the question. “Globalization”, “sustainability” and “risk” are the main subjects proposed by them. In this paper, using the results of the related review papers, and based on the surveys done through the 3 main related databases (Science Direct, Springer, and IEEE); the mentioned question will be replayed. Finally the importance of the recognized gap (global sustainable supply chain risk modeling) will be explained based on the future works of the recent published papers.
Track: Grand Challenges in Modeling and Simulation

Summer Computer Simulation Conference (SCSC)

Abstract

The SILAS model: Sexual Infections as Large-scale Agent-based Simulation
Stefan Scholz, Manuel Batram and Wolfgang Greiner
(Submission #94)

Summary
The SILAS model is an agent-based simulation of human sexual behavior incorporating heterogeneous behavior of agents with respect to age, sex, sexual orientation and relationship status. Behavior rules are not only applied to the realization of sexual contacts, but also on ending and forming relationships, death and child birth. Thus, the agent population endogenously re-populates itself. This allows not only to simulate the transmission of STIs between adult agents, but also mother-child infection paths. The model can simulate the effect on the overall population and can therefore be used for the epidemiological, public health or health economic evaluation of tailored interventions for sub-populations.
Track: Modeling and Simulation in Medicine

A Second Look at Oblivious Simulation
Peter Maurer
(Submission #95)

Summary
The two predominant logic simulation techniques are event-driven simulation, and levelized compiled code simulation. In the past, studies have been performed to characterize these algorithms, and compare their performance under various different conditions. However, these studies were done a number of years ago on equipment that varies substantially from the equipment that is available to us today. Today's equipment is less dependent on small tight loops than the equipment of several years ago. Furthermore, the studies that were done years ago were generally done assuming a uniform activity rate throughout all parts of a complex circuit. In fact, activity rate varies substantially within a circuit, with high bursts of activity at various times. This paper examines a combined approach that can increase performance despite very low activity rates. A large number of studies were performed that show that the earlier assumptions about event-driven vs. oblivious simulation should be re-examined.
Track: Modeling and Simulation in the Design Automation Flow

Linguistic Geometry for Intelligent Analysis of Courses of Action for Training
Oleg Umanskiy, Boris Stilman, Vlad Yakhnis, Latika Eifert and Jonathan Stevens
(Submission #96)

Summary
Linguistic Geometry (LG) is a type of game theory scalable to solving complex real world problems that are considered intractable by conventional approaches. Modern applications of LG, related to the modeling and simulation applied to US national defense, generate, in real time, intelligent Courses of Action (COAs) much faster and of higher quality than those generated by human commanders. While LG tools have been applied to analysis of COAs in the military command and control domain (within the context of modeling and simulation) for many years, its use in educational settings for tactical training has not been previously explored. Reducing needs for human training staff via automatic generation of COAs represents a significant challenge and can provide multiple benefits beyond merely replicating some of the required capabilities of the instructor. This paper reports results of such usage of LG-assisted modeling and simulation.
Track: Grand Challenges in Modeling and Simulation

An Agent Based Exploration of a Relationship between Daily Routines and Convenience Store Footfalls
Vivek Balaraman, Deepa Athle and Meghendra Singh
(Submission #97)

Summary
Convenience stores (C-stores) compete not on price but on what are called convenience factors: faster shopping, proximity to home or work, longer work hours. A significant challenge with c-stores is estimating store footfall. We hypothesize that people's daily routines may serendipitously determine their c-store choice. We explore this possibility in two ways. First we look into past studies that suggest this relation. Second we build an agent based model of a community with c-stores where footfalls are triggered by proximity to the store. We use this model to study shopping patterns in the virtual community. We first look at mean distance to stores from home and from a point on one's route. We then explore footfall estimates with and without routines for 3 different layouts. We use T-means to check if the footfall patterns with and without routines are different. We then examine how the factor which determines the frequency of visits to the c-store influences the choice of c-store. Together these explorations provide strong pointers that the relationship between routine and footfall needs to be further researched.
Track: Agent-Directed Simulation

PACT: a Participant-centered Clinical Trial Framework
Ross Gore and Manasi Sheth-Chandra
(Submission #99)

Summary
Our Participant-centered Clinical Trial (PACT) Framework is a new approach to the design and analysis of clinical trials in the behavioral, social and health sciences. The PACT Framework is based on the seemingly–impossible idea that data can be privately maintained by participants and never revealed to researchers, while still enabling statistical models to be fit and scientific hypotheses tested. PACT rests on the assumption that clinical trial data should belong to, be controlled by, and remain in the possession of participants. Since data have value, individuals can thus accumulate personal wealth by participating in science. The innovation of the PACT Framework is that statistical models are fit by sending an objective function and vector of parameters to each participants' personal device (e.g., smart-phone), where the likelihood of that individual's data is calculated locally. Only the likelihood value is returned to the central optimizer. The optimizer aggregates likelihood values from all participants and selects a set of new parameters until the model converges. The PACT Framework solves or simplifies many current problems that plague human participant clinical trials. A PACT study provides significantly greater privacy for participants; automatic management of opt–in and opt–out consent; lower cost for the researcher and funding institute; a larger base of participants; and faster determination of results. PACT facilitates the use of mobile devices that can enable many trials to be performed while participants remain in their normal living environments, thus opening new paths in the way one thinks about research methods. Furthermore, if a participant opts into many clinical trials simultaneously, all of the studies could automatically have access to individual–level longitudinal data sharing.
Track: Modeling and Simulation in Medicine

Summer Computer Simulation Conference (SCSC)

Abstract

A System-of-Systems Approach for Integrated Energy Systems Modeling and Simulation
Saurabh Mittal, Mark Ruth, Annabelle Pratt, Monte Lunacek, Dheepak Krishnamurthy and Wesley Jones
(Submission #101)

Summary
Energy systems integration combines energy carriers, including electricity, with infrastructures, to maximize efficiency and minimize waste. In order to study systems at a variety of physical scales—from individual buildings to distribution systems—interconnected through these energy infrastructures, NREL is developing an Integrated Energy System Model (IESM), with an initial focus on the electricity system. Today's electricity grid is the most complex system ever built—and the future grid is likely to be even more complex because it will incorporate distributed energy resources (DERs) such as wind, solar, and various other sources of generation and energy storage. The complexity is further augmented by the possible evolution to new retail market structures that would provide incentives to owners of DERs to support the grid. The IESM can be used to understand and test the impact of new retail market structures and technologies such as DERs, demand-response equipment, and energy management systems on the system's ability to provide reliable electricity to all customers. The IESM is composed of a power flow simulator (GridLAB-D), building and appliance models including home energy management system implemented using GAMS/Pyomo, a market layer, and is able to include hardware-in-the-loop simulation (testing appliances such as air conditioners, dishwashers, etc.). The IESM is a system-of-systems (SoS) simulator wherein the constituent systems are brought together in a virtual testbed. We will describe a SoS approach for developing a distributed simulation environment. We will elaborate on the methodology and the control mechanisms used in the co-simulation illustrated by a case study.
Track: Modeling and Simulation in Energy Systems Integration and Smart Grid

An Architecture to Support Integrated Manikin-Based Simulations
James Leathrum, Roland Mielke, Michel Audette, Frederick McKenzie, Robert Armstrong, Geoff Miller, Mark Scerbo and Andrew Cross
(Submission #103)

Summary
A radically new approach to the design and implementation of high-technology, computer-driven manikin-based simulation environments for medical training is proposed. The approach utilizes a novel, component-based manikin hardware architecture currently under research for the U.S. military. A new distributed software architecture is proposed in this paper that facilitates interoperability among manikin components and provides the potential to easily integrate other real or virtual devices normally present in a real medical facility.
Track: Modeling and Simulation in Medicine

Approach to Examine Efficacy of Game-Based and Virtual Simulation Training
Jonathan Stevens, Douglas Maxwell, Eric Ortiz and Lauren Reinerman-Jones
(Submission #104)

Summary
The United States Army has heavily leveraged, developed and expanded its use of virtual simulation training, as this class of simulation has been empirically demonstrated to be effective in the transfer of skills to the live environment. Game-based training, an alternative class of simulation, is characterized by its lower overhead and cost and potentially represents a less expensive alternative to virtual simulation training. In an effort to reduce the cost of training simulation, the U.S. Army has recently socialized the concept of potentially replacing select virtual simulation trainers with game-based simulations. While lowering the cost of simulation is a noble endeavor, the aforementioned concept requires further investigation as minimal empirical evidence exists regarding the effectiveness of game-based training, particularly at the collective echelon of training. In this paper, we lay the foundation to conduct an investigation of whether a game-based simulation may be as equally an effective collective training apparatus as a higher-cost, higher-fidelity, virtual simulation. Specifically, we discuss a planned Training Effectiveness Evaluation (TEE) of both the Aviation Combined Arms Tactical Trainer (AVCATT) and a game-based aviation simulation that will empirically determine whether or not virtual training in the AVCATT could potentially be replaced by an equally effective, but less costly, game-based simulation. We discourse on our proposed design of experiment, which will utilize qualified Army aviators performing a tactical, collective mission in two discrete training treatments (AVCATT and a game based simulation) at Fort Rucker, Alabama.
Track: Grand Challenges in Modeling and Simulation

Towards Visulations of Astrophysical Accretion Disk on HPC Clusters with AccretionSim
Amit Goel, Oddny Brun, Michele Montgomery and Peter Kincaid
(Submission #105)

Summary
In this paper we present a novel architecture for visulations of astrophysical accretion disk on HPC Clusters. Visulation is a portmanteau describing a coupled system where graphic visualization and computer simulation occur simultaneously. Accretion disk investigations are critical for advancing research in astrophysical phenomena such as star birth, stellar collisions and black hole formation. However, there is lack of accelerated simulations and accelerated visulations of such simulations for accretion disks. Our ongoing research attempts to fulfil this gap by providing accelerated visulations.
Track: Computer Graphics for Simulation

Harnessing Emergence: The Control and Design and Emergent Behavior in System of Systems Engineering
Saurabh Mittal and Larry Rainey
(Submission #107)

Summary
According to Ashby, emergent behavior manifests itself due to a lack of understanding of the system. The problem while apparent in monolithic systems takes on center-stage in a system of system (SoS), components of which is geographically displaced and has independent managerial, evolutionary and operational controls. The emergent behavior in SoS manifests in-situ and lack computational and systems engineering approaches to prevent the engineering of emergent behaviors in SoS modeling and simulation (M&S). The subject of computational emergence requires a much needed focus. This article will discuss key emergent behaviors important to SoS engineering. We will apply Systems Theory, Control Theory and principles of Cybernetics to suggest a way forward for engineering of emergent behaviors in SoS M&S.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

Calcium Induced Calcium Release with Stochastic Uniform Flux Density in a Heart Cell
Matthew Brewster, Jonathan Graf, Xuan Huang, Zana Coulibaly, Matthias Gobbert and Bradford Peercy
(Submission #108)

Summary
Calcium is a critical component in many cellular functions. It serves many important functions such as signal transduction, contraction of muscles, enzyme function, and maintaining potential difference across excitable membranes. We examine the self-organization of calcium waves in a heart cell and how they propagate through the cell. Specifically, the crucial parameter of flux density that controls the amount of calcium released at each calcium release unit is assumed a known constant in the original model. In reality, this value is not known exactly, thus we design parameter studies where the flux density is made a stochastic parameter for each simulation. This technique from uncertainty quantification allows for determining the range of the flux density, in which calcium waves are likely to self-organize, but without physiologically unrealistic saturation of the cell and without electrical stimulation.
Track: Modeling and Simulation in Medicine

Appending Variable-Structure to Modelica Models (WIP)
Daniel Gomez Esperon, Alexandra Mehlhase and Thomas Karbe
(Submission #110)

Summary
Modeling languages and tools support the development of large simulation models based on components from libraries. In particular model types it is desirable to change components during simulation for performance reasons or to change behavior. Variable-structure models provide a solution with the concept of modes describing sets of systems of equations and transitions between modes. Experimental tools exist, but their reusability is limited due to special languages or the need to implement each mode manually. This paper presents a methodology to append variable-structure simulation behavior to existing models implemented in common component-oriented languages by only defining local component exchanges. The prototypical tool MoVasE implements the proposed methodology and introduces a meta-model to hold the variable-structure information separated from the original models. Based on this information, necessary modes are generated automatically. The variable-structure simulation is executed as a series of conventional simulations.
Track: Work in Progress Session

Optimal Porosity for Gas Diffusion Layers of Hydrogen Fuel Cells
Jamal Hussain Al-Smail
(Submission #113)

Summary
In this paper, we introduce a mathematical model for reacting oxygen-hydrogen gases in the cathode of hydrogen fuel cells. The model is a two dimensional nonlinear, coupled system of Darcy, continuity, and convection-diffusion equations, incorporated with suitable boundary conditions modeling electrochemical reactions in the cathode catalyst. The system is coupled with an optimization problem aiming to find an optimal porosity function of the cathode gas diffusion layer, such that the oxygen-hydrogen reaction rates become even over the cathode catalyst. The numerical results show that gas diffusion layers designed with optimized porosity can uniformly distribute the oxygen molecules over the catalyst, resulting in a uniform electrochemical reaction rate. This contributes in increasing the lifetime of the cell as it prevents major issues: accumulation of heat in the membrane of the cell, and water in cathode diffusion layer.
Track: Modeling and Simulation in Energy Systems Integration and Smart Grid

Cyber Modeling & Simulation for Cyber-Range Events
Jerry Couretas
(Submission #115)

Summary
The speed and combinatorial nature of the evolving cyber threat demands a more flexible modeling and simulation (M&S) approach utilizing cyber ranges. In this paper, we provide a summary of the base-line process to conduct cyber-range events. In addition, we introduce the logical range construct that allows event environments to be constructed in a location independent manner, along with its application to the various phases of cyber range events. We also describe how cyber M&S is utilized in cyber-range events, and the need for using more intelligent and autonomous simulations in the event control plane.
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

An Agent-Based Model of Supplier Management in Regional Food Systems (WIP'15)
Hardik Bora and Caroline Krejci
(Submission #116)

Summary
Demand for regionally-produced food has seen tremendous growth in over the last decade, amid increasing consumer concerns over food safety, nutrition, and quality, origin, and production practices. Regional food systems provide economic support for small- and medium-sized farmers and help consumers become better-informed about their food, emphasizing the development of producer-consumer relationships and transparency with regard to production practices. In this paper, we describe new developments to our work in the area of RFSC supplier selection. We are currently testing the impacts of a variety of supplier selection policies on regional food system success, as well as assessing how coordination among producers would impact these policies. In our current research we are specifically interested in studying coordinated farmer logistics. To study this system, we developed an agent-based model (ABM) of a theoretical regional food system in NetLogo which consists of 100 farmer agents and one distributor (or "food hub") agent.
Track: Work in Progress Session

Simulation Validation Using Metamorphic Testing (WIP)
Mohammad Raunak and Megan Olsen
(Submission #118)

Summary
Model validation is an inherently difficult task, as we often lack an oracle that defines correct behavior. Without an oracle it is difficult to apply results validation to determine if the model matches the system being studied. Although there are other techniques that do not require an oracle, they are not considered to be as powerful as results validation. In this paper we describe a new validation technique called ``metamorphic testing'' that creates pseudo-oracles to combat this problem. This technique is based on the software verification technique of the same name, which we extend to apply to validating simulation models.
Track: Work in Progress Session

Efficient Parallel Cell List Algorithms for Monte Carlo Simulations (WIP)
Kamel Rushaidat, Loren Schwiebert, Brock Jackman, Jason Mick and Jeffrey Potoff
(Submission #119)

Summary
Designing efficient algorithms for many-core and multicore architectures requires using different strategies to allow for the best exploitation of the hardware resources on those architectures. This work describes efficient many-core and multicore large-scale energy calculations for Monte Carlo Gibbs ensemble using cell lists. Designing Monte Carlo molecular simulations is challenging as they have less computation and parallelism when compared to similar molecular dynamics applications. Our modified cell list allows for more speedup gains for energy calculations on both many-core and multicore architectures when compared to other implementations without cell lists. We present our results and analysis of the cell list algorithms for each one of the parallel architectures using top of the line GPUs, CPUs, and Intel's Phi coprocessors. We evaluate the performance of the cell list algorithms for different problem sizes and different radial cutoffs.
Track: Work in Progress Session

Building the Virtual Product with Big Models
Barclay Brown, Saurabh Mittal, Andreas Tolk and Sayyidul Arafat
(Submission #122)

Summary
Models have demonstrated proven benefits in specific aspects of the engineering process. Mechanical models, performance models, algorithmic models, systems engineering architecture models and others have proven useful and even perhaps indispensable. Models provide value at different points in the lifecycle with some supporting design and architecture while others simulate and evaluate aspects of the new product or system. The panel and paper will explore the question, "what will be needed to build a virtual product using comprehensive, multi-domain (big) models?" What new processes, concepts and frameworks must be embraced and what old ones must be discarded?
Track: Modeling and Simulation for Intelligent, Adaptive and Autonomous Systems

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Approximate Mean Value Analysis for Multi-core Systems
Lei Zhang and Douglas Down
(Submission #4)

Summary
Mean Value Analysis (MVA) has long been a standard approach for performance analysis of computer systems. While the exact load-dependent MVA algorithm is an efficient technique for computer system performance modeling, it fails to address several features of multi-core platforms. In addition, the load-dependent MVA algorithm suffers from numerical difficulties under heavy load conditions. The goal of our paper is to find an efficient and robust method which is easy to use in practice and also achieves accuracy for performance prediction for multi-core platforms. Our contributions are: We present a flow-equivalent performance model designed specifically to address multi-core computer systems. We identify the influence on the CPU demand of the effects of Dynamic Frequency Scaling (DFS) and Hyper-Threading Technology (HTT). We adopt an approximation technique to estimate resource demands to parameterize the MVA algorithm. We use a modified Conditional MVA (CMVA) algorithm to address the potential numerical instability. To validate the application of our method, we investigate a case study of an e-commerce web server which is equipped with diverse classes of user requests. We show that our method achieves better accuracy compared with other commonly used MVA algorithms.

OpenCounter: Counting Unknown Flows inSoftware Defined Networks
Christian Callegari, Stefano Giordano, Michele Pagano and Gregorio Procissi
(Submission #6)

Summary
The software defined paradigm is recently emerging as a very promising approach to simplify the way complex network applications are designed and integrated in large scale network scenarios. Typical examples of network–wide applications that may well benefit for such an approach are monitoring and security applications that collect information from multiple vantage points to provide higher lever analyses. In this context, this paper adopts the software defined approach to propose a novel distributed architecture that permits to effectively count the number of unknown flows in an SDN network, allowing the development of several monitoring security applications on top of it. The presented work relies on standard OpenFlow switches and on ad–hoc probabilistic variations of the sketch data structure. The proposed architecture is fully seamless for the underlying network behavior and the performance analysis carried out in laboratory test–bed proves its practical effectiveness.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Histogram Cloning and CuSum: An Experimental Comparison between Different Approaches to Anomaly Detection

Christian Callegari, Stefano Giordano and Michele Pagano

(Submission #5)

Summary

Due to the proliferation of new threats from spammers, attackers, and criminal enterprises, Anomaly-based Intrusion Detection Systems have emerged as a key element in network security and different statistical approaches have been considered in the literature. To cope with scalability issues, random aggregation through the use of sketches seems to be a powerful prefiltering stage that can be applied to backbone data traffic. In this paper we compare two different statistical methods to detect the presence of anomalies from such aggregated data. In more detail, histogram cloning (with different distance measurements) and CuSum algorithm (at the bucket level) are tested over A well-known publicly available data set. The performance analysis, presented in this paper, demonstrates the effectiveness of the CuSum when a proper definition of the algorithm, which takes into account the standard deviation of the underlying variables, is chosen.

Low Latency Network Traffic Processing with Commodity Hardware

Torsten M. Runge, Alexander Beifuß and Bernd E. Wolfinger

(Submission #9)

Summary

Packet processing on commodity hardware is a cost-efficient and flexible alternative to specialized networking hardware. In case of Linux, the classical QoS mechanisms (e.g DiffServ) assume that the outgoing link is the bottleneck. However, on commodity hardware the CPU typically becomes the bottleneck in packet processing. Taking into account current trends in the Internet, we assume that the percentage of latency-sensitive applications (e.g. VoIP, video conferencing, online gaming) will increase. Thus, we propose to extend the Linux NAPI with respect to preferring latency-sensitive traffic at the ingress before reaching the CPU. In this paper, we investigate a new concept for the Linux NAPI for low latency packet processing. Based on a model of a Linux software router, we show in a case study that our concept strongly improves the packet latency of real-time packets at acceptable low costs regarding the achievable maximum throughput. Our model is calibrated and validated based on real testbed measurements (e.g. profiling).

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Multi-class SVMs Analysis of Side-Channel Information of Elliptic Curve Cryptosystem
Ehsan Saeedi, MD. Selim Hossain and Yinan Kong
(Submission #13)

Summary
Cryptosystems, even after recent algorithmic improvements, can be vulnerable to side-channel attacks (SCA). In this paper, we investigate one of the powerful class of SCAs based on machine learning techniques in the forms of Principal Component Analysis (PCA) and multi-class classification. For this purpose, a support vector machine (SVM) is investigated as a robust and efficient multi-class classifier along with a proper kernel function and its appropriate parameters. Our experiment performed on data leakage of a FPGA implementation of elliptic curve cryptography (ECC), and the results, validated by cross a validation approach; compare the efficiency of different kernel functions and the influence of function parameters.

Optimizing Latency and CPU Load in Packet Processing Systems
Paul Emmerich, Daniel Raumer, Alexander Beifuß, Lukas Erlacher, Florian Wohlfart, Torsten M. Runge, Sebastian Gallenmüller and Georg Carle
(Submission #14)

Summary
High-speed network cards supporting 10 or 40GbE (Gigabit Ethernet) are available today. Software frameworks for high-speed packet reception and transmission were created to exhaust the performance of these cards. However, these frameworks are not applicable as general-purpose solution. Thus, it is necessary to revisit general purpose network IO software that was designed more than a decade ago. In standard Linux settings connectivity between applications and physical networks happens via the New API (NAPI). This motivated us to investigate how underlying NIC drivers can be adapted to improve latency in combination with the Linux NAPI. Based on testbed measurements we propose an optimized algorithm for the NIC driver to dynamically adapt the Interrupt Throttling Rate (ITR). We implemented the algorithm and evaluated it with latency and throughput measurements based on the Linux module of Open vSwitch that operates on top of the NAPI. Our measurements show that our new ITR algorithm strongly improves the packet latency on behalf of free CPU capacities.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

User inactivity modeling and simulation for power management of PC fleets
Ramón Medrano, Daniel F. García, Joaquín Entrialgo and Javier García
(Submission #15)

Summary
Energy consumption of the computer fleet can be one of the main costs for corporations to maintain local sites or offices. In order to adjust the power management policies used to put the computers in a low-consumption state, the utilization pattern of the users must be known. In particular, the inactivity periods of the users must be characterized. This paper presents a method to extract the parameters that make possible to model the inactivity of the users in order to simulate the behavior of the whole fleet. A simulation tool developed in Python with SimPy is also presented. The results of the simulation tool can be used as input to an informed decision of which power management policies to apply to the computer fleet.

Load Balancing Probabilistic Spectrum Handoff for Cognitive Radio Networks
Ahmed Tayel and Sherif Rabia
(Submission #23)

Summary
Spectrum mobility in cognitive radio networks aims to enhance spectrum utilization by allowing unlicensed secondary users (SUs) to access the licensed frequency bands of the primary users (PUs). It also helps to vacate the channel from the SU when the licensed PU arrives at the channel, and finds a suitable channel for the interrupted SU. In this paper, we propose a probabilistic approach to determine the target channel for the interrupted SUs. This approach is analysed based on the preemptive resume priority (PRP) M/M/1 queuing network model to evaluate and compare the latency performance and load-balancing of connection-based spectrum handoff in cognitive radio networks. The analytical formulas obtained for the extended data delivery time and the channel busy probability are used to compare the proposed approach with other spectrum handoff strategies based on the target channel sequences specified in the IEEE 802.22 wireless regional area networks (WRAN) standard (the always stay and always change). The results reveal the advantage of the probabilistic approach (based on the total arrival rate to each channel) in load balancing in terms of the variance of the channels' busy probabilities.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Novel Channel Estimation Scheme in Fast Fading Channel Applied to Sidehaul System
Sangmi Moon, Hun Choe, Myeonghun Chu and Intae Hwang
(Submission #25)

Summary
Recently, the 3rd Generation Partnership Project (3GPP) has developed a sidehaul system to cope with the explosively increasing mobile data traffic. The sidehaul system is based on single carrier-frequency division multiple access (SC-FMDA) due to its low peak-to-average power ratio (PAPR). Also, a demodulation reference signal (DMRS) is designed to support multiple input multiple output (MIMO). In this paper, we propose the DFT-based channel estimation scheme for the sidehaul system. The proposed scheme uses the 2 -dimensional minimum mean square error (2-D MMSE) interpolation scheme for the user moving at a high speed. Simulation results show that the proposed channel estimation scheme can improve the normalized mean square error (NMSE), error rate, and throughput of the conventional system

Bio-inspired Exploring and Recruiting Tasks in a Team of Distributed Robots over Mined Regions
Floriano De Rango, Nunzia Palmieri, Xin She Yang and Salvatore Marano
(Submission #27)

Summary
In this paper, the problem of coverage and exploration of unknown and mined spaces is investigated using a team of robots. The goal is to propose a strategy capable to minimize the overall exploration and mine disarming time, while avoiding that robots pass many times through the same places. The key problem is that the robots simultaneously have to explore different regions of the environment and for this reason they should spread among the search areas. However, at the same time, when a mine is discovered, more robots are needed to be engaged in order to disarm the mine. Because the problem of the unknown lands with the constraint to disarm mine is a NP hard problem, we proposed a combined approach using two bio-inspired meta-heuristic approaches such as Ant Colony Optimization (ACO) and Firefly algorithm (FA) to perform the coordination task among robots. We have compared the simulation results considering a common exploration task of the robot spreading and an ACO based robot recruiting(ATS-RR) and Firefly inspired (FTS-RR) strategies to perform the mine disarming task. Performance has been evaluated in terms of both overall exploring time and mine disarming time and in terms of number of accesses distributed in the operative grid area. The results show that the combined approach provides a better tool for both exploration and disarmament.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Multi-layer Sociality in Opportunistic Networks: an Extensive Analysis of Online and Offline Social Behaviors

Annalisa Socievole, Antonio Caputo and Salvatore Marano

(Submission #29)

Summary

The large diffusion of mobile devices able to derive human sociality from wireless encounters and the growing use of online social networks is increasingly driving the research community on opportunistic networks towards social-based techniques and hence, towards the analysis of user social behavior. Within these challenged networks where node connectivity is highly intermittent and contact opportunities are exploited to communicate without network infrastructure, node mobility is basically driven by human sociality. As such, understanding the social behavior of nodes within these networks is of paramount importance, especially for finding suitable relays in message forwarding. In this paper, we focus on the analysis of a collection of multi-layer social networks derived from six different datasets containing mobility data and Facebook friendships of nodes moving in opportunistic network environments. Analyzing egocentric and sociocentric node behaviors on the opportunistic social network detected through wireless encounters and on the corresponding Facebook social network, we show that online and offline degree centralities are significantly correlated on most datasets. On the contrary, between closeness and eigenvector centralities show medium-low correlation values. Considering that opportunistic networks are highly dynamic and in the bootstrapping phase of the network having a clear social behavior of nodes in terms of offline centrality is one of the main issues, these results show that in some cases, online centrality which is easier to compute can predict offline node centrality. Moreover, we show that in most datasets, most of the strong ties correspond to Facebook friendships.

Analytical Model of Two-Level Scheduling Algorithm for WiMAX Networks

Zeeshan Ahmed and Salima Hamma

(Submission #31)

Summary

Two Level Scheduling Algorithm (TLSA) is a QoS-enabled fair and efficient connection admission control and packet scheduling algorithm for WiMAX networks. At the first level, an inter-class scheduling algorithm distributes bandwidth among various WiMAX service classes. Then at the second level, class specific algorithms distribute bandwidth among connections of the associated class. The present paper focuses on a Markov chain based analytical model of TLSA that is comprehensive enough to depict the behavior of inter-class and intra-class scheduling algorithms. Extensive simulations were performed and different criteria were considered to assess the accuracy of the proposed model. We considered bandwidth allocation in inter-class and intra-class scheduling algorithms, percentage of lost packets and the service ratio. The experiments indicate that the analytical model faithfully captures the behavior of TLSA

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Tactical Data Link System with Cognitive Anti-Jamming Capability
Sangho Choe, Euny Ko and Seongwoun Jeon
(Submission #32)

Summary
In this paper, we present a Link-16-based tactical data link (TDL) system with cognitive anti-jamming capability (CAJC). CAJC improves anti-jamming capability of existing TDL by adding the cognitive radio (CR) spectrum sensing-based jammer detection. In the presented TDL, each terminal that senses (or detects) the jammer signal can avoid the jammer spectrum opportunistically. For jammer signal detection, each terminal employs generic CR spectrum sensing schemes like signal energy sensing (SE) and signal-to-jammer-plus-noise ratio sensing (SJNR) or hybrid CR spectrum sensing schemes like beacon plus signal strength sensing (BC_SE) and beacon plus signal-to-jammer-plus-noise ratio sensing (BC_SJNR). In this paper, we design a Matlab/Simulink-based simulator for the verification of presented TDL. This simulator includes a cyclic code shift keying (CCSK) data symbol modulator, a minimum shift keying (MSK) chip symbol modulator, a Rician fading channel module, and a partial-band noise jamming (PBNJ) module. Using this simulator, we can evaluate the bit-error-rate (BER) performance of the proposed TDL and verify that the proposed TDL is more robust to conventional TDL over PBNJ environments.

Self-Learning Adaptive Algorithm for Maritime Traffic Abnormal Movement Detection based on Virtual Pheromone Method
Julius Venskus, Mindaugas Kurmis, Arūnas Andziulis, Žydrūnas Lukošius, Miroslav Voznak and Denisas Bykovas
(Submission #33)

Summary
The paper deals with a newly designed self-learning adaptive algorithm enabling detecting any non-standard movement in marine traffic based on the bio-inspired virtual pheromone method. The algorithm detects non-standard vessel movements purely based on the common marine traffic patterns from the Automated Identification System. The proposed approach provides rapid self-learning and fast adaptation characteristics. We verified the algorithm's accuracy in two modes, each of which incorporates different learning factors. The dataset for the verification of the proposed algorithm was provided by the the marine traffic Automated Identification System of the Klaipeda seaport.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Linear Dynamic Adaptation of the BW Granularity Allocation for Elastic Optical OFDM Networks
Luae Al-Tarawneh and Sareh Taebi
(Submission #34)

Summary
In this paper, we consider the impact of spectrum fragmentation along the optical Single/Multipath routing transmission on the efficiency of the elastic optical network (EON). Using O-OFDM multicarrier transmission as a promising technique makes it possible to choose an adequate portion of available spectrum to satisfy the requested capacity. In a multipath routing scheme, distributing the light path request (LR) capacity over many paths results in increasing the network management complexity; meanwhile, using only single path scheme leads to an increase in the blocking probability ratio. In addition to these drawbacks, the spectrum fragmentation degrades the spectrum efficiency over the entire network. This work involves reducing the fragmentation effects by dynamically updating and controlling a suitable minimum bandwidth (BW) allocation granularity (g) for dynamic single/multipath routing over EON. We investigated the concept of "BW allocation granularity adaptation" based on dynamic change of g to replace using a fixed minimum bandwidth granularity over all candidate path(s) to serve the light path requests over multipath networks. We adopted a dynamic linear adaptation mechanism that is proportional to the optical link/path bandwidth fragmentation status. Simulation results show that improved performance over fixed minimum bandwidth allocation granularity with respect to the bandwidth blocking probability, throughput, and the number of path splitting.

Memory and Memoryless Optimal Time-Window Controllers for Secondary Users in Vehicular Networks
Nicola Cordeschi, Danilo Amendola, Mohammad Shojafar, Paola Gabriela Vinueza Naranjo and Enzo Baccarelli
(Submission #36)

Summary
In this paper, a primary-secondary resource-management controller on vehicular networks is designed and tested. We formulate the resource-management problem as a constrained stochastic network utility maximization problem and derive the optimal resource management controller, which dynamically allocates the access time-windows to the secondary-users. We provide the optimal steady-state controllers under hard and soft primary-secondary collision constraints, showing as the hard controller does not present any optimality gap in the average utility respect to the soft one, while, on the contrary, it is able to make the outage-probability vanishing. Then, we present as a particular case the subset of memoryless controller, that are unable to exploit the system statistics, derive the throughput-gain of the general controllers with respect to the memoryless ones and discuss conditions of applicability and advantages of each subclass.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Cloud and Network Service Orchestration in Software Defined Data Centers
Davide Adami, Christian Callegari, Pietro Castoldi, Lisa Donatini, Molka Gharbaoui, Stefano Giordano, Barbara Martini and Andrea Sgambelluri
(Submission #38)

Summary
Cloud Data Centers are becoming a more and more important reality nowadays, as more and more services are being offered in the form of Cloud resources. In order to accommodate as many requests as possible, Data Centers typically deploy oversubscription, which requires a thoughtfully calibrated usage of the computing and network resources of the system. We especially need to re-think the usage of network resources, as the kinds of demands from applications we see today have more stringent network requirements than in the past. The Software-Defined Network paradigm offers new tools to manage the network in agile, flexible ways, according to specific needs. It enables to build new customized functions in order, for example, to monitor the instantaneous load of traffic, slice the network, route each flow according to specific policies that can be modified accordingly with the needs of the system. In this paper we present an orchestrator for Software-Defined Data Center, and the strategies used to allocate Virtual Machines, basing our decisions on the current state of the system.

Scalability Evaluation of an Energy-Aware Resource Management System for Clusters of Web Servers
Simon Kiertscher and Bettina Schnor
(Submission #40)

Summary
For green cluster computing resource management systems have to be energy-aware. CHERUB is such an energy-aware resource management system which works together with the Linux Virtual Server. Experiments in a small cluster setup with two nodes have shown the benefit of CHERUB. This paper presents necessary design changes to make CHERUB also work in big cluster setups. Our methodological approach is two-fold. First, we present unit measurements to evaluate the scaling of the re-implemented functions. Second, a cluster simulator is presented and validated which makes it possible to test CHERUB for backend clusters of arbitrary size.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Energy-efficient Optical HPC and Datacenter Networks using Optimized Wavelength Channel Allocation
Jingyan Wang, Conor McArdle and Liam Barry
(Submission #42)

Summary
This paper presents a novel energy-efficient all-optical switch architecture for high-performance computing (HPC) systems and datacenter networks (DCNs), that employs the arrayed waveguide grating router (AWGR) and wavelength selective switches (WSSs). To enable flexible wavelength allocation (WA) at switch output ports, we propose an adaptive load-balancing wavelength assignment optimization algorithm. The proposed flexible scheme enhances network resource utilization, and thus significantly alleviates the contention conditions in the network. Further, by developing a tractable analytic model to approximate blocking probability between source-destination node pairs, the flexible allocation scheme can optimally allocate optical buffering using fibre delay lines (FDLs). In simulation experiments, it is shown that the dynamic resource allocation scheme supports high load operation and enhances the network performance and energy efficiency significantly, compared to a uniformly-dimensioned switch, under non-uniform hotspot traffic load. For a target packet loss rate of <10^(-6), the proposed architecture achieves a power reduction of 25%, thus enabling increased network scalability. With the addition of a small-scale electronic buffer, packet loss rates may be reduced to <10^(-10), without a significant increase in energy consumption.

pfs: Parallelized, Flow-based Network Simulation
Mukta Gupta, Ramakrishnan Durairajan, Meenakshi Syamkumar, Paul Barford and Joel Sommers
(Submission #48)

Summary
Simulation is a compelling option for evaluating Internet protocols, configurations and behaviors. While current simulation tools have been used effectively to consider questions in small-scale networks, they are incapable of evaluating large scale phenomena such as routing configurations, DDoS attacks and data center deployments. In this paper, we describe pfs, a parallelized version of the fs flow-level simulator [1] that offers the opportunity to conduct very large-scale simulations of networks. Our approach to parallelization is based on decomposing simulation configurations both spatially and temporally into independent chunks that can be run simultaneously on massively scalable, parallel processing infrastructures. We demonstrate the capabilities of pfs through a series of experiments that highlight both the speedup that can be achieved as well as the costs that are incurred in terms of the accuracy of the simulation results.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

Efficient Network Level Beamforming Training for IEEE 802.11ad WLANs
Anique Akhtar and Sinem Coleri Ergen
(Submission #51)

Summary
Millimeter-wave (mmWave) communications is a promising technology that enables high rate (Giga-bit) multimedia applications. In this paper, we consider the directional multigigabit (DMG) transmission problem in IEEE 802.11ad wireless local area network (WLAN). We propose an amendment to the original MAC design of IEEE 802.11ad to eliminate the need to perform beamforming training during station (STA) to STA communication. During A-BFT access period, all STAs beamform with the Access Point (AP) using different time slots. Our mechanism makes STAs listen to other STAs beamform with the AP. We call this Intelligent Listening during A-BFT (ILA). Using this mechanism, each DMG STA can listen to other DMG STAs sector sweep with the AP and get their approximate beam direction which is later used during STA-STA beamforming to considerably reduce the beamforming overhead. We demonstrate via simulations that ILA mechanism considerably improves the network throughput at higher network size.

Efficient Broadcasting for Route Discovery in Mobile Ad-hoc Networks
Haitham Adarbah, Shakeel Ahmad, Bassel Arafeh and Alistair Duffy
(Submission #54)

Summary
Broadcasting is used in on-demand routing protocols to discover routes in Mobile Ad-hoc Networks (MANETs). On-demand routing protocols, such as AODV (Ad-hoc On-demand Distance Vector) routing, commonly employ pure flooding based broadcasting. In pure flooding, the RREQ (route request) packet is broadcasted by the source node and each receiving node rebroadcasts it. This continues until the RREQ packet arrives at the destination node. Pure flooding generates excessive redundant routing traffic that may lead to broadcast storm problem (BSP) and deteriorate the performance of MANETs significantly. Probabilistic broadcasting schemes were proposed in the literature to address BSP. However, these schemes do not consider thermal noise and interference which exist in real life MANETs, and therefore, do not perform well in real life MANETs. This paper presents a novel Channel Adaptive Probabilistic Broadcast (CAPB) scheme to disseminate RREQ packets efficiently. The proposed CAPB scheme determines the probability of rebroadcasting RREQ packets on the fly according to the current SINR (Signal to Interference plus Noise Ratio) and node density in the neighborhood. The proposed scheme and two related state of the art (SoA) schemes from the literature ([1] and [2]) are implemented in the standard AODV routing protocol to replace the pure flooding based broadcast. Extensive ns -2 simulation results show that the proposed scheme outperforms the standard AODV and the two competitors in terms of routing overhead, throughput and end-to-end delay significantly.

International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2015)
Abstract

New caching algorithms performance evaluation
Nezer Jacob Zaidenberg, Limor Gavish and Yuval Meir
(Submission #56)

Summary
In this paper we propose new caching and test their performance. We use Memcached platform to test the caching algorithm performance. Memcached is an extremely popular open-source, distributed key-value store system that powers several of the Internet's busiest websites such as LiveJournal, Wikipedia, Facebook and others. Currently, Memcached uses a trivial Least Recently Used algorithm for cache eviction decision-making. We describe modifications to the Memcached caching system and the introduction of alternate caching policies and benchmark them as well. 3 new caching algorithms are introduced and 2 new implementations of well-known algorithms are benchmarked as well. We discuss the caching algorithm and the simulation methods used in this paper. By introducing superior caching algorithms, we demonstrate a 10-20% improvement of hit rates. This feature has been sent to Memcached upstream and was met with positive feedback.

Management of Non-Conformant Traffic in OpenFlow Environments
Luca Boero, Marco Cello, Chiara Garibotto, Mario Marchese and Maurizio Mongelli
(Submission #59)

Summary
Nowadays many systems and applications require the identification of traffic classes, which must be compliant to specific pre-defined constraints. Traditional networking approaches are based on traffic shaping, which is used to force the traffic to comply to the service agreements. This task is usually demanded to the underlying devices and this choice causes limited flexibility since the network functionalities are strictly dependant on the specific hardware. In this paper we propose a solution based on SDN, which implements a software strategy to cope with non-conformant traffic flows inside a class-based system. This approach is therefore independent of the underlying hardware, as it is conceived to run as an algorithm inside the SDN controller. The proposed strategy will manage non-conformant flows, based on a set of statistic data gathered by a modified version of the Beacon controller, in order to limit the quality degradation of flows traversing the network.

Upcoming SCS Conferences

2016 Power Plant Simulation Conference

February 1-3, 2016

Holiday Inn Riverwalk; San Antonio, TX, USA

The 2016 Power Plant Simulation Conference (PowerPlantSim'16) is an annual conference sponsored by SCS. This conference focuses on the special needs of the nuclear and fossil power plant simulation community and includes presentations by technology and industry leaders, technical sessions, panel and roundtable discussions, and vendor exhibits. The primary goal of the conference is to promote open exchange of simulator related information between all attendees. All individuals associated with the maintenance, management, regulation, or application of nuclear and fossil power plant simulators are encouraged to participate by submitting original presentations.

2016 Spring Simulation Multi-Conference

April 3-6, 2016

The Westin Pasadena; Pasadena, CA, USA

The Spring Simulation Multi-Conference 2016 (SpringSim'16) brings leading experts in various domains of Modeling and Simulation together. The Theory of Modeling and Simulation (TMS/DEVS 2016) will be a sub-conference of SpringSim. The following symposia are typically organized under SpringSim: Annual Simulation Symposium (ANSS), Agent-Directed Simulation (ADS), Communications and Networking Symposium (CNS), High Performance Computing Symposium (HPC), Symposium on Simulation for Architecture and Urban Design (SimAUD), Poster Session and Student Colloquium.

And don't forget to join us next year for SummerSim 2016 in Montreal, Canada! Dates and other info coming soon!

Please visit www.scs.org/conferences for more information on our conferences.

Things to Do in Chicago

Millennium Park

201 East Randolph Street, Chicago, IL

Website: www.millenniumpark.org

With 25 acres of awe-inspiring landscape, breathtaking architecture and an iconic collection of public art, Millennium Park is Chicago's premier green space.

Don't miss "The Bean," an eye-catching favorite year round. Take a picture in front of Cloud Gate, the official name for this massive, stainless steel structure that's become Chicago's signature landmark. In its mirror-like surface you'll see not only your own reflection, but the magnificent downtown skyline.

Also in Millennium Park, escape into Lurie Garden, a four-seasons urban oasis that pays homage to Chicago's motto — "Urbs in Horto," or City in a Garden. Stand beneath Crown Fountain, two 50-foot towers that reflect the faces of Chicago. See the architecturally-stunning Jay Pritzker Pavilion. Grab a bite at the on-site restaurant Park Grill or picnic on the main plaza.
Open 6am-11pm daily with free admission.

Navy Pier

600 E. Grand Street, Chicago, IL

Website: https://navypier.com/

You can't truly experience Chicago without a trip to Navy Pier. This 50-acre playground of entertainment, museums, activities, restaurants, and shops is the perfect place for some family fun time. You can take a ride on the 150-ft Ferris wheel at Pier Park, explore educational wonders at the Chicago Children's Museum, or see a blockbuster on Chicago's largest movie screen at the IMAX Theater. During the warmer months, get off the shores and board one of the many sightseeing and dining boat cruises. Or catch cutting edge performances and classics at the Chicago Shakespeare Theater. Navy Pier also hosts many special events and has numerous dining options, including Harry Caray's Tavern and Bubba Gump Shrimp Company.

Things to Do in Chicago

Museum of Science and Industry

57th Street and Lakeshore Drive, Chicago, IL

Website: http://www.msichicago.org/

Climb aboard a World War II German submarine. Plunge into a working coal mine. Take a tour of your digestive system. Control a 40-foot tornado. And this season, step into the magical world of Walt Disney to uncover 90 years of archives.

Those experiences and more await you at the Museum of Science and Industry — the largest science museum in the Western Hemisphere. Home to more than 35,000 artifacts and hundreds of exhibits, there are enough "wow" moments to be had here to last a lifetime.

Art Institute of Chicago

111 S. Michigan Avenue, Chicago, IL

Website: http://www.artic.edu/

Home to one of the country's most impressive collections of Impressionist and Post-Impressionist art (as well as works from numerous other genres), the Art Institute of Chicago earns high praise from recent visitors. The expansive facility features more than 300,000 works from all over the world in its permanent collection, with paintings spanning the ages. You'll find pieces created in the Byzantine era, as well as paintings done just a few decades ago. The Art Institute's exhibits also include all sorts of intriguing artifacts, from European armor to the Thorne Miniature Rooms, which showcase interior design and furnishings in Europe and America from the 17th to 20th centuries.

Willis Tower Skydeck

233 South Wacker Drive, Chicago, IL

Website: http://theskydeck.com/

Occupying the 103rd floor of the 110-story Willis Tower, the Skydeck boasts breathtaking views of the city. Visit on a sunny day and you may be able to see far beyond Chicago's borders to other parts of Illinois, as well as to Indiana, Michigan and Wisconsin. The highlight for most visitors is the Ledge. Extending outward from the Skydeck, this platform is made entirely of glass — even the floor. Open 9am-10pm daily, adult tickets are $19.

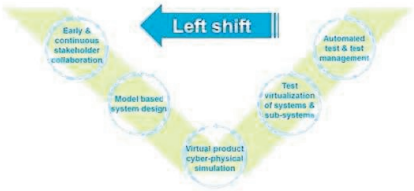
Notes

IBM solutions for Continuous Validation and Verification

Prevent rework and achieve higher quality faster

Continuous Validation and Verification is the practice of modeling physical and systems behavior early in the product development lifecycle, and then continuing to apply simulation and test technologies in successive stages until the design is mature – to prevent rework and achieve faster time to quality

- **Rational Rhapsody and Rhapsody Design Manger** model physical and systems behavior early and validate through simulation
- **Rational DOORS and DOORS Next Gen** requirement management solution to manage complex requirements
- **Rational Quality Manager** continuously test and verify your product throughout the development lifecycle



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