Scientific Report

First name / Family name	Hamidreza Arjmandi
Nationality	Iranian
Name of the *Host Organisation*	Norwegian University of Science and Technology (NTNU)
First Name / family name of the *Scientific Coordinator*	Ilangko Balasingham
Period of the fellowship	01/06/2019 to 31/01/2021

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my fellowship, my research mainly focused on the characterization of molecular communication channels in biological environments. Firstly, we worked on the mathematical modelling of the blood vessel as a molecular transport channel that can be used for the characterization of the underlying processes and higher-level functions in the circulatory system. We proposed a continuous-time Markov chain framework to simply model active transport mechanisms e.g. transcytosis, across the single-layered endothelial cells building the inner vessel wall. Correspondingly, a general homogeneous boundary condition over the vessel wall was considered. Also, coupled with the derived boundary condition, the flow-induced diffusion problem in an ideal vessel structure was formulated and the corresponding concentration Green's function was obtained. Secondly, we provided a semi-analytical approach for channel modelling in diffusion-based molecular communication networks (DMCNs) including multiple transmitters, receivers, and other objects with arbitrary geometries and boundary conditions. We characterized the channel model for DMCN with the general homogeneous boundary conditions employing the fundamental concentration Green's function (CGF). In addition, we proposed a sequential

SAM reducing the computational complexity of original SAM method. Finally, we emphasized on the potential of extracellular vesicles (EVs) for diagnostic and therapeutic applications. To enhance the potential of EVs for more extensive functionalities, we motivated the concept of the engineered EV-mediated communication nanonetworks. Corresponding with the EV-mediated intercellular signalling network components that naturally extend the limited ability of individual cells to perform the intricate vital functions, we proposed a fundamental molecular communication network framework and reviewed the potential experimental techniques to obtain data for its validation. We expect the proposed framework paves the way for the development of engineered EV-mediated communication networks and enables novel approaches, perspectives, tools, and metrics to reveal the principles and emergent properties of biological EV-mediated signalling networks whose understanding is yet obscure.

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II – PUBLICATION(S) DURING YOUR FELLOWSHIP

I have provided the list of published papers and submitted manuscripts during this fellowship:

1- H. Arjmandi, M. Zoofaghari, V. Roozegar, M. Veletic, I. Balasingham, "On Mathematical Analysis of Active Drug Transport Coupled with Flow-induced Diffusion in Blood Vessels," IEEE Transactions on Nanobioscience, vol. 20, no. 1, pp. 105-115, Jan. 2021.

2-Hamidreza Arjmandi, M. Zoofaghari, I. Balasingham, "Characterization of Diffusive Molecular Channels based on Green's Second Identity," In Proceedings of the Sixth Annual ACM International Conference on Nanoscale Computing and Communication Sep. 2019.

3-M. Zoofaghari, Hamidreza Arjmandi, A. Etemadi , I. Balasingham, "A Semi-analytical Method for Channel Modeling in Diffusion-based Molecular Communication Networks," Submitted to IEEE Transactions on Communications (Major revision).

4-Hamidreza Arjmandi, H. Khoshfekr, J. Santos, M. Zoofaghari, O. Ievglevskyi, M. Kanada, A. Khaleghi, and I. Balasingham, M. Veletic, "Extracellular Vesicle-mediated Communication Networks: Opportunities and Challenges", Submitted to IEEE Communication Magazine (Major revision).

5-M. Veletić, M. T. Barros, Hamidreza Arjmandi, S. Balasubramaniam and I. Balasingham, "Modeling of Modulated Exosome Release From Differentiated Induced Neural Stem Cells for Targeted Drug Delivery," IEEE Transactions on NanoBioscience, vol. 19, no. 3, July 2020.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

I attended in the Sixth Annual ACM International Conference on Nanoscale Computing and Communication, that was held in Dublin, Ireland, Sep. 2019. In this conference, I presented a conference paper while I was a TPC member.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

I planned to visit Fraunhofer Institut fuer Biomedizinische Technik (IBMT) in Spring for doing research exchange program. However, I could not visit IBMT due to the pandemic situation as you remember. However, we had two virtual meetings (one on 28 Aug 2019, and one on 19 Sep 2019) where we discussed based on the my idea of mathematical modeling of BBB based on the testbed in IBMT.