

# Enhancing ICT-Based Multidisciplinary Collaboration in Cross-Border Context: FRUCT-Facilitated Karelia ENPI Project Success Stories

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**Abstract**—The paper summarizes success stories of Finnish and Russian research organizations that joined forces towards development of leading-edge ICT competences and their use in multidisciplinary applications. The partner organizations from both countries have developed close collaboration framework, which enabled them to implement three cross-border cooperation projects co-funded by the Karelia ENPI CBC Programme. The paper describes this framework as a complex combination of various activities, including educational events, practical R&D, as well as infrastructure development and dissemination activities. Following the development of regional cooperation ecosystem and enhancement of ICT competences (KA179 project), rest of the activities were focused on practical and multidisciplinary applications. In these projects, novel approaches and latest information and Internet technologies were used to increase regional tourism attractiveness (KA322 project) and to improve quality of life for people with disabilities by addressing issues related to social exclusion, accessibility and mobility (KA432 project). The aim of the paper is to share practical experiences, gained during implementation of these cross-border cooperation projects, and to present developed ICT applications in a multidisciplinary context.

## I. INTRODUCTION

Rapid development of modern technologies provides novel opportunities to face challenges created by current economical and financial turbulence as information and communication technologies underpin innovation and competitiveness across private and public sectors and enable scientific progress in all disciplines [1]. Besides, strong cooperation between universities, businesses, governmental organizations, as well as citizens facilitates development of dynamic ecosystems, adopting innovations and new approaches towards economic and social growth. Therefore, Finnish and Russian research organizations joined forces towards a common vision highlighting importance of development of leading-edge ICT competences and their multidisciplinary applications.

One of the regional financial instruments, enabling the implementation of this vision, is Karelia ENPI CBC – cross-

border cooperation Programme co-financed by European Union, Russia and Finland. It covers the regions of Kainuu, North Karelia and Oulu in Finland and the Republic of Karelia in Russia, and its key objective is to increase wellbeing and economical competitiveness of the programme region with the cross-border cooperation [2].

The paper describes three projects, co-financed by Karelia ENPI programme, implemented by Petrozavodsk State University (as the lead partner) in cooperation with FRUCT, Center for Internet Excellence (CIE) at University of Oulu, among others. FRUCT [3], as the leading academia-to-industry cooperation community, has enabled fast launch of the projects and has been significantly involved in all phases of projects implementation. Latest information and internet technologies, and novel competences and approaches have been used in these projects facilitating and enabling multidisciplinary research and development in a number of fields, including e-Tourism, quality of life of people with disabilities, healthcare, and wellbeing.

The aim of the paper is to share practical experiences gained during the implementation of these cross-border cooperation projects with special emphasis given to ICT applications in a multidisciplinary context. In the following Section II we present the cross-border collaboration framework for competence development. Section III describes multidisciplinary applications of developed competences. Section IV presents main results and lessons learned during the implementation of the projects. Conclusions, as well as already launched follow-up activities that ensure sustainability of the collaboration framework are summarized in the final section.

## II. CROSS-BORDER COOPERATION FRAMEWORK FOR COMPETENCE DEVELOPMENT

Nowadays information and communication technologies (ICTs) are integral part of innovation processes and significantly contribute towards economic and social growth

of society. However, ICT as a rapidly growing industry is driven by constant change. Ability to adapt and respond to industry changes is more important than ever before, especially for businesses. It is a challenge for businesses to remain competitive in this field, as dramatic shortening of the period, when technology remains commercially viable is distinctive feature of modern ICT industry. Besides, competitiveness of ICT companies is rooted in underlying motivation, competencies and skills of personnel, including readiness and ability to bring-in and quickly adopt new ideas and solutions and to face new challenges.

Current education and learning programs in both regions provide great fundamental knowledge, however, there remains a need for further practical training for graduates to efficiently work in ICT industry, and adopt the latest and advanced technologies after the graduation. Close education and research organization cooperation with industry enables to follow industry trends, as well as provides universities with challenging and concrete research tasks.

This vision served as the basis and the starting point for complex development of regional cooperation in the field of open ICT innovations. It had been implemented by Petrozavodsk State University, Center for Internet Excellence at University of Oulu and FRUCT within the scope of the three-year cross-border cooperation project KA179 co-funded by Karelia ENPI CBC Programme. This project focused on the development of ICT competences incubation infrastructure and preparing graduates capable of performing independent and challenging research, development and entrepreneurship activities. During the project implementation, a complex set of activities were carried out. These activities included identification of focus areas for competence development, educational, research and development activities especially for students from both Russian Karelia and Oulu regions, and establishment of proper infrastructure. Besides, variety of events, such as conferences, educational courses, workshops, advanced technical trainings, and seminars were organized to foster mutual understanding and knowledge sharing between industry and academy representatives.

#### *A. Focus areas for competence development*

During the project implementation, Smart Spaces and Internet of Things [4] were identified among priority focus areas for competence development. FRUCT community members inherited competences in this area, earlier developed in cooperation with Nokia [5, 6, 7, 8], however it was critical to further enhance them, create own research and development agenda and start development of services that apply these technologies into practice. During the project implementation FRUCT community has become a recognized R&D player in these fields. A number of notable academic and practical results has been achieved

and has been served as a ground for launch of new large regional projects. For example, findings and contributions to development of Smart-M3 open-source platform were published in scientific papers [9], [10], and presented at various events in the region and outside of it. Besides, open-source platform TIZEN has been perceived as strategically important for competence development. This platform is based on open Linux and may be seen as direct successor of Maemo and MeeGo projects, but optimized for wearable and mobile devices. Nowadays, it is one of the strongest industry platform candidates for development of Internet of Things services and solutions. The market future of the platform is pushed by Samsung and Intel, along with the large consortia of world-leading IT companies [11].

Another priority focus area identified during the project implementation, was development of competences in geo-location and geo-tagging solutions on top of Geo2Tag location-based services platform. This open-source platform has been impressively improved by the community, and is currently recognized as the world leading open-source platform for location-based services [12]. Currently, FRUCT community members, including the project team, are among the main contributors to development of this platform [13].

In addition, mobile healthcare is relatively new and very promising market with huge growth potential. It is projected to be a 26 billion dollar industry already by 2017 [14]. 2013 was noted for surge of mobile applications related to health, sports, and nutrition. Health, wellness and well-being could be the next mega cycle stretching all the way to the 2050 and beyond. The definition of healthcare will change as economies struggle to afford healthcare costs, which will affect 20% of a nation's GDP in a developed world [15]. FRUCT community currently is among the leaders in Russia, what has recognized the potential for development competences in the mobile healthcare.

Developing competences, flexibility and ability to respond on industry changes is of significant importance. For instance, Android platform within 5 years has skyrocketed to the position of the absolute world leader in smartphone sales: in 2008 it had 0% market share, and now it accounts for 78.4% of smartphones and 42% of all phones sales in the world. On the contrary, Symbian, which in 2008 had 60% share of smartphone sales, by 2013 has ceased to exist. Due to industry changes, project partners developed competences in a wide range of mobile platforms, namely, Android, iOS, Windows Phone, Tizen and Asha. In addition, it is expected that by 2020 there will be over 80 billion connected devices worldwide, and 5 billion internet users with over 50% using handheld devices [15]. This connectivity will spread to daily lives bringing the 3 silos (work, home and surrounding environment) into 1 seamless experience termed as "connected living". While "green" was a mega trend of the last decade, a shift is expected towards

“smart” products – intelligent, connected and able to sense, process, report, and take corrective action.

### *B. Educational and R&D activities for competence development*

Considering identified focus areas for competence development, more than 10 new study disciplines were incorporated into the curriculum of Petrozavodsk State University. Besides, more than 20 advanced trainings and 3 winter schools on mobile programming, as well as individual study projects were organized in strong cooperation with FRUCT community and industry. Among others, there were organized trainings on Smart-M3, QT, MeeGo, QML, Geo2Tag platforms, as well as mobile platforms, like Windows and Asha. Winter schools focused on mobile programming, for example on iOS programming (Winter school held in Petrozavodsk, Russia, February 4-8, 2013), and mobile application development using HTML5 (Winter school held in Petrozavodsk, Russia, February 5-7, 2014). These educational activities enabled narrowing of the gap between industry demands and educational standards.

Besides, proper lab infrastructures has been developed. For example, Mobile and Wireless Systems Laboratory (MoWiSeL) with 20 workplaces was established at Petrozavodsk State University for improving the efficiency of educational and research activities in the field of open ICT development and innovations. An important part of MoWiSeL is the Smart room – service-oriented system aiming at automation of holding such events as conferences, meetings, lectures, and trainings [16], [17]. It provides a set of services that simplifies activity organization and participation, as well as automates technical functions of information acquisition, sharing and transformation.

All educational and R&D activities strongly promoted the idea of project-based training and learning, and involvement of students into application development under guidance of experienced professionals. As a result, 15 small-scale and 2 advanced R&D projects were carried out [9, 10, 16, 31]. Among developed applications are for example Origami Zoo [18] and Mushrooms [19].

Thus, the involved students were able to operate with the latest technologies and practically participate in applications development with clear focus on measurable outcome. Besides, application development contributed to creation of the methodology for industry-oriented project development in ICT and increased the visibility of cooperation framework and developed competences.

### *C. Exchange of experiences and cooperation*

Public events, such as conferences, forums and exhibitions provide unmatched networking and collaboration possibilities, as well as enable knowledge sharing and feedback collecting. The project has significantly contributed to organization of 7 international

conferences of FRUCT Association. These conferences are both educational and information sharing events, which include invited presentations by leading academic and industrial researchers. FRUCT conferences are organized as a R&D forum for the most active students, academic experts, industrial researchers and influential representatives of business and government. The conferences provide opportunities for student teams to present progress and results of their R&D projects, meet new interesting people and form new R&D teams.

### III. MULTIDISCIPLINARY APPLICATIONS OF DEVELOPED COMPETENCES

The cooperation framework and competences, developed and enhanced during the first project, have served as a basis for further collaboration activities, focusing on multidisciplinary applications of novel technologies and competences. Activities implemented as separate Karelia ENPI projects are presented in this section.

#### *A. e-Tourism*

The accelerating and synergistic interaction between technology and tourism in recent times has brought fundamental changes in the tourism industry and our perceptions of its nature [20]. Thus, the project KA322 "Smart e-Tourism" aims to increase tourism attractiveness of the Karelia and Oulu regions by developing e-tourism solutions using state-of-the-art information technologies. This project has been implemented by Petrozavodsk State University, FRUCT and Center for Internet Excellence at University of Oulu in close cooperation with Information Tourist Center of the Republic of Karelia and St. Petersburg Institute for Informatics and Automation of Russian Academy of Sciences. Besides, a number of meetings and brainstorming activities have been held with tourism organizations and ICT experts to discuss ideas and proposals for e-tourism solution development.

Study involving 373 companies and organizations from both regions with aim to cognize how organizations use ICT to interact with customers, including tourists [21], that ICT has become an integral part of contemporary tourism business activities, and organizations and companies use ICT to carry out variety of functions. For example, web pages, and social networks are perceived to be especially beneficial and useful for information distribution, marketing and communication. However, there is a great need still for new ICT solutions in both regions.

Based on evaluation results, 10 new e-Tourism solutions for regional application are being developed [22]. In particular, the set of applications "Natural wealth of Karelia" provides guiding and interactive maps indicating locations of hunting, fishing and recreation areas. The "Virtual road signs" [23], application provides information and instructions to travelers about directions and distances

specifically to regional points of interests. The "Audio guide" application provides commentaries to city visitors enjoying self-guided tours, and "My Trips" application facilitates the exchange with travel-related information using social networks. The "3D Virtual Kizhi Island" environment, accessible over the Internet, helps prospective tourists by providing informative and entertaining setting, as well as unique immersive and engaging virtual experiences and social interactions. The "Intelligent Mobile Tourist Guide (TAIS)" [24, 25] provides traveler recommendations taking account their preferences and current situation. These digital services and mobile applications will assist tourists in finding offers that meet their needs and individual preferences. Even though there are still evident gaps in the infrastructure, e-Tourism solutions show encouraging outcomes [21].

Competences and results of the first cross-border cooperation project have significantly contributed to the development of e-Tourism solutions. For example, "Intelligent Mobile Tourist Guide (TAIS)" have been developed using open source platform Smart-M3, which provides implementation to the smart space methodology. Mobile applications, like "Natural wealth of Karelia, as well as "Virtual road signs", have been developed upon open-source LBS platform Geo2Tag platform. Besides, 3D virtual Kizhi model has been developed using 3D Internet open source platform realXtend, technology developed in Oulu.

Using these open source platforms, we also contribute to the development of platforms as such, and thus enable everyone to utilize developed extensions to platforms for further e-Tourism solution development. For example, significant part of the project has been devoted to specification and development of functionality extensions for the Geo2Tag platform, which currently are used in multiple applications and use-cases in Russian Karelia region.

To ensure project continuation and further development of e-Tourism infrastructure, project partners have been sharing their competences and experiences willingly during a range of dissemination activities, including seminars, trainings and workshops. For example, two regional seminars on e-Tourism were organized in Russian Karelia and Oulu regions [26], [27] to foster dialogue and mutual knowledge between academic researchers and tourism business representatives from Russia and Finland. These seminars were aimed at creating a platform for exchanging experiences and best practices in using perspective approaches and latest information technologies for the development of e-Tourism services and infrastructures in Karelia and Oulu regions [28]. The seminars started important discussions, initiated development of new applications and identified new business opportunities for

emerging technologies, like 3D Internet [29]. Application development progress has been regularly described in scientific publications and papers, as well as presented in conferences

### *B. Wellbeing and healthcare*

Along with regional development strategies and guidelines of Ministry of Health and Social Development of Karelia, wellbeing and healthcare, especially of people with disabilities have been identified as another important field for applications of developed competences. Technologies indeed are transforming many aspects of our lives, including the way we communicate, learn and work. However, for people with disabilities technologies may provide even more, for example greater degree of independence, support for living and inclusion in the community. Thus, the project KA432 "Social Navigator" aims to improve quality of life of people with disabilities by addressing social issues related to social exclusion, accessibility and mobility of disabled people using advanced information and communication technologies. The project scope has been specified in further development of mobile healthcare competences and in practical application development to address regional demand for an accessibility map for people with different types of disabilities. The first technology exploration in the field of mobile healthcare was made by FRUCT joint working group in 2010 [30].

The project is being implemented in close cooperation with Ministry of Health and Social Development of Karelia, and is targeted to develop a user-friendly ecosystem of digital services and mobile applications for people with disabilities taking into account their individual impairments and needs.

At the initial phase of the project implementation, it was of significant importance to study and review international and national regulations and guidelines, as well measures of Russian governmental program "Accessible environment" [31]. These guidelines include requirements and recommendations that shall be used when evaluating accessibility of social infrastructure and services, as well as creating maps with accessibility information, to ensure the use of unified approach to increasing social wellbeing of persons with disabilities. According to the guidelines, accessibility of social infrastructure and services should be evaluated based on "Accessibility passports". Accessibility information about social infrastructure and services is a prerequisite for further development of digital and mobile solutions for people with disabilities. Creation of such passports is a complex process, including detailed facility assessment and on-site evaluation. Thus, evaluation of social infrastructure and services following the guidelines has been coordinated and carried out by Ministry of Health and Social Development of Karelia. Besides, a dedicated web-based system, enabling accessibility information collection

and processing, has been developed [32]. The “Accessibility passports” contains information about governmental, healthcare, educational, social, and cultural facilities. The system is integrated with Geo2Tag platform.

The “Accessibility passports” service is used as a foundation for development of information environment for persons with disabilities, as the data stored in the system creates the information basis for “Accessibility Map” and “Social Navigator” services. The “Accessibility map” is the mobile service for cartographic visualization of information about social facilities categorized by accessibility levels and types of disability. The “Social Navigator” is the mobile route planning service adapted for abilities of persons with various impairments [33, 34, 35].

Another application, being further developed within this project scope, is the mobile arrhythmia detector CardiaCare, used for heart function monitoring of a patient. Cardiovascular diseases are among most significant causes of death in the region. Therefore, for patients in the risk group it is necessary to support continuous monitoring of heart functions. The existing devices, like Holter monitor used in Russia are not suitable for long-term monitoring. On the contrary, a compact digital sensor paired with a smartphone with special software offer a more convenient solution, which allows simplifying detection of heart problems. The CardiaCare application provides a connection between wearable cardiac monitor, patient and doctor. Currently, Alive Bluetooth ECG and Activity Monitor are supported. In the case of arrhythmia detection the patient is warned. In emergency case the application can automatically make a call or send an SMS to doctor or patient's relatives.

#### IV. MAIN PROJECT RESULTS AND LESSONS LEARNED

Cooperation framework developed during the complex set of activities, including educational, practical research and development activities, infrastructure development and close collaboration and networking, now serves as a stable ground for further development of competences, implementation of new cooperation projects between research and industry organizations.

Implementation of the cross-border cooperation projects enabled the partner organizations to identify a number of priority focus areas for competence development. Through the joint work sustainable competences were incubated in such promising areas, as Internet of Things and Smart Spaces; geo-location, geo-tagging and location-based services; health, wellness and well-being; 3D Internet. Developing competences, flexibility and ability to respond to constant industry changes is of significant importance. Rapid industry changes should be considered planning and organizing further educational, research and development activities to stay up-to-date and meet industry demands.

Project-based training and learning, involving local teams and prospective students into the R&D projects with strong practical implications and under guidance of experienced professionals, has proven to be especially beneficial. The project-based approach has increased awareness of importance of practical training, and has enabled to develop methodology for industry-oriented project implementation

Besides, developed competences have been enhanced and applied in a multidisciplinary context. Concrete solutions needed to increase regional tourism attractiveness and wellbeing of people with disabilities have been developed. In the solution development process, it was of significant importance to recognize regional development priorities, as well as needs and preferences of prospective users.

End-user feedback on solutions being developed has greatly contributed towards advancements of application ideas and features. For example, during demonstration of “3D Virtual Kizhi Island” [36], at the annual international Travel Fair “Matka 2014” in Helsinki, a lot of encouraging feedback both from tourism industry professionals and prospective travelers was received. Using virtual reality headset, visitors were able to step inside virtual world and seamlessly experience this unique tourist destination. Such interactive approach attracted a lot of attention. Nearly all who visited 3D Virtual Kizhi Island expressed intention to visit Kizhi Island in real life. The three dimensional model of Kizhi Island, developed jointly with the Kizhi state open-air museum and cooperation partners, nowadays is one of the best regional examples of practical applicability and potential of 3D Internet technology.

The mHealth application CardiaCare is already in pilot use for monitoring patients with certain types of heart arrhythmias at cardiology department of Petrozavodsk City Hospital. In 2012 this application has won prestigious Russian Mobile industry award in nomination “Best Mobile Service” – Russian Mobile VAS Awards 2012 [37]. In 2013 it was awarded the Golden medal of Contest “Best Innovative Project and Scientific and Technical Development of the Year”. This mHealth application has strong potential for further research and business development, which will be continued also after the completion of Karelia ENPI projects.

These awards and recognitions confirm that project teams are capable to successfully perform challenging research and development and produce demanded and competitive solutions.

#### V. CONCLUSION

The paper illustrates how Finnish and Russian research organizations cooperated towards implementation of the common vision regarding multidisciplinary application of advanced ICT competences.

The common vision and cooperation between all partners were the critical factors for successful implementation of the activities, described in the paper. Cooperation among representatives from governmental, business and research institutions across boundaries of national borders, particular industries and organizations, has been underlying all activities.

Due to developed strong competences in the fields Smart Spaces and IoT, FRUCT community take active part in the Finnish IoT program [38].

The up-to-date competences, infrastructure, and research background, developed during implementation of the Karelia ENPI projects, have also enabled Petrozavodsk State University and FRUCT to win 2 research projects from Russian Ministry of Education and Science to be implemented until December 2016:

1) Methods of programming for service-oriented intelligent systems based on ontological models of interaction in heterogeneous computing environments of Internet of Things, project # 1481.

2) Methods for ontology-driven development and intelligent Internet technologies for semantic services of the next generation in the area of cultural tourism, project # 2.2336.2014/K.

In addition the team won Federal Target Program “Research and development on priority directions of scientific-technological complex of Russia for 2014-2020” project # 14.574.21.0060 “Development of technology for intellectualization of localized computing environments of Internet of Things and for personalized construction and proactive delivery of services”.

They are related to developing the technology of intellectualization of localized digital environments of Internet of Things for personalized creation and proactive delivery of services in several fields, including mHealth, historical-cultural tourism, and industrial Internet. These grants will provide solid foundation for continuation of activities and enhancement of results, achieved during implementation of the projects, presented in this paper.

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