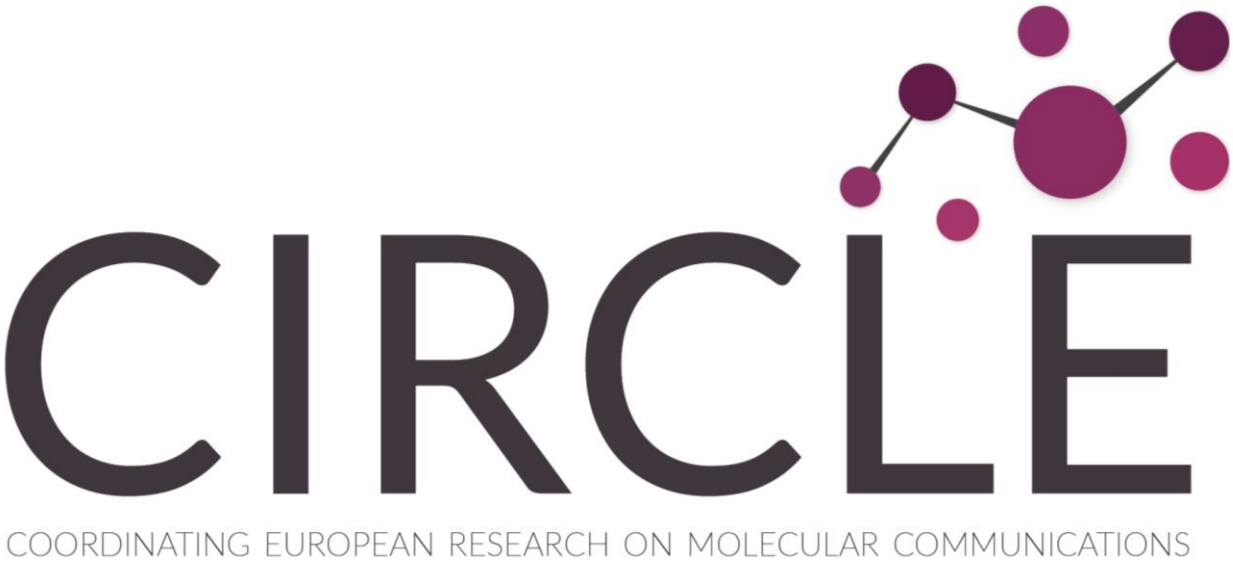
HORIZON 2020



D3.1 Knowledge Sharing and Best Practice Report

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Document Number	D3.1
Document Title	Knowledge Sharing and Best Practice Report
Version	2.0
Status	Final
Work Package	WP3
Deliverable Type	Report
Responsible Partner	CNIT
Dissemination level	PU

Change History

Version	Date	Status	Author (Unit)	Description
1.0	15/JUL/2015	Rejected	Gianluca Reali (CNIT) and Mauro Femminella (CNIT)	Create working version of deliverable
1.1	14/JUL/2016	Draft	Gianluca Reali (CNIT) and Mauro Femminella (CNIT)	Draft version of the D3.1 deliverable (revised)
2.0	14/JUL/2016	Rejected	Gianluca Reali (CNIT), Mauro Femminella (CNIT), Paolo Gresele (UNIPG), Marco Malvestiti (UNIPG)	Final version of the D3.1 deliverable (revised)
3.0	09/MAR /2017	Final	Gianluca Reali (CNIT), Mauro Femminella (CNIT), Paolo Gresele (UNIPG), Marco Malvestiti (UNIPG)	Final version of the D3.1 deliverable (revised)

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1. Introduction

The general objective of the WP3 is knowledge sharing in MolCom. Since all the project beneficiaries have been developing innovative and unconventional research methodologies and tools for investigating molecular communications and their applications, WP3 activities aim at sharing the achieved knowledge and expertise (analytical models and relevant software toolboxes, simulation platforms, best practices) so as to build a common and interdisciplinary research framework across Europe. For these purposes, WP3 also promotes creativity of individual researchers and provides them with all the necessary information and tools for developing new ideas for MolCom systems.

This report describes the initial procedures, the general objectives and the strategic plans that will be adopted by the Consortium for effective knowledge sharing within CIRCLE. In particular, the report will systematically collect and exchange information on the MolCom research activities by each CIRCLE participant, enabling to the formulation of best practices.

A special focus is devoted to young researchers. For them, WP3 activities for knowledge sharing will produce and make available the so-called "MolCom starter kit", which consists of selected research material enabling an accessible introduction into the Molcom research area.

In addition, the activities of knowledge sharing include staff exchange between partners, deemed fundamental in order to coordinate their research activities. This report gives an overview of the plans for staff exchanges at the beginning of the project.

The report is organized as follows. The Section 2 reviews the main objectives of CIRCLE, and shows how the WP3 activities will contribute to achieve each of them. The Section 3 illustrates the ongoing and planned activities in WP3, so as to highlight the strategic plan in CIRCLE for sharing knowledge in molecular communications. The Section 4 illustrates the MolCom Started Kit, whereas the Section 5 reports the plans for personnel exchange. The Section 6 reports the measurable parameter used to assess knowledge sharing. Some concluding remarks are reported in Section 7.

We underline that the content of the document reflects the state of the project at the beginning of the project. Any amendments to these plans, agreed during the project lifetime, will be illustrated in the follow-up reports, namely D3.3 (to be delivered at month 12) and D3.4 (to be delivered at month 24).

2. Objectives of WP3

Although the nature of CIRCLE allows all the involved beneficiaries to contribute to all the CIRCLE general objectives, some of them are specifically related to the WP3 activities. In this section, we recapitulate the general objectives and formulate a synthetic description of corresponding action plans relevant to the WP3 activities.

- **O1: Harmonize heterogeneous islands of research in Molecular Communications across Europe by providing a structured research agenda through the collaborative specification and continual refinement of a research roadmap.**

  During the CIRCLE kick-off meeting, partners have agreed on a number of WP3 initiatives aiming at harmonizing their own research methodologies and best practices, with the aim of establishing as a roadmap for contributing the MolCom research. These activities are illustrated in Section 3.1.1.

- **O2: Stimulate guided learning for young researchers entering the area of Molecular Communications, through improving efficiency of knowledge acquisition in key disciplines.**

  The knowledge sharing activities illustrated in Section 3.1.1. will create the suitable conditions for young researchers to speed up the acquisition of key expertises. For example, the current and future MolCom researchers will benefit from each other's expertise, research approaches, lab equipment, and focus on common research objectives. This approach will allow CIRCLE to promote interdisciplinary research collaborations, in particular between young researchers having different background, by understanding each other's research objectives and methodologies, thus removing any cultural barriers.

- **O3: Build a structured community across Europe of research leaders and collaborators working in the area of Molecular Communications.**

  The existing research groups in CIRCLE are committed to develop intense collaboration activities and MolCom related events in order to establish a sound and collaborative research network in the EU, with significant links also with other research organizations worldwide. The organization of workshops involving multiple disciplines will provide a common forum, enabling regular interaction resulting into a gradual self-organization into sub-communities, each with their own focus, toolset and methodology.

- **O4: Accelerate the exchange of knowledge and best practice between researchers with Europe and internationally focusing on Molecular Communications.**

  Collaboration and coordination of research activities will allow introducing a privileged way for exchanging research results. These exchanges will be organized according to a structured managerial approach. A low-level coordination process will allow exchange of results between

organizations that have direct research collaborations (e.g. research groups that are involved in bacteria communication nanonetworks). At the same time, high-level collaborations will assure cross-fertilization between different initiatives. In this regards, extensive time-consuming research operations such as biological lab experiments could be shortened by exchanging experimental data as well as experimental information. Examples of this experimental information includes experimental methodologies, materials and consumables used for experiments, as well as methodologies for growing and managing biological organisms. The latter case will provide useful knowledge for ICT researchers to understand the constraints and properties of biological organisms/systems that may benefit or affect the communication process. In addition, reducing the probability of hitting a dead end is a further important outcome. Frequent networking and dissemination activities focused on this objective will be organized.

- **O5: Facilitate a staff exchange program between partners within CIRCLE focusing in particular on young researchers.**

  Young academic researchers, who are typically not obliged to teaching and managerial activities, will have the opportunity to spend a considerable amount of time in other hosting institutions and extend their knowledge and capabilities of leading future pioneering teams. Senior researchers will also have this opportunity. Supporting visits between the different institutes will foster collaborative research culture, which in turn will help promote and spread knowledge for this new research area.

- **O6: Reduce the barriers for entry into the area of Molecular Communications for high tech SME through the collaborative specification and continual refinement of an industry engagement roadmap**.

  Although this strategic objective of CIRCLE is suitably handled in other WPs, the WP3 personnel will collaborate to this aim by extending the knowledge sharing initiatives to any interested industrial organization and other initiatives organized in the framework of other WPs.

3. Knowledge sharing objectives: ongoing and planned activities

This section describes both the strategic plan defined in WP3 to contribute to the general objectives of CIRCLE illustrated in the previous section, and the actions that have been undertaken in the initial phase of the project, which have contributed to putting the project in motion. These actions/plans will be framed within each of the four WP3 tasks.

3.1. General Objectives of the WP3 tasks

- Task 3.1 - **Collect and exchange knowledge between research groups**. We share research methodologies through staff exchange and dedicated events (e.g. doctoral schools and workshops). This activity will include the different categories relevant to molecular communications (communication paradigms, molecular communication models, physical information transfer methodologies, etc). This task will contribute to **O1** and **O2**.
- Task 3.2 - **Collect and exchange simulation/modeling tools used in Molecular communications**. Execution of simulations is a typical research approach used to evaluate performance of the analysed systems and the relevant components. This task has the aim of *sharing* the currently developed simulators at molecular levels. They include both software packages developed from scratch and packages integrated in well-known simulators, such as NS2. Sharing and, whenever possible, harmonizing these tools is strategic in order to help researchers in tackling research issues through the best available solutions. This task will contribute to **O4**.
- Task 3.3 - **Collect and exchange approaches and experimental methodologies**. Experimental activities is a key aspect for successfully undertake research in molecular communications. They are essential, for example, for tuning simulators in order to let them modeling the biologic environments, so as to predict cell and bacteria interactions with a suitable degree of confidence. The staff exchange and the events organized by CIRCLE will allow researchers, in particular young ones, to share their knowledge and expertise. Also this task will contribute to **O2**.
- Task 3.4 - **Collect and exchange knowledge/best practice at Member State and EU level.** The aim of this task is to harmonize the best practices for pushing European researchers towards this interdisciplinary area, through a well assessed roadmap and well organized EU wide research structures and working network. This task will allow achieving a strategic research vision, direction, roadmap, also in the view of the expected socio-ethical issues related to the involved disruptive technologies and their future impact on society. This task will contribute to **O3**, **O4** and **O5**.

3.1.1. Planned activities to fulfil the objectives of WP3

The initial set of these activities, discussed and agreed during the CIRCLE kick off meeting, are listed in what follows.

- Task 3.1:
    - Develop a *catalogue of skills* and available Master/PhD programs for Molecular Communications. All the activities aiming to promote fruitful PhD programs in MolCom include the development of a catalogue of skills needed to successfully pursue a MolCom PhD research and the available PhD programs in the field.
    - Contribute or *organize a PhD school* of the CIRCLE project, in order to facilitate knowledge sharing between students, as well as to put students in contact with leading experts in the field. A target of this activity should be to recruit instructors coming from different research field, including both ICT and bio-related fields.
    - *Preparing educational material* on molecular communications for Master and/or PhD students. This will include tutorials, to be provided by online videos and/or through publication in prestigious journals, in order to attract students willing to purse the academic career in this novel research field.
    - Organise an *edited book on molecular communications* with invited chapters. Knowledge sharing and dissemination activities, including both simulation details and other knowledge sharing initiatives, will proceed through the organization of an edited book on MolCom, organized in different chapters, each covering a specific aspect of MolCom.
- Task 3.2:
    - Prepare a *catalogue of Molecular Communication simulators*. Most of the CIRCLE partners have already spent a considerable amount of time in developing or adapting simulators of MolCom systems. These simulators are currently quite different in terms of both IT technologies and the simulated MolCom environments. For promoting a suitable exchange of research methodologies in CIRCLE it is believed that one of the project activities is to harmonise research tools and, in particular, the existing simulators. For this purpose, a catalogue of the currently available simulators is needed, in order to define a harmonization plan, which aims at producing a Molcom package of interacting components.
    - Prepare a *position paper on Molecular Communications simulators*. The harmonization of the MolCom simulators will produce also a position paper showing the progresses if CIRCLE and the potentials of the MolCom Simulation Suite, illustrated in what follows.

- *MolCom Simulation Suite*. It is the MolCom package that will be made available to the MolCom research community. It will be accessible through an effective user interface. This toolbox will integrate some of the different software tools already available (see previous points), which need to be harmonized and integrated through a software orchestrator, able to select the most suitable software tool to run a specific simulation experiments. This way, a multi-scale and multi-purpose simulator will be realized. An additional contribution of this task will be the definition of a common configuration language, which could ease the setup of each simulation tool taking part in the MolCom Toolbox.

- Task 3.3:
  - Skill development will be pursued through a number of activities, including the preparation of a so-called *starter-kit for young ICT researchers*, aiming at facilitating the approach to the highly inter-disciplinary field of MolCom.
  - This activity will include the *identification of the best practices* for (i) the cross-fertilization of lab experiments and numerical performance evaluation, (ii) pursue of common research methodologies of ICT and biomedical personnel, (iii) organization of events such as PhD schools. This objective will be pursued also by resorting to tutorials or videos. The interdisciplinary partnership of CIRCLE is believed to be the suitable environment for achieving this objective.
  - *Identify funding schemes* for PhD training and prepare a *plan for submitting proposals*. As part of the skill development goal, access to funding schemes for PhD training is critical for pursuing this goal. The CIRCLE partners will actively explore the possibilities offered by both national and EU organizations.
  - Identifications of the *essential elements for Molecular Communications Training*. In addition to the Starter Kit, during the first year we will compile a set of Journal and Conference venues where young researchers could publish their work, or read the published papers on molecular communications. Since molecular communications is an emerging field, the number of journal that include this topic in their scope is increasing.

- Task 3.4:
  - Prepare an item for IEEE Technical Committee Simulation (TCSIM) *newsletter*. The MolCom knowledge sharing and coordination activities in CIRCLE will also be illustrated by a contribution submitted to an IEEE newsletter. This newsletter will be complemented with a periodic bulletin published in the CIRCLE web site, in order to stimulate novel ideas in young researchers.

- *Organize CIRCLE workshop*. The CIRCLE team is committed to organize a number of CIRCLE workshops in order to provide an open forum to researchers for exchanging ideas, tools, and research methodologies.
- *Position CIRCLE in the organization of MolCom conferences*. The CIRCLE team is part of the organization of the ACM Nanocom conference, which is held annually and is an event focused on nanoscale communications, including molecular communications. Being sponsor of these events, including the possibility to illustrate CIRCLE goal by means of talks and flyers, and organizing sponsored talks by leading experts, is a key to raise the awareness of the Molcom research community about the CIRCLE activities.
- Extensive usage of the *CIRCLE Forum and web site*. The CIRCLE Forum is a tool realized in the framework of WP2. Nevertheless, its extensive usage can allow exchanging knowledge/best practice, promoting follow-up activities of events (see previous points), or advertising CIRCLE sponsored events (talks, conferences, workshops). In addition, these platforms will host material relevant to these events, such as slides and/or videos of talks. This way, an open platform to exchange research ideas will be realized, open also to non-CIRCLE researchers.

3.2. Coordination activities undertaken to fulfil the WP3 objectives

The following coordination activities have been undertaken since the beginning of the project CIRCLE:

- The coordinator of UCAM (Prof. Pietro Liò) and the team of CNIT (Dr. Mauro Femminella and Prof. Gianluca Reali) have agreed to *combine their complementary expertise*, namely inter-cell molecular communications (CNIT) intra-cell molecular communications (UCAM). This activity has lead to the preparation and submission of a joint survey about potential applications to nanomedicine in molecular communications. This work has been submitted to the Elsevier Nano Communication Networks Journal.
- The coordinator of CNIT has planned the following WP3 activities which can be carried out during the project lifetime:
  - Exchange of personnel, the details of which are reported in Section 5.
  - Exchange of information about software tools, which is part of the MolCom Starter Kit, detailed in Section 4.
  - Exchange of analytical models and toolboxes for the analysis of molecular communications, which is part of the MolCom Starter Kit, detailed in Section 4.

- Exchange of reports with written best practices to carry out wet lab experiments dealing with molecular communications and the relevant applications, with special focus on medical applications. This activity is aimed to be complemented by the production of a reference document illustrating, step by step, the preparation, execution, data extraction, and data analysis of a wet lab experiment.

These activities have been presented by the CNIT coordinator (Prof. G. Reali) during the WP3 presentation in the CIRCLE kick off meeting (8-9 July, Barcelona, Spain, at UPC premises), and agreed by the whole consortium.

4. Molecular communications starter kit

One of the main contributions of WP3 is the preparation of the Starter Kit for young researchers that are willing to approach research in molecular communications. This activity will allow fulfilling the objective O2 of the CIRCLE project, and is a genuine result of the Task 3.3. The Starter Kit will be advertised in the project web site and in the CIRCLE Forum, in order to increase the awareness of molecular communications in young researchers.

The Starter kit includes a collection of research material regarding the basic background and research on molecular communications, including the software tools recently developed. In more detail, the Starter Kit will be composed of

- A set of *introductory papers* in molecular communications, which provides the basic principles of the subject and main applications of it, deemed necessary for attracting the interest of young researchers.
- A set of *books* in molecular communications and in the related disciplines, able to provide the background material to start doing research in molecular communications.
- A standard recommended practice for the molecular communication framework, which is currently the only *standardization* initiative in this subject.
- A set of *research oriented papers* in molecular communications, which provide focused contributions on specific research issues in molecular communications. Currently, we have identified the following topics:
    - Specificity
    - Perturbation
    - Field
    - Motion
    - Message Carriers
    - Media
    - Molecular absorptions
    - Molecular flows and feedbacks

  These topics are linked and contribute to determining the essential characteristics of a MolCom system. In this way, students approaching MolCom can begin a systematic study plan to acquire the necessary skills.

- A list of *software tools* useful to simulate molecular communication systems, together with the relevant documentation. Currently, we have identified the following tools:
    - BiNS2: It is a simulator written in Java, designed to simulate multiple 3D environments.
    - NanoSim: It is a simulator written in Java, designed to simulate static environments.
    - NanoNS: It is a simulator written in C++, it is the adaptation of the well-known NS2, extensively used in telecommunications networks.
    - HLA-based simulator: High level architecture for a distributed simulation platform, based on the standard IEEE 1516.
    - CalComSim: It is a calcium signaling-based molecular communication system simulator designed for both synthetic and natural cellular communication inside 3D human tissues.
    - BNSim: It is multithread java simulator of Bacteria-based networks, which interconnect engineered bacteria that communicate at nanoscales.
    - NCSim: It is a comprehensive simulation framework for molecular communications, which can simulate flagellated bacteria, assumed to be possible carriers for information delivery. The major focus of the framework is on different message encoding techniques.
    - COMSOL multiphysics: It is a commercial simulator, able to handle also the simulations with cells in blood vessels.

This set of software components will be refined when the MolCom Simulation Suite will be available.

- A set of software toolboxes designed for analysing data.
- A set of software toolboxes, which include the software implementation of theoretical models commonly used in molecular communications.
- A set of guidelines, for young researchers, to write papers in the field of molecular communications, with a special focus on preparation of sections dealing with simulations, lab experiments descriptions, and justifications of paper assumptions.
- A set of typical lab experiments, defined to measure physical properties of molecular communications, together with the relevant manual. A list of labs available for carrying out these types of experiments will be provided together with the user manual.
- A list of contact points for each of the above points (name, email, institution, position, telephone number) will be provided.

4.1.1. List of books dealing with MolCom

A list of books and book chapters dealing with MolCom:

- Molecular Communication, T. Nakano, A. W. Eckford, T. Haraguchi, Cambridge University Press, October 2013, ISBN: 9781107023086
- Fundamentals of Diffusion-Based Molecular Communication in Nanonetworks, M. and I.F. Akyildiz, Foundations and Trends in Networking: Vol. 8: No. 1-2, pp 1-147, 2014, dx.doi.org/10.1561/1300000033
- Molecular Communications and Nanonetworks, B. Atakan, Springer-Verlag New York, 2014, ISBN: 978-1-4939-0739-7, dx.doi.org/10.1007/978-1-4939-0739-7
- Nanoscale Communication Networks, S. F. Bush, Artech House, 2010, ISBN: 978-1-60807-003-9

These books are characterized by an ICT background, and are published or edited by ICT researchers who are active in the MolCom area. In addition to them, a number of books relevant to the bio-related disciplines exist, and are instructive for young researching willing to approach MolCom. For example, they can provide the biological background over which novel ideas can be developed. A non-exhaustive list of such books follows:

- Cellular Signal Processing, Friedrich Marks, Ursula Klingmüller, Karin Müller-Decker, Garland Science, 2008, ISBN: 9780815342151.
- Cell Signaling, Wendell Lim, Bruce Mayer, Tony Pawson Garland Science, 2014, ISBN: 9780815342441.
- Handbook of Cell Signaling (Second Edition), Ralph A. Bradshaw and Edward A. Dennis, Elsevier, 2009, ISBN: 978-0-12-374145-5.
- Cancer Cell Signalling, Amanda Harvey, Wiley Blackwell, 2013, ISBN: 978-1-119-96757-6.
- Signal Transduction (Second Edition), Bastien D. Gomperts, IJsbrand M. Kramer and Peter E.R. Tatham, 2009, ISBN: 978-0-12-369441-6.

4.1.2. Initial list of research papers

4.1.2.1. Introductory papers

- Akyildiz, I. F., Brunetti, F., and Blazquez, C., "Nanonetworks: A New Communication Paradigm," Computer Networks, June 2008.
- T. Nakano, T. Suda, Y. Okaie, M.J. Moore, and A.V. Vasilakos, “Molecular Communication Among Biological Nanomachines: A Layered Architecture and Research Issues,” IEEE Transactions on NanoBioscience, vol. 13, no. 3, pp. 169-197, September 2014.
- T. Nakano, M. Moore, F. Wei, A. Vasilakos, and J. Shuai. Molecular communication and networking: Opportunities and challenges. IEEE Transactions on NanoBioscience, 11(2):135–148, 2012.

4.1.2.2. Standards

- IEEE P1906.1 — Draft Recommended Practice for Nanoscale and Molecular Communication Framework. IEEE P1906.1 is an IEEE standards working group sponsored by the IEEE Communications Society Standards Development Board, the goal of which is to develop a definition and common framework for nanoscale and molecular communications. Being MolCom an emerging technology, the standard is meant to elicit innovation by determining common definitions, terminology, framework, goals, metrics, and use-cases designed to encourage greater innovation and enable the technology to advance at a faster rate. This standard defines the fundamental definition and building blocks of nanoscale communications.

4.1.2.3. Specificity

For what concerns specificity, we highlight contributions focused on enabling a nanoscale Message Carrier to convey its information to a desired receiver, or to a class of receivers, while minimising any loss of information along the way due to reception events happening in different receivers or classes of them.

- T.A. Sanders, E. Llagostera, and M. Barna, "Specialized Filopodia Direct Long-range Transport of SHH During Vertebrate Tissue Patterning," Nature, vol. 497, no. 7451, pp. 628–632, 30 May 2013.
- S. Roy, H. Huang, S. Liu, and T.B. Kornberg, "Cytoneme-Mediated Contact-Dependent Transport of the Drosophila Decapentaplegic Signaling Protein," Science, vol. 343, no. 6173, 21 February 2014.
- L. Bardwell, X. Zou, Q. Nie, and N. L. Komarova, "Mathematical Models of Specificity in Cell Signaling," Biophysical Journal, vol. 92, no. 10, pp. 3425-3441, 15 May 2007.

4.1.2.4. Perturbation

In this case we indicate contributions focused on novel ideas involving nanoscale encoding, signaling, and modulation.

- M.J. Moore, T. Suda, and K. Oiwa, "Molecular Communication: Modeling Noise Effects on Information Rate," IEEE Transactions on NanoBioscience, vol. 8, no. 2, pp. 169-180, June 2009.

4.1.2.5. Field

In this case we indicate contributions that emphasize directionality and coordinated control of message carriers at the nanoscales.

- I.V. Dokukina, M.E. Gracheva, E.A. Grachev, and J.D. Gunton, "Role of Network Connectivity in Intercellular Calcium Signaling," Physica D: Nonlinear Phenomena, vol. 237, no. 6, pp. 745-754, 15 May 2008.
- S. Schuster, M. Marhl, and T. Hofer, "Modelling of Simple and Complex Calcium Oscillations," European Journal of Biochemistry, vol. 269, no. 5, pp. 1333-1355, March 2002.

- Y. Tang and H.G. Othmer, “Frequency Encoding in Excitable Systems with Applications to Calcium Oscillations,” Proceedings of the National Academy of Sciences, vol. 29, no. 17, pp. 7869-7873, 15 August 1995.

4.1.2.6. Motion

The following contributions are related to the description and analysis of the elementary Message Carrier movements at the nanoscales.

- W.H. Bossert, and E.O. Wilson, “The Analysis of Olfactory Communication Among Animals,” Journal of Theoretical Biology, vol. 5, no. 3, pp. 443–469, November 1963.
- I. Llatser, A. Cabellos-Aparicio, and E. Alarcon, “Networking Challenges and Principles in Diffusion-Based Molecular Communication,” IEEE Wireless Communications, vol. 19, no. 5, pp. 36-41, October 2012.
- S. Kadloor, R.S. Adve, and A.W. Eckford, “Molecular Communication Using Brownian Motion with Drift,” IEEE Transactions on NanoBioscience, vol. 11, no. 2, pp. 89-99, June 2012.
- K. Francis and B.O. Palsson, “Effective Intercellular Communication Distances are Determined by the Relative Time Constants for Cyto/Chemokine Secretion and Diffusion,” Proceedings of the National Academy of Sciences, vol. 94, no. 23, pp. 12258-12262, 11 November 1997.
- S. Klumpp, T.M. Nieuwenhuizen, and R. Lipowsky, “Self-Organized Density Patterns of Molecular Motors in Arrays of Cytoskeletal Filaments,” Biophysical Journal, vol. 88, no. 5, pp. 3118-32, May 2005.
- N. Farsad, A.W. Eckford, and S. Hiyama, “A Markov Chain Channel Model for Active Transport Molecular Communication,” IEEE Transactions on Signal Processing, vol. 62, no. 9, pp. 2424-2436, May 2014.
- S. Balasubramaniam and P. Lio, “Multi-Hop Conjugation Based Bacteria Nanonetworks,” IEEE Transactions on NanoBioscience, vol. 12, no. 1, pp. 47-59, March 2013.

4.1.2.7. Message Carrier

The following contributions regard design and construction of message carriers at the nanoscales.

- S. Hiyama, T. Inoue, T. Shima, Y. Moritani, T. Suda, and K. Sutoh, “Autonomous Loading, Transport, and Unloading of Specified Cargoes by Using DNA Hybridization and Biological Motor-Based Motility,” Small, vol. 4, no. 4, pp. 410-415, April 2008.
- Frank Walsh, Sasitharan Balasubramaniam, "Reliability and Delay Analysis of Multi-hop Virus-based Nanonetworks," IEEE Transactions on Nanotechnology, 12: 5. pp. 674-684, September 2013.

4.1.2.8. Media

The following contributions aim at emphasizing novel media in which nanoscale message carriers reside and propagate.

- Y. Chahibi, M. Pierobon, S.O. Song, and I.F. Akyildiz, "A Molecular Communication System Model for Particulate Drug Delivery Systems," IEEE Transactions on Biomedical Engineering, vol. 60, no. 12, pp. 3468-3483, December 2013.
- N. Farsad, A.W. Eckford, S. Hiyama, and Y. Moritani, "On-Chip Molecular Communication: Analysis and Design," IEEE Transactions on NanoBioscience, vol. 11, no. 3, pp. 304-314, September 2012.

4.1.2.9. Molecular absorptions

The following contributions regard the mechanisms and the models of the absorption processes, through which message carriers are received, along with and their statistics and dynamic behaviour.

- H. Yilmaz, A. Heren, T. Tugcu, and C.-B. Chae. Three-dimensional channel characteristics for molecular communications with an absorbing receiver. IEEE Communications Letters, 18(6):929–932, June 2014.
- A. Akkaya, H. Yilmaz, C. Chae, and T. Tugcu. Effect of receptor density and size on signal reception in molecular communication via diffusion with an absorbing receiver. IEEE Communications Letters, 19(2):155–158, Feb 2015.
- L. Felicetti, M. Femminella, G. Reali, J. Daigle, M. Malvestiti, and P. Gresele. Modeling CD40-based molecular communications in blood vessels. IEEE Transactions on NanoBioscience, 13(3):230–243, 2014.

4.1.2.10. Molecular flows and feedbacks

The following papers are about the mechanisms that regulate continuous molecular flows, with a special focus on drug delivery.

- T. Nakano, Y. Okaie, and A. V. Vasilakos. Transmission rate control for molecular communication among biological nanomachines. IEEE Journal on Selected Areas in Communications, 31(12, supplement):835-846, 2013.
- L. Felicetti, M. Femminella, G. Reali, T. Nakano, and A. V. Vasilakos. TCP-like molecular communications. IEEE Journal on Selected Areas in Communications, 32(12):2354-2367, 2014.

4.1.3. Initial list of papers associated with simulation packages

4.1.3.1. BiNS2

- L. Felicetti, M. Femminella, and G. Reali. A simulation tool for nanoscale biological networks. Nano Communication Networks, 3(1):2–18, 2012.
- L. Felicetti, M. Femminella, and G. Reali. Simulation of molecular signaling in blood vessels: software design and application to atherogenesis. Nano Communication Networks, 4(3):098 – 119, 2013.
- L. Felicetti, M. Femminella, G. Reali, P. Gresele, and M. Malvestiti. Simulating an in vitro experiment on nanoscale communications by using BiNS2. Nano Communication Networks, vol. 4, no. 4, pp. 172 – 180, 2013.

4.1.3.2. NanoSim

- N. Garralda et al., "Diffusion-based physical channel identification in molecular nanonetworks," Nano Communication Networks, vol. 2, no. 4, pp. 196–204, Dec. 2011.

4.1.3.3. NanoNS

- E. Gul, B. Atakan, and O. B. Akan, "Nanons: A nanoscale network simulator framework for molecular communications," Nano Communication Networks, vol. 1, no. 2, pp. 138–156, 2010.

4.1.3.4. HLA

- Ali Akkaya, Gaye Genc, Tuna Tugcu, HLA based architecture for molecular communication simulation, Simulation Modelling Practice and Theory, Volume 42, March 2014, Pages 163-177, ISSN 1569-190X, http://dx.doi.org/10.1016/j.simpat.2013.12.012.

5. Exchange of personnel

During the project kick off meeting, a specific point about exchange of personnel has been discussed. At present, the staff exchange plan of the proposal has been suitably revised in order to comply with the emerging needs. Exchanges will be concentrated in the second year of the project.

During the project lifetime this plan could be revised in order to address any emerged needs. It is important to specify that, although this plan has been initially designed for young researchers working in the CIRCLE project, it is open to a broader audience. In particular, it is possible for CIRCLE partners to host researchers and/or students coming from institutions not involved in the CIRCLE consortium. Similarly, it is possible for CIRCLE participants to get an internship in institutions actively involved in molecular communications, but not funded by the CIRCLE project. Finally, not only young researchers could be exchanged but, if necessary for the effectiveness of the project initiatives, even senior researchers. In this case, it is recommended that senior researchers will be involved, in the hosting organization, in the training activities of young researchers, thus contributing to the quality of the education in molecular communications. In addition, if exchanges will involve also senior researchers, they can contribute to the preparation of follow-on research proposals (e.g. research proposals for funding PhD scholarships) in the field of molecular communications, or related fields that use molecular communications as an enabling technology. In this regard, it is instructive to observe the diagram shown in Figure 1, which highlights how molecular communication is the bridge between many different research areas.

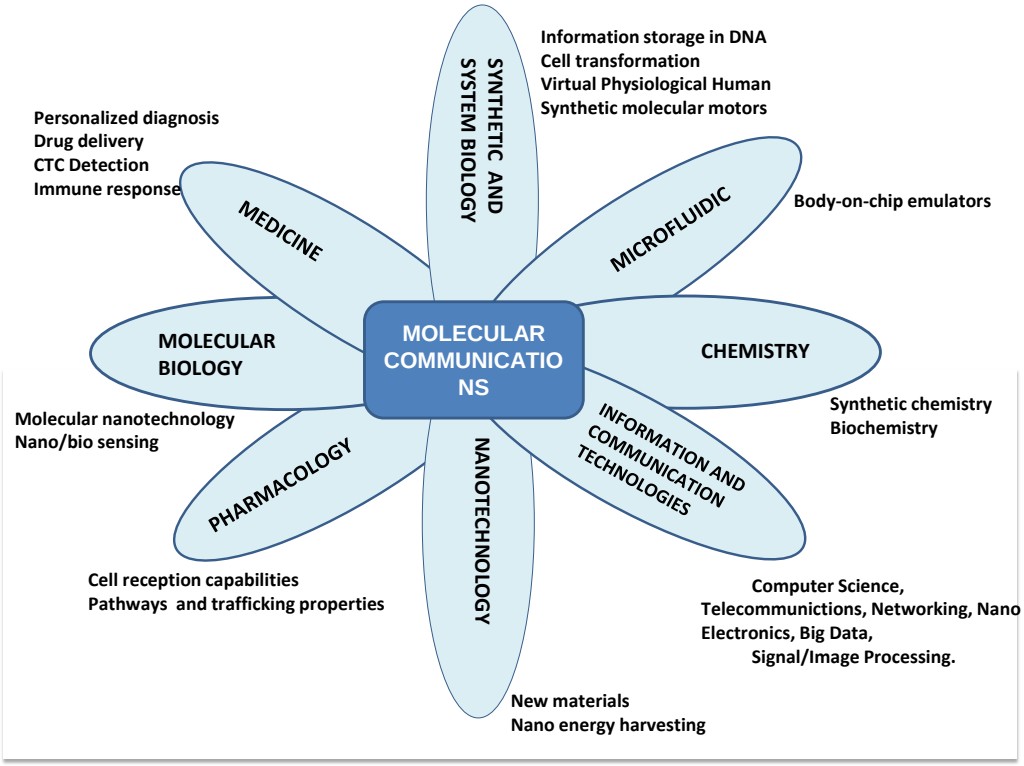

Figure 1: MolCom and related disciplines.

In addition, we stress that the exchange of researchers is extremely useful due to the complementarity of expertise available in the research groups of the CIRCLE participants, which is sketched in Figure 2.

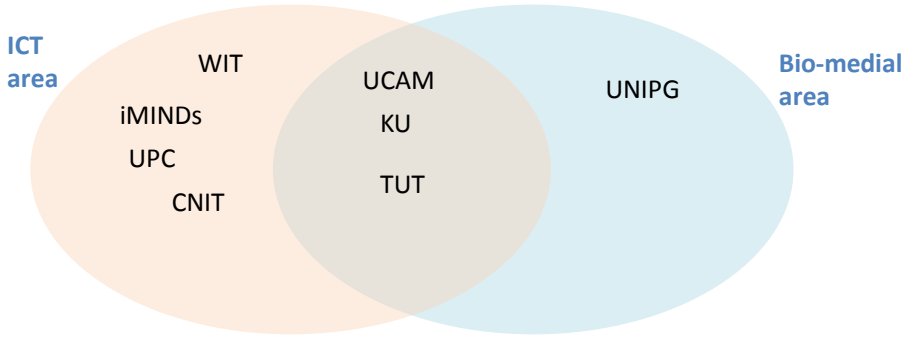

Figure 2: Classification and visualization of the expertise in CIRCLE partners.

The list of planned exchanges is detailed in what follows.

The plans for staff exchange are illustrated for each individual CIRCLE beneficiary.

They will be further detailed in the Deliverable D3.3.

Waterford Institute of Technology - WIT

Staff Exchange #1

a) Collaborating organization: Federal University of Campina Grande, Brazil.

b) Period: 14th of September to 07th of November of 2016.

Staff Exchange #2

a) Collaborating organization: Tampere University of Technology

b) Period: 3rd March - 3rd April

University of Cambridge - UCAM

Staff Exchange #1

a) Collaborating organization: CNIT

b) Period: One week February 2017, one week March 2017

Staff Exchange #2

a) Collaborating organization: Univ. of Electronic Science and Tech. of China, Chengdu, China

b) Period: One year since Fall 2016 (supported also by other initiatives)

i-Minds

Staff Exchange #1

a) Collaborating organization: N3CAT Barcelona

b) Period: 1 month by the end of the project.

Koc University - KU

Staff Exchange #1

a) Collaborating organization: University of Cambridge

b) Period: February 2017 - March 2017.

Staff Exchange #2

a) Collaborating organization: University of Cambridge

b) Period: February 2017 - March 2017

Staff Exchange #3

a) Collaborating organization: Tampere University of Technology

b) Period: February 2017 - March 2017

University of Perugia - UNIPG

Staff Exchange #1

a) Collaborating organization: VU University Medical Center, Amsterdam (NL)

b) Period: March-July 2017

Tampere University of Technology - TUT

Staff Exchange #1

a) Collaborating organization: TSSG, Waterford Institute of Technology.

b) Period: the exchange period will be for 6 weeks for each organization by the end of the project.

Staff Exchange #2

a) Collaborating organization: Koc University.

b) Period: the exchange period will be for 6 weeks by the end of the project.

UPC

Staff Exchange #1

a) Collaborating organization: CNIT

b) Period: 1 month by the end of the project.

CNIT

Staff Exchange #1

a) Collaborating organization: Waterford Institute of Technology

b) Period: One week, May 2017

Staff Exchange #2

a) Collaborating organization: University of Cambridge

b) Period: One week, May 2017

6. Definition of measurable parameters for knowledge sharing.

This section describes the qualitative and quantitative assessment model used to evaluate the impact of knowledge sharing in CIRCLE. This model takes into account the knowledge sharing initiatives illustrated in this document and associates performance metrics to them. This assessment is deemed necessary in order to verify if the perceived effectiveness of CIRCLE corresponds to a real appreciable quality level. This assessment is oriented to both individuals and research groups involved in the project.

First of all, it is necessary to consider that some significant outcomes of the project CIRCLE will appear well beyond the project lifetime, such a sound presence of highly innovative companies exploiting the research results in molecular communications.

The model proposed follows the six general objectives of the project and the relevant milestones, which contribute to each of them. Verification of the milestones is a necessary condition for the achievement of the project objectives. In what follows, we report the project milestones along with the condition for them to be verified.

- **MS1: First CIRCLE Workshop executed.** This milestone will be verified when the first CIRCLE workshop will be done. Related objectives: 1, 2, 6.
- **MS2: Advisory Board and Expert Working group established.** This milestone will be verified when the advisory board and expert working groups will be in place with appropriate terms of references defined. Related objectives: 1, 2, 6.
- **MS3: Web portal and the CIRLCE Forum has been established and community members have been invited.** This milestone will be verified when the web portal and the forum are in place, and the forum is accessed. Related objective: 3.
- **MS4: Document and Code repository has been established and consortium members have been invited to join.** This milestone will be verified when the code repository will bw operational. Related objective: 4.
- **MS5: A Staff exchange reporting process and register has been defined.** This milestone will be verified when the staff exchange reporting process will be operational. Related objective: 5.
- **MS6: Initial draft of the Skills Development plan prepared by the expert working group.** This milestone will be verified when the skills development plan will be in place. Related objective: 2.

Although these milestones are relevant to all the activity of the project CIRCLE, their accomplishment is considered necessary, but not sufficient, for the performance assessment of the knowledge sharing initiatives in CIRCLE. This assessment needs the following conditions to be verified, for each objective of the project illustrated in Section 2.

- **O1:** Submission of consortium wide papers on molecular communications. At least a research paper, demonstrating the contribution of different research groups in CIRCLE, will be submitted by the end of the first year of the project. It is expected, for very positive assessment, multiple papers to be published.

- **O2:** At least a tutorial paper published. This tutorial paper should include the expertise of different disciplines and demonstrate the suitable integration of the biomedical expertise and the ICT expertise.
- **O3:** The performance assessment relevant to this objective can be done well beyond the end of the project. A qualitative positive assessment consists of the presence of published papers co-authored by at least five young researchers, demonstrating original and innovative thinking.
- **O4:** Performance assessment of knowledge sharing relevant to this objective consists of fulfilling the following four requirements:
  - O4.1: Presence of at least one follow-on initiative oriented to support research in molecular communications.
  - O4.2: Presence of a research initiative compliant with the existing standardization activities.
  - 04.3: Accomplishment of a comprehensive analysis on the current opportunities for undertaking studies at master and PhD levels in molecular communications.
  - O4.4: CIRCLE sponsorship to a specialized conference on molecular communication and contribution to a doctoral school.
- **O5:** The performance assessment of this objective is purely quantitative. Full assessment of it consists of the realization of the personnel exchanges illustrated. These exchanges are expected to happen essentially during the second year of the project.
- **O6:** The performance assessment relevant to this objective can be done well beyond the end of the project. A qualitative positive assessment consists of the attendance of representatives of companies to the dissemination events organized by the project CIRCLE.

7. Conclusion

In this report, we gave an overview of the knowledge sharing and best practice activities undertaken in the initial phase of the project CIRCLE. First, we have shown the expected WP3 activities that will contribute to the achievements of general objectives of the CIRCLE project. After that, we have illustrated the ongoing and planned activities in WP3. Some specific and well defined activities have been detailed, such as the production of the MolCom Started Kit. In addition, the current plans for personnel exchange are documented. The final part of the document reports the measurable parameters to be used to assess the effectiveness of knowledge sharing.

We underline that the content of the document reflects the state of the project at the beginning of the project. Any amendments to these plans, agreed during the project lifetime, will be illustrated in the follow-up reports, namely D3.3 (to be delivered at month 12) and D3.4 (to be delivered at month 24).