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TATA-ICIS RESEARCH PROJECT

RESEARCH NOTES

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BACKGROUND

Introduction

This document provides an ongoing and updated repository of the research project ICIS has undertaken for TATA. This project is initiated based on the Letter Agreement executed by ICIS and TATA by 01/11/2012 for TATA to receive research and education services from ICIS.

Beginning of the Project

Upon receiving the executed Letter Agreement from TATA on 01/11/2012, ICIS began internal research meetings to staff and frame Project Approach as well as the research problem.

TATA Point of Contact

On February 11, 2012, Badri N. Parthasarathy, TATA's VP of IP Engineering was assigned as the point of contact for the project.

Weekly Project Meetings

Weekly project meetings began on March 1, 2012. Dr. Shiva Ayyadurai will attend the weekly meetings from ICIS and Badri Narayanan Parthasarathy from TATA. Other personnel will be invited base on the topic of the meeting.

Project Timeline

12-month. January 11, 2012 to January 10, 2013.

Project Approach

Both TATA and ICIS recognize the virgin nature of this project. To this end, an initial 6-month project approach is outlined as follows:

1. Identify research project focus to support TATA's goals to develop new models to optimize spot pricing by better modeling bandwidth utilization. Based on the conceptual research framework of the "Biomimetics of Media and Communication" one of the following two (2) areas of study will be selected as the "Biological Analogy" to utilize in pursuing this research:
   A. Arterial flow in the venous system e.g. the flow models, both transient and steady state --- basing on the hypothesis that biological systems have evolved to ensure survival by careful modulation of flow to optimize efficiency; OR,
   B. Intracellular transmission and signaling paradigms --- the cell has become quiet efficient at signaling and employing its "bandwidth" in very effective ways to preserve energy.
2. Conduct project meetings to select the appropriate Biological Analogy.
3. Review current Telecom models and parameters affecting bandwidth utilization
4. Review System Biology and computational cell modeling approaches to evoke any parallels
5. Review Systems Dynamics and Visualization approaches to map Telecom components into a systems model
6. Conduct onsite educational workshops and executive presentations to develop systems "biological" models of telecom
7. Rigorously test the chosen mathematical approach based on TATA's past data using correlation analysis to evoke similarity and/or divergence.
8. Recommend advanced next steps based on (4) to optimize the biological model to better fit TATA's data --- this research will provide insight on where the biological models diverge and why.

Report from Week 1: 01/16 to 01/20, 2012

Internal research was conducted through literature review on existing arterial flow and cell signaling models. First, a review was done on Arterial flow models.

References for Arterial flow models

Berthier et al., 2002

B. Berthier, R. Bouzerar, C. Legallais

Blood flow patterns in an anatomically realistic coronary vessel: influence of three different reconstruction methods

Journal of Biomechanics, 35 (2002), pp. 1347–1356

Bertolotti and Deplano, 2000

C. Bertolotti, V. Deplano

Three-dimensional numerical simulations of flow through a stenosed coronary bypass

Journal of Biomechanics, 33 (2000), pp. 1011–1022

Bertolotti et al., 2001

C. Bertolotti, V. Deplano, J. Fuseri, P. Dupouy

Numerical and experimental models of post-operative realistic flows in stenosed coronary bypasses

Journal of Biomechanics, 34 (2001), pp. 1049–1064

Boutsianis et al., 2004

E. Boutsianis, H. Dave, T. Frauenfelder, D. Poulikakos, S. Wildermuth, M. Turina, Y. Ventikos, G. Zund

Computational simulation of intracoronary flow based on real coronary geometry

European Journal of Cardio-Thoracic Surgery, 26 (2004), pp. 248–256

Calafiore, 1996

A.M. Calafiore

Use of the inferior epigastric artery for coronary revascularization: operative techniques

Cardiovascular Surgery, 1 (1996), pp. 147–159

Caro et al., 1971

C.G. Caro, J.M. Fitzerald, R.C. Schroeter

Atheroma and wall shear: observation, correlation and proposal of a shear dependent mass transfer mechanism of atherogenesis

Proceedings of the Royal Society of London, 177 (1971), pp. 109–159

Chen et al., 2006

J. Chen, X.Y. Lu, W. Wang

Non-Newtonian effects of blood flow on hemodynamics in distal graft anastomoses

Journal of Biomechanics, 39 (2006), pp. 1983–1995

Deplano and Souffi, 1999

V. Deplano, M. Souffi

Experimental and numerical study of pulsatile flows through stenosis: wall shear stress analysis

Journal of Biomechanics, 32 (1999), pp. 1081–1090

Ethier et al., 1998

D.R. Ethier, D.A. Steinman, X. Zhang, S.R. Karpik, M. Ojha

Flow waveform effects on end to side anastomotic flow patterns

Journal of Biomechanics, 31 (1998), pp. 609–617

Fei et al., 1994

D.Y. Fei, J.D. Thomas, S.E. Rittgers

The effect of angle and flow rate upon hemodynamics in distal graft anastomoses: a numerical model study

ASME Journal of Biomechanical Engineering, 116 (1994), pp. 331–336

Galea and Markatos, 1991

E.R. Galea, N.C. Markatos

The mathematical modelling and computer simulation of fire development in aircraft

International Journal of Heat and Mass Transfer, 34 (1991), pp. 181–197

Gijsen et al., 1999

F.J.H. Gijsen, E. Allanic, F.N. van de Vosse, J.D. Janssen

The influence of the non-Newtonian properties of blood on the flow in large arteries: unsteady flow in a 90° curved tube

Journal of Biomechanics, 32 (1999), pp. 705–713

Grondin et al., 1984

C.M. Grondin, L. Campeau, J. Lesperance, M. Enjalbert, M. Bourassa

Comparison of later changes in internal mammary artery and saphenous vein grafts in two consecutive series of patients 10 years after operation

Circulation, 70 (Suppl. 1) (1984), pp. 208–221

Hughes and How, 1995

P.E. Hughes, T.V. How

Flow structures at the proximal side-to-end anastomosis: influence of geometry and flow division

ASME Journal of Biomechanical Engineering, 117 (1995), pp.

224–236

Imparato et al., 1972

A.M. Imparato, A. Bracco, G.E. Kim, R. Zeff

Intimal and neointimal fibrous proliferation causing failure of arterial reconstruction

Surgery, 72 (1972), pp. 1007–1017

Inzoli et al., 1996

F. Inzoli, F. Migliavacca, G. Pennati

Numerical analysis of steady flow in aorto-coronary bypass 3-D model

ASME Journal of Biomechanical Engineering, 118 (1996), pp. 172–179

Johnston et al., 2004

B.M. Johnston, P.R. Johnston, S. Corney, D. Kilpatrick

Non-Newtonian blood flow in human right coronary arteries: steady state simulations

Journal of Biomechanics, 37 (2004), pp. 709–720

Johnston et al., 2006

B.M. Johnston, P.R. Johnston, S. Corney, D. Kilpatrick

Non-Newtonian blood flow in human right coronary arteries: steady state simulations

Journal of Biomechanics, 39 (2006), pp. 1116–1128

Kleinstreuer et al., 1996

C. Kleinstreuer, M. Lei, J.P. Archie

Flow input waveform effects on the temporal and spatial wall shear stress gradients in a femoral graft–artery connector

ASME Journal of Biomechanical Engineering, 118 (1996), pp. 506–510

Ku and Giddens, 1983

D.N. Ku, D.P. Giddens

Pulsatile flow in a model carotid bifurcation

Atherosclerosis, 3 (1983), pp. 31–39

Ku et al., 1985

D.N. Ku, C.K. Zarins, D.P. Giddens, S. Clagov

Pulsatile flow and atherosclerosis in the human carotid bifurcation: positive correlation between plaque localization and low and oscillating shear stress

Arteriosclerosis, 5 (1985), pp. 292–302

Lee and Chen, 2000

D. Lee, J.Y. Chen

Numerical simulation of flow fields in a tube with two branches

Journal of Biomechanics, 33 (2000), pp. 1305–1312

Liao et al., 2004

W. Liao, T.S. Lee, H.T. Low

Numerical studies of physiological pulsatile flow through constricted tube

International Journal of Numerical Methods for Heat and Fluid Flow, 14 (2004), pp. 689–713

Lieber and Giddens, 1990

B.B. Lieber, D.P. Giddens

Post-stenotic core flow behavior in pulsatile flow and its effects on wall shear stress

Journal of Biomechanics, 23 (6) (1990), pp. 597–605

Liepsch, 2002

D. Liepsch

An introduction to biofluid mechanics—basic models and applications

Journal of Biomechanics, 35 (2002), pp. 415–435

Liepsch et al., 1993

Liepsch, D.W., Poll, A., Pflugbeil, G., 1993. In vitro laser anemometry blood flow systems. In: Laser Anemometry Advances and Applications, SPIE—International Society for Optical Engineering, vol. 2052, pp. 163–174.

Long et al., 2001

Q. Long, X.Y. Xu, K.V. Ramnarine, P. Hoskins

Numerical investigation of physiologically realistic pulsatile flow through arterial stenosis

Journal of Biomechanics, 34 (2001), pp. 1229–1242

Markatos and Pericleous, 1984

N.C. Markatos, A. Pericleous

Laminar and turbulent natural convection in an enclosed cavity

International Journal of Heat and Mass Transfer, 27 (5) (1984), pp. 755–772

Maurits et al., 2007

N.M. Maurits, G.E. Loots, A.E.P. Veldman

The influence of vessel wall elasticity and peripheral resistance on the carotid artery flow waveform: a CFD model compared to in vivo ultrasound measurements

Journal of Biomechanics, 40 (2007), pp. 427–436

Migliavacca and Dubini, 2005

F. Migliavacca, G. Dubini

Computational modelling of vascular anastomoses

Biomechanics and Modeling in Mechanobiology, 3 (2005), pp. 235–250

Milnor, 1989

W.R. Milnor

Hemodynamics

(second ed.)Wiliams and Wilkins, Baltimore (1989)

Moore et al., 1992

J.E. Moore Jr., D.N. Ku, C.K. Zarins, S. Clagov

Pulsatile flow visualization in the abdominal aorta under differing physiological conditions: Implications for increased susceptibility to atherosclerosis

ASME Journal of Biomechanical Engineering, 114 (1992), pp. 391–397

Ojha, 1994

M. Ojha

Wall shear stress temporal gradient and anastomotic intimal hyperplasia

Circulation Research, 74 (1994), pp. 1227–1231

Ojha et al., 1993

M. Ojha, R.S. Cobbold, K.W. Johnston

Hemodynamics of a side-to-end proximal arterial anastomosis model

Journal of Vascular Surgery, 17 (1993), pp. 646–655

Report from Week 2: 01/23 to 01/27, 2012

Internal research was conducted through literature review on existing arterial flow and cell signaling models. The second part of the review was done on Cell Signaling models.

K.Y. Volokh

Cytoskeletal architecture and mechanical behavior of living cells

Biorheology, 40 (2003), pp. 213–220

M. Zajac, G.L. Jones, J.A. Glazier

Simulating convergent extension by way of anisotropic differential adhesion

J Theor Biol, 222 (2003), pp. 247–259

H. Bolouri, E.H. Davidson

Modeling transcriptional regulatory networks

Bioessays, 24 (2002), pp. 1118–1129

B.S. Hendriks, L.K. Opresko, H.S. Wiley, D. Lauffenburger

Quantitative analysis of HER2-mediated effects on HER2 and epidermal growth factor receptor endocytosis: distribution of homo- and heterodimers depends on relative HER2 levels

J Biol Chem, 278 (2003), pp. 23343–23351

H. Resat, J.A. Ewald, D.A. Dixon, H.S. Wiley

An integrated model of epidermal growth factor receptor trafficking and signal transduction

Biophys J, 85 (2003), pp. 730–743

Using stochastic spatial models of biochemical signaling and trafficking, the authors analyze the EGFR (epidermal growth factor receptor) trafficking in hundreds of endocytotic compartments in response to two ligands. The authors constrain their model results using experiments on cellular localization. This is one of the most extensive and detailed models of this system.

S. Yamada, T. Taketomi, A. Yoshimura

Model analysis of difference between EGF pathway and FGF pathway

Biochem Biophys Res Commun, 314 (2004), pp. 1113–1120

U.S. Bhalla, P.T. Ram, R. Iyengar

MAP Kinase phosphatase as a locus of flexibility in a mitogen-activated protein kinase signaling network

Science, 297 (2002), pp. 1018–1023

The MAPK network is shown to exhibit sustained activity, thresholding, and several other signaling functional properties in this combined experimental and modeling study. Regulation by negative feedback controls which property is expressed.

H.F. Nijhout, A.M. Berg, W.T. Gibson

A mechanistic study of evolvability using the mitogen-activated protein kinase cascade

Evol Dev, 5 (2003), pp. 281–294

M. Hatakeyama, S. Kimura, T. Naka, T. Kawasaki, N. Yumoto, M. Ichikawa, J.H. Kim, K. Saito, M. Saeki, M. Shirouzu et al.

A computational model on the modulation of mitogen-activated protein kinase (MAPK) and Akt pathways in heregulin-induced ErbB signalling

Biochem J, 373 (2003), pp. 451–463

Y. Gong, X. Zhao

Shc-dependent pathway is redundant but dominant in MAPK cascade activation by EGF receptors: a modeling inference

FEBS Lett, 554 (2003), pp. 467–472

B. Schoeberl, C. Eichler-Jonsson, E.D. Gilles, G. Muller

Computational modeling of the dynamics of the MAP kinase cascade activated by surface and internalized EGF receptors

Nat Biotechnol, 20 (2002), pp. 370–375

G. Moehren, N. Markevich, O. Demin, A. Kiyatkin, I. Goryanin, J.B. Hoek, B.N. Kholodenko

Temperature dependence of the epidermal growth factor receptor signaling network can be accounted for by a kinetic model

Biochemistry, 41 (2002), pp. 306–320

This combined experiment/simulation study exposes the EGFR signaling network to different temperatures, thus introducing a range of changes into kinetic properties. The authors show that the same signaling circuit can account for behavior over these conditions, with reasonable temperature dependencies of specific kinetic rates.

A. DeWitt, T. Iida, H.Y. Lam, V. Hill, H.S. Wiley, D.A. Lauffenburger

Affinity regulates spatial range of EGF receptor autocrine ligand binding

Dev Biol, 250 (2002), pp. 305–316

A.R. Reynolds, C. Tischer, P.J. Verveer, O. Rocks, P.I. Bastiaens

EGFR activation coupled to inhibition of tyrosine phosphatases causes lateral signal propagation

Nat Cell Biol, 5 (2003), pp. 447–453

Using high-resolution imaging and modeling, the authors show how positive feedback in the EGFR system can give rise to local bistability as seen by thresholding and a bimodal distribution of responses in the population. The mechanism for the feedback involves reactive oxygen species. When local regions are promoted to the activated state, their neighboring receptors are exposed to this elevated activity and also switch on. Thus activity propagates laterally in the plane of the membrane to amplify the spatial extent as well as the magnitude of the signal.

S.Y. Shvartsman, C.B. Muratov, D.A. Lauffenburger

Modeling and computational analysis of EGF receptor-mediated cell communication in Drosophila oogenesis

Development, 129 (2002), pp. 2577–2589

I. Swameye, T.G. Muller, J. Timmer, O. Sandra, U. Klingmuller
Identification of nucleocytoplasmic cycling as a remote sensor in cellular signaling by databased modeling
Proc Natl Acad Sci USA, 100 (2003), pp. 1028–1033

S. Yamada, S. Shiono, A. Joo, A. Yoshimura
Control mechanism of JAK/STAT signal transduction pathway
FEBS Lett, 534 (2003), pp. 190–196

A. Goldbeter
Computational approaches to cellular rhythms
Nature, 420 (2002), pp. 238–245

Z. Qu, W.R. MacLellan, J.N. Weiss
Dynamics of the cell cycle: checkpoints, sizers, and timers
Biophys J, 85 (2003), pp. 3600–3611

Z. Qu, J.N. Weiss, W.R. MacLellan
Regulation of the mammalian cell cycle: a model of the G1-to-S transition
Am J Physiol Cell Physiol, 284 (2003), pp. C349–C364

A. Ciliberto, B. Novak, J.J. Tyson
Mathematical model of the morphogenesis checkpoint in budding yeast
J Cell Biol, 163 (2003), pp. 1243–1254

W. Sha, J. Moore, K. Chen, A.D. Lassaletta, C.S. Yi, J.J. Tyson,

J.C. Sible

Hysteresis drives cell-cycle transitions in Xenopus laevis egg extracts

Proc Natl Acad Sci USA, 100 (2003), pp. 975–980

The authors test several predictions of cell cycle models in the Xenopus egg extract system. They show that hysteresis (the tendency of a switch to commit to a given state) is important in controlling cell-cycle transitions.

J.J. Tyson, A. Csikasz-Nagy, B. Novak

The dynamics of cell cycle regulation

Bioessays, 24 (2002), pp. 1095–1109

B.D. Aguda, C.K. Algar

A structural analysis of the qualitative networks regulating the cell cycle and apoptosis

Cell Cycle, 2 (2003), pp. 538–544

J. Herrick, S. Jun, J. Bechhoefer, A. Bensimon

Kinetic model of DNA replication in eukaryotic organisms

J Mol Biol, 320 (2002), pp. 741–750

The timing of genetic events is critical in many signaling networks, and this study directly models the kinetics of DNA replication. The authors extract kinetic information from images of fluorescently labeled DNA replication forks. They show that their model is formally equivalent to well-studied stochastic models of crystal growth.

G. Kurosawa, Y. Iwasa

Saturation of enzyme kinetics in circadian clock models

J Biol Rhythms, 17 (2002), pp. 568–577

G. Kurosawa, A. Mochizuki, Y. Iwasa

Comparative study of circadian clock models, in search of processes promoting oscillation

P. Smolen, D.A. Baxter, J.H. Byrne

A reduced model clarifies the role of feedback loops and time delays in the Drosophila circadian oscillator

Biophys J, 83 (2002), pp. 2349–2359

J.C. Leloup, A. Goldbeter

Toward a detailed computational model for the mammalian circadian clock

Proc Natl Acad Sci USA, 100 (2003), pp. 7051–7056

D. Gonze, J. Halloy, J.C. Leloup, A. Goldbeter

Stochastic models for circadian rhythms: effect of molecular noise on periodic and chaotic behaviour

C R Biol, 326 (2003), pp. 189–203

D. Gonze, J. Halloy, A. Goldbeter

Robustness of circadian rhythms with respect to molecular noise

Proc Natl Acad Sci USA, 99 (2002), pp. 673–678

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Report from Week 3: 01/30 to 02/03, 2012

An initial draft of the project approach and project plan was prepared.

Project initiation meeting was held on 02/01/2012. Meeting was attended by John Hayduk from TATA and Dr. V.A. Shiva Ayyadurai from ICIS.

The Project Approach was outlined and submitted to John H. for feedback.

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Report from Week 4: 02/06 to 02/10, 2012

Internal paper review of the following papers on both Arterial and Cell Signaling model were performed.

J.M. Vilar, H.Y. Kueh, N. Barkai, S. Leibler
Mechanisms of noise-resistance in genetic oscillators
Proc Natl Acad Sci USA, 99 (2002), pp. 5988–5992

M.T. Hutt, U. Rascher, F. Beck, U. Luttge
Period-2 cycles and 2:1 phase locking in a biological clock driven by temperature pulses
J Theor Biol, 217 (2002), pp. 383–390

A. Bohn, S. Hinderlich, M.T. Hutt, F. Kaiser, U. Luttge
Identification of rhythmic subsystems in the circadian cycle of crassulacean acid metabolism under thermoperiodic perturbations
Biol Chem, 384 (2003), pp. 721–728

P. Smolen, D.A. Baxter, J.H. Byrne
Reduced models of the circadian oscillators in Neurospora crassa and Drosophila melanogaster illustrate mechanistic similarities
OMICS, 7 (2003), pp. 337–354

D. Gonze, M.R. Roussel, A. Goldbeter
A model for the enhancement of fitness in cyanobacteria based on resonance of a circadian oscillator with the external light-dark cycle
J Theor Biol, 214 (2002), pp. 577–597

T. Roenneberg, M. Merrow
Life before the clock: modeling circadian evolution
J Biol Rhythms, 17 (2002), pp. 495–505

P.C. Rida, N. Le Minh, Y.J. Jiang
A Notch feeling of somite segmentation and beyond
Dev Biol, 265 (2004), pp. 2–22

F. Nedelec
Computer simulations reveal motor properties generating stable antiparallel microtubule interactions
J Cell Biol, 158 (2002), pp. 1005–1015

G.W. Brodland, J.H. Veldhuis
Computer simulations of mitosis and interdependencies between mitosis orientation, cell shape and epithelia reshaping
J Biomech, 35 (2002), pp. 673–681

M. Herant, W.A. Marganski, M. Dembo
The mechanics of neutrophils: synthetic modeling of three experiments
Biophys J, 84 (2003), pp. 3389–3413

S. Portet, O. Arino, J. Vassy, D. Schoevaert
Organization of the cytokeratin network in an epithelial cell
J Theor Biol, 223 (2003), pp. 313–333

The authors consider the processes of synthesis, diffusion, nucleation of fiber formation and polymerization as the basis for producing extraordinarily realistic cytokeratin meshes in their model. The analysis is laid out in some mathematical detail, and is followed by numerical simulations of the cytokeratin network formation. Mechanical inputs lead to formation of a network that can respond appropriately to applied stresses.

R. Wedlich-Soldner, S. Altschuler, L. Wu, R. Li

Spontaneous cell polarization through actomyosin-based delivery of the Cdc42 GTPase

Science, 299 (2003), pp. 1231–1235

The authors perform experimental manipulations to study the role of Cdc42 in yeast polarization, and propose a feedback circuit where actin cables help transport Cdc42 to the membrane, where the Cdc42, in turn, promotes actin assembly. They simulate this circuit and show that small stochastic initial asymmetries can be amplified by this mechanism to establish the cell polarity axis.

J.E. Ferrell Jr., E.M. Machleder

The biochemical basis of an all-or-none cell fate switch in Xenopus oocytes

Science, 280 (1998), pp. 895–898

M.B. Elowitz, S. Leibler

A synthetic oscillatory network of transcriptional regulators

Nature, 403 (2000), pp. 335–338

M.R. Atkinson, M.A. Savageau, J.T. Myers, A.J. Ninfa

Development of genetic circuitry exhibiting toggle switch or

oscillatory behavior in Escherichia coli
Cell, 113 (2003), pp. 597–607

Scotti and Finol, 2007

C.M. Scotti, E.A. Finol

Compliant biomechanics of abdominal aortic aneurysms: a fluid-structure interaction study

Computers and Structures, 85 (2007), pp. 1097–1113

Singh and Sosa, 1984

R.N. Singh, J.A. Sosa

Internal mammary artery: a “live” conduit for coronary bypass

Journal of Thoracic and Cardiovascular Surgery, 87 (1984), pp. 936–938

Siouffi et al., 1998

M. Siouffi, V. Deplano, R. Pelissier

Experimental analysis of unsteady flows through a stenosis

Journal of Biomechanics, 31 (1998), pp. 11–19

Sottiurai et al., 1989

V.S. Sottiurai, J.S.T. Yao, R.C. Batson, S.L. Sue, R. Jones, Y.A. Nakamura

Distal anastomotic intimal hyperplasia: histopathological character and biogenesis

Annals of Vascular Surgery, 1 (1989), pp. 26–33

Speziale, 2001

G. Speziale

Competitive Flow and Steal Phenomenon in Coronary Surgery. Intraoperative Graft Patency Verification in Cardiac and Vascular Surgery

Futura Publishing, New York (2001)

Torii et al., 2007

R. Torii, M. Oshima, T. Kobayashi, K. Takagi, T.E. Tezduyar

Influence of wall elasticity in patient-specific hemodynamic simulations

Computers and Fluids, 36 (2007), pp. 160–168

Tu and Deville, 1996

C. Tu, M. Deville

Pulsatile flow of non-Newtonian fluids through arterial stenoses

Journal of Biomechanics, 29 (1996), pp. 899–908

Tutty, 1992

O.R. Tutty

Pulsatile flow in a constricted channel

ASME Journal of Biomechanical Engineering, 114 (1992), pp. 50–52

Valencia and Villanueva, 2006

A. Valencia, M. Villanueva

Unsteady flow and mass transfer in models of stenotic arteries considering fluid–structure interaction

International Communications in Heat and Mass Transfer, 33 (2006), pp. 966–975

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Windnall and Sullivan, 1973

S.E. Windnall, J.P. Sullivan

On the stability of vortex rings

Proceedings of the Royal Society of London A, 332 (1973), pp. 335–353

Report from Week 5: 02/13 to 02/17, 2012

*** TATA Point of Contact B. N. Parthasarathy was appointed.

*** Internal paper review of the following papers on both Arterial and Cell Signaling model were performed.

Politis et al., 2007

A.K. Politis, G.P. Stavropoulos, M.N. Christolis, F.G. Panagopoulos, N.S. Vlachos, N.C. Markatos

Numerical modeling of simulated blood flow in idealized composite arterial coronary grafts: steady state simulations

Journal of Biomechanics, 40 (5) (2007), pp. 1125–1136

Rhie and Chow, 1983

C.M. Rhie, W.L. Chow

Numerical study of the turbulent flow past airfoil with trailing edge separation

AIAA Journal, 21 (1983), pp. 1525–1532

Royse et al., 1999

A.G. Royse, C.F. Royse, K.L. Groves, B. Bus, G. Yu

Blood flow in composite arterial grafts and effect of native coronary flow

Annals of Thoracic Surgery, 68 (1999), pp. 1619–1622

Samagaio and Vlachos, 1989

A. Samagaio, N.S. Vlachos

Calculation of three-dimensional laminar flows in T-shaped junctions

Computer Methods in Applied Mechanics and Engineering, 75

(1989), pp. 393–407

Zendehbudi and Moayeri, 1999

G.R. Zendehbudi, M.S. Moayeri

Comparison of physiological and simple pulsatile flow through stenosed arteries

Journal of Biomechanics, 32 (1999), pp. 959–965

Zheng and Yang, 1992

L. Zheng, W.J. Yang

Biofluid dynamics at arterial bifurcations

Critical Reviews in Biomedical Engineering, 19 (1992), pp. 455–493

.

E. Alm, A.P. Arkin

Biological networks

Curr Opin Struct Biol, 13 (2003), pp. 193–202

B.M. Slepchenko, J.C. Schaff, J.H. Carson, L.M. Loew

Computational cell biology: spatiotemporal simulation of cellular events

Annu Rev Biophys Biomol Struct, 31 (2002), pp. 423–441

K.W. Kohn

Molecular interaction map of the mammalian cell cycle control and DNA repair systems

Mol Cell Biol, 10 (1999), pp. 2703–2734

M. Hoebeke, H. Chiapello, P. Noirot, P. Bessieres

SPiD: A Subtilis Protein interaction Database

Bioinformatics, 17 (2001), pp. 1209–1212

U.S. Bhalla, R. Iyengar

Emergent properties of networks of biological signaling pathways

Science, 283 (1999), pp. 381–387

A. Eldar, D. Rosin, B.Z. Shilo, N. Barkai

Self-enhanced ligand degradation underlies robustness of morphogen gradients

Dev Cell, 5 (2003), pp. 635–646

J.B. Gurdon, P.Y. Bourillot

Morphogen gradient interpretation

Nature, 413 (2001), pp. 797–803

M.D. Levin, T.S. Shimizu, D. Bray

Binding and diffusion of CheR molecules within a cluster of membrane receptors

Biophys J, 82 (2002), pp. 1809–1817

Sharma P, Varma R, Sarasij RC, Ira, Gousset K, Krishnamoorthy G, Rao M, Mayor S: Nanoscale organization of multiple GPI-anchored proteins in living cell membranes. Cell 2004, 116:577-589.

R.R. Gabdoulline, U. Kummer, L.F. Olsen, R.C. Wade

Concerted simulations reveal how peroxidase compound III formation results in cellular oscillations

Biophys J, 85 (2003), pp. 1421–1428

This paper spans an unusual range of modeling approaches. It uses Brownian dynamics methods to estimate how protein structure limits diffusional access of substrate to an enzyme active site. This is used to predict a reaction rate term, which is then used in a biochemical model of a cellular oscillator.

M.S. Hutson, Y. Tokutake, M.S. Chang, J.W. Bloor, S. Venakides, D.P. Kiehart, G.S. Edwards

Forces for morphogenesis investigated with laser microsurgery and quantitative modeling

Science, 300 (2003), pp. 145–149

Report from Week 6: 02/20 to 02/24, 2012

Internal paper review of the following papers on both Arterial and Cell Signaling model were performed.

Palmen, 1994

Palmen, D.E.M., 1994. The influence of minor stenoses on carotid artery flow. Ph.D. Thesis, Eindhoven University of Technology.

Patankar and Spalding, 1972

S.V. Patankar, D.B. Spalding

A calculation procedure for heat, mass and momentum transfer in three-dimensional parabolic flows

International Journal of Heat and Mass Transfer, 15 (1972), pp. 1787–1806

Pedersen et al., 1994

E.M. Pedersen, H.W. Sung, A.P. Yoganathan

Influence of abnominal aortic curvature and resting versus exercise conditions on velocity field in the normal abdominal aortic bifurcation

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*** A decision made to use Cell Signaling models as the biological base of models for telecom modeling.

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Report from Week 7: 02/27 to 03/02, 2012

Project meeting was held this week. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS.

Following topics were discussed at the meeting:

(1) Introductions
(2) Project Approach
(3) Decision to use Cell Signaling Models
(4) Review of 6-Month project plan
(5) Request for Badri to provide an introduction of Telecom Parameters

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Report from Week 8: 03/05 to 03/09, 2012

Project meeting was held this week. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS.

Following topics were discussed at the meeting:

(1) Review of Project Approach
(2) Overview of Systems Biology

Internal Meetings were held to do background review of Badri's PPT and assess the kinds of cell signaling models that may be most appropriate.

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Report from Week 9: 03/12 to 03/16, 2012

ICIS team met internally to present the internal research findings. Based on the findings, talking points for the weekly meeting on 03/15/2012 was prepared.

Badri was under weather --- no meeting with TATA this week.

Report from Week 10: 03/19 to 03/23, 2012

On 03/19/12, the ICIS team met to review in detail the project progress and discussion points from the weekly meeting that was held on 03/15/12.

Project meeting was held this week on 03/22/2012. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS.

First Review of Badri PPT presentation on Telecom Parameters

Internal research & discussion on topics from 03/15/2012 meeting

Report from Week 11: 03/26 to 03/30, 2012

ICIS team met to prepare for the two-day Systems Biology immersion program to be offered to TATA on May 2012. A detailed plan is developed for the two-day program including selection of topics and presenters.

ICIS team also planned for the TATA executive presentation and additional brainstorming session during the May 2012 visit of TATA team.

ICIS team prepared the initial draft agenda for the three-day program which is tentatively scheduled to start on May 21, 2012.

Project meeting was held this week on 03/29/2012. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS. Detailed Review of Badri PPT Slides.

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Report from Week 12: 04/02 to 04/06, 2012

Internal research was conducted to prepare presentation for project meeting on 04/05/2012.

Project meeting was held this week on 04/05/2012. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS. Review of Molecular Pathway Models and initial introduction to Systems Dynamics approaches.

On 04/06/12, the ICIS team met to review in detail the presentation material provided by TATA.

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Report from Week 13: 04/09 to 04/13, 2012

No Meeting – Badri was traveling

ICIS team met on 04/10/12 to prepare detailed program for the May 21-23 Systems Biology immersion program. Internal research findings necessary for preparing the presentations are identified.

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Report from Week 14: 04/16 to 04/20, 2012

Meeting was held this week on 04/19/2012. Meeting was attended by Badri Narayanan Parthasarathy from TATA and Dr. V.A. Shiva Ayyadurai from ICIS.

Following topics were discussed at the meeting:
(1) Review of molecular pathway diagrams
(2) Systems Dynamics approaches analogous to pathway diagrams for modeling telecom
(3) Workshops for May 21-24 in Cambridge --- Agenda review.

The ICIS team met on 04/18/2012 to review initial collection of information to prepare presentation material for the May 21-23 educational program. The team arrived at the overall plan for first two sessions i.e. Biomimetics in Media and Communication and Systems Biology Overview.

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Report from Week 15: 04/23 to 04/27, 2012

The ICIS team reviewed information compiled for three more sessions for the presentation material for the May 21-23 educational program and arrived at the overall plan for these three sessions. The sessions are Electronic Communications and Organizations Dynamics, Systems Dynamics and Molecular Pathway Dynamics.

Todd and Shiva reviewed Systems Dynamics Notes for Educational Workshop for TATA presentation. Todd has produced a simplified version for immersive training during the workshop. Shiva is now combining those notes with molecular pathway notes for workshop study material for TATA team.

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Report from Week 15: 04/30 to 05/04, 2012

ICIS Team met internally to prepare for May 21-24 ICIS-TATA Educational Workshop and Executive Presentation to be held at MIT. This week the team met on 05/02/2012 to prepare additional sessions of the educational program. The team reviewed compilation of information on Systems Biology and Drug Development and how Systems Biology principles impact telecom. Overall plan for three sessions are prepared.

No meeting this week with Badri.