

BRAINE - Big data pRocessing and Artificial Intelligence at the Network Edge

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Editor	Luca Valcarenghi (SSSA)

Abstract	This report highlights the dissemination and standardization efforts and outcome of activities during the third year of the project.
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Keywords	Dissemination, communication, standardization, social media, website

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1. Executive summary

This document reports the results achieved by the project dissemination activities (in the rest of the document differentiated in dissemination and communication activities) and standardization activities until M43. In the document *dissemination* includes activities related to raising awareness of the project results in the technical community working on the same research field. *Communication* includes all the activities related with the promotion of the project and its results beyond the project's own community.

The project achieved all the targets established for the dissemination and communications activities planned in the Grant Agreement.

The performance achieved, for what concerns dissemination activities, are the following:

- Thirty-three (33) articles were accepted for publication in proceedings of top ranked scientific conferences (target twenty (20)/year) and presented in Year 3, with total of sixty seven (67) conferences at the end of M43.
- Seven (7) articles were accepted for publication in Q1 and Q2 Scimago Journal Ranking (SJR) international journals (target five (5)/year) in the project Year 3, with the total of twenty-four (24) at the end of M43.
- BRAINE participated in the organization of ten (10) workshops at scientific events (target three (3)/year) with the total of nineteen (19) at the end of M43. Three (3) demonstrations were accepted at the world's leading global conference and exposition for optical communications and networking professionals including OFC 2022, ECOC 2021 and Mobile world congress.
- BRAINE collaborated in eleven (11) events organized with groups outside the BRAINE consortium (target three (3) during the project).
- Thanks to the availability of BRAINE components and solutions, industrial dissemination achieved eleven (11) demonstration of prototypes and talks at industry-dominated events and thirty-two (32) meetings with business units and commercial staff of industry.

For what concerns communication activities, the following performance were achieved:

- The website received 21k visits during the last year of the project.
- Twenty-five (25) press releases/wider public publications were issued (target 5 during the project).
- Instagram reached 163 followers and 63 posts, Twitter reached almost one hundred and seventy-three (173) followers since May 2020 and with a peak of 732 profile visits, LinkedIn page reached 135 followers.

Another important communication activity consisted of the BRAINE YouTube channel. Through the YouTube channel the project delivered a series of panels entitled "Ask BRAINE", with the aim of explaining to a general audience which are the topics the project is working on, and multimedia contributions related to the project activities. The channel has already reached more than 1.5K visits.

For what concerns standardization activities BRAINE' partners have participated to several standardization topics: security and cryptography, distributed computing, ontology for industrial applications, telecommunications, and of course, Edge related standards. Thus, some consortium partners participated to the activities of Standardization bodies and industrial associations, such as ISO/IEC, ETSI, NIST, Open RAN (O-RAN) Alliance,

Open Grid Alliance and 5G-PPP, 3GPP, W3C/NFDI4Ing and also contributed to opensource standard implementation projects.

In conclusion, the dissemination, communication, and standardization activities performed very well despite the COVID-19 pandemic. In particular, during the second and third year the project was capable of boosting several scientific publications, doubling the target number and the BRAINE collaboration with groups outside the consortium. Finally, the participation to Standard Developing Organizations (SDOs), such as ISO/IEC, ETSI, NIST, Open RAN (O-RAN) Alliance, Open Grid Alliance and 5G-PPP, 3GPP, W3C/NFDI4Ing, allowed to bring project results into the standards.

2. Introduction

This deliverable is related to the task "T6.2 Dissemination" and task "T6.3 Standardization" of the project. This deliverable reports the dissemination, communication, and standardization activities carried out during the third year of the project and during the entire duration of the project. These activities include widespread visibility in the form of scientific publication, participation to conferences and workshops, magazines, newsletters and on different social media platform to raise the awareness of the project in different scientific and public events. For what concerns standardization activities, they are related to active participation in Standard Developing Organization (SDO) activities.

In the next coming sections, we present, first the overview of target indicators during the third year of activities, followed by the explanation and listing of these indicators. The methodology utilized to monitor the dissemination and communication activities follows the plan defined in the Grant Agreement and in D6.2 based on key performance indicators (KPIs). For example, some of the considered KPIs for the dissemination activities are the number of papers published in proceedings of international conferences, the number of papers published in international top ranked journals, the demonstrations in scientific and industrial events. Some of the considered KPIs for communications activities are the number of visits to the project webpage, the number of LinkedIn and Twitter followers. Such KPIs are monitored periodically and presented at the project plenary meetings to steer the dissemination and communication activities to reach the targets established in the Grant Agreement and in D6.2.

The following sections detail the results achieved by the dissemination, communication, and standardization activities both in the last year of the project and overall. Moreover, they are compared against the established targets.

3. Dissemination

In this section we report on the dissemination activities of the project. During the project, BRAINE carried out several dissemination activities, including presentations in conferences, seminars, and forums. Some of them were performed remotely due to the COVID-19 pandemic.

The KPI values achieved during the third year and the whole project are reported in **Table 3.1**- and compared with the target KPI values.

Dissemination Output	Target Indicator	First year	Second year	Third year	Total	
Scient	ific Dissemi	nation				
Publications appearing in conference proceedings	20 / year	16	18	33	67	
Journal publications	5 / year	6	11	7	24	
Workshops organized at scientific events	3 / year	5	4	10	19	
Indust	rial Dissemi	nation				
Meetings with selected business units and commercial staff of the industrial and SME partners	10	0	16	16	32	
Demonstrations of derived prototypes and motivational talks at industry- dominated events (summits etc.)	10	2	4	5	11	
C	Collaboration					
Joint publications, workshop organization and/or standardization activity with groups (industrial or research) outside of the BRAINE consortium to extend outreach	3	10	11	2	13	

Table 3-.1 Dissemination activities: target indicators and achievements

Publication in conference proceedings reached the established target (i.e., 20/year). This can be considered as satisfactory result as in the initial period of the project, due to the COVID-19 pandemic, conferences have been delayed or cancelled. However, during the later years, satisfactory dissemination activities were carried out with thirty-three (33) conference papers have been accepted and presented in the conferences only in the last year of the project.

The most noticeable achievement of the project is the acceptance of twenty-four (24) journal papers during the total period of the project. This result confirms the high-quality of the scientific activity of the consortium, considering also the, usually, higher time to publication of journals. Moreover, all the journal publications are in Q1 and Q2 of the Scimago ranking (https://www.scimagojr.com/).

Moreover, BRAINE project was demonstrated, in six different venues, overall, among which it is worth mentioning the Optical Networking and Communication Conference &

Exhibition 2022 (OFC 2022), the world's leading global conference and exposition for optical communications and networking professionals. Along with that, there was a demonstration of BRAINE in 2021 European Conference on Optical Communication (ECOC) held in Nov 21 in Bordeaux, France. Moreover, the project was also demonstrated in mobile world congress by Comcores held in Barcelona in Feb 2022.

Another milestone achieved during this period is the successful completion of a master thesis entitled "Optimizing Machine Usage and Flow Time in Task Scheduling with Value-Based Deep Reinforcement Learning" under the framework of BRAINE project.

Finally, BRAINE project participated to nineteen (19) joint Talks/Panels/Workshops (categorized in this document as "Joint publications, workshop organization and/or standardization activity with groups (industrial or research) outside of the BRAINE consortium to extend outreach"). Although the established target has been already achieved within year 2, the project continued targeting this type of dissemination and achieved a high score.

During the later years of the project, several activities related to industrial dissemination were executed. In summary, a total of thirty-two dissemination activities related to meetings with selected business units and commercial staff have been conducted. Along with that there was a total of eleven demonstrations of prototypes and talks at industry-dominated events. We summarize all scientific and industrial activities in Figure 1.



Figure 1: Year wise summary of scientific and industrial dissemination.

In the following subsections the dissemination activities details are reported.

3.1. Publications and technical dissemination

This section reports the BRAINE peer-reviewed articles presented in conferences (*Table 3.2*), published in scientific journals (*Table 3.3*), organized workshops and short course (*Table 3.4*), given talks/panel (*Table 3.5*), Meetings with business units and commercial staff of industry (*Table 3.6*), and finally demonstration of prototypes and talks at industry-dominated *events* in (*Table 3.7*). It must be noted that, thanks to the availability of BRAINE 1.0 components and solutions, industrial dissemination largely increased during the last year of the project.

#	Authors	BRAINE Partner	Title	Conference	Publication Date
1	Nour Ramzy, Sören Auer, Hans Ehm, Javad Chamanara	IFX, LUH	SENS: Semantic Synthetic Benchmarking Model for integrated supply	ECIS 2022	June 18-24, 2022

Table 3.2 Dissemination activities: conference publications

#	Authors	BRAINE Partner	Title	Conference	Publication Date
			chain simulation and analysis		
2	Emilio Paolini, Federico Civerchia, Lorenzo De Marinis, Luca Valcarenghi, Luca Maggiani and Nicola Andriolli	SMA, SSSA	Photonic-Aware Neural Networks for Packet Classification in URLLC Scenarios	2022 IEEE 23rd International Conference on High Performance Switching and Routing (HPSR)	June 6 - 8, 2022
3	Emilio Paolini, Lorenzo De Marinis, Marco Cococcioni, Luca Valcarenghi, Luca Maggiani and Nicola Andriolli	SMA, SSSA	Photonic-Aware Neural Network: a fixed-point emulation of photonic hardware	27th OptoElectronics and Communications Conference/Inter national Conference on Photonics in Switching and Computing (OECC/PSC) 2022.	July 3 - 7, 2022
4	Adam Flizikowski, Evgeniy Alkhovik, Md Munjure Mowla and Md Arifur Rahman	IS-Wireless	Data Handling Mechanisms and Collection Framework for 5G vRAN in Edge Networks	IEEE Conference on Standards for Communications and Networking (CSCN 2022)	Nov 28 - 30, 2022
5	Juan Carlos Hernandez- Hernandez, David Larrabeiti, Maria Calderon, Ignacio Soto, Bruno Cimoli, Hui Liu, Idelfonso Tafur Monroy	TUE	Quantum Key Distribution Resource Sharing Schemes for Metropolitan Area Networks	2022 International Conference on Optical Network Design and Modelling (ONDM)	May 16 -19, 2022
6	Catalina Stan, Carlos Rubio Garcia, Bruno Cimoli, Juan José Vegas Olmos, Idelfonso Tafur Monroy, Simon Rommel	TUE MLNX	Securing Communication with Quantum Key Distribution: Implications and Impact on Network Performance	Signal Processing in Photonic Communications (SPPCom)	July 24 - 28, 2022
7	E. Paolini, F. Civerchia, L. De Marinis, L. Valcarenghi, L. Maggiani and N. Andriolli	SMA, SSSA	Photonic-aware Neural Networks for Packet Classification in URLLC scenarios	Hpsr 2022	June 6 - 8, 2022
8	E. Paolini, L. De Marinis, L. Maggiani and N. Andriolli	SMA, SSSA	Accelerating Pooling Layers in Photonic Convolutional Neural Networks	Psc 2022	July 3 - 6, 2022
9	E. Paolini, L. De Marinis, M. Cococcioni, L. Valcarenghi, L. Maggiani and N. Andriolli	SMA, SSSA	Photonic-Aware Neural Network: a fixed-point emulation of photonic hardware	Psc 2022	July 3 - 6, 2022
10	E. Paolini, F. Civerchia, L. De Marinis, L. Valcarenghi, L.	SMA, SSSA	Photonic-aware Neural Networks for Packet Classification in Beyond 5G Networks	Nof 2022	Oct 5 - 7, 2022

#	Authors	BRAINE Partner	Title	Conference	Publication Date
	Maggiani and N. Andriolli				
11	P. Szántó	BME	Heterogeneous accelerators in BRAINE	HiPEAC 2022	June 20 - 22, 2022
12	P. Szántó, T. Kiss, K.J. Sipos	BME	Energy-efficient AI at the Edge	MECO'2022	June 07-11, 2022
13	B. Scherer	BME	Card Level Management Solution for the BRAINE edge framework	IMEKO TC10	Sept 26 - 27, 2022
14	M. F. Silva, A. Pacini, A. Sgambelluri, F. Paolucci, L. Valcarenghi	SSSA	Confidentiality- Preserving Machine Learning Scheme to Detect Soft-Failures in Optical Communication Networks	ECOC 2022	September 18 - 22, 2022
15	S. Ramanathan, A. Bhattacharyya, K. Kondepu, M. Razo, M. Tacca, L. Valcarenghi, A. Fumagalli	SSSA	Demonstration of Containerized Central Unit Live Migration in 5G Radio Access Network	2022 IEEE 8th International Conference on Network Softwarization (NetSoft), 2022	June 27- July 1, 2022
16	V. R. Chintapalli, V. Gudepu, K. Kondepu, A. Sgambelluri, A. Franklin, B. R. Tamma, P. Castoldi, L. Valcarenghi	SSSA	WIP: Impact of AI/ML Model Adaptation on RAN Control Loop Response Time	2022 IEEE 23rd International Symposium on a World of Wireless, Mobile and Multimedia Networks	June 14 - 17, 2022
17	F Alhamed, D Scano, P Castoldi, F Paolucci, F Cugini, I Verschkov, JJ Vegas Olmos	CNIT, NVIDIA	P4 Postcard Telemetry Collector in Packet-Optical Networks	International Conference on Optical Network Design and Modeling (ONDM)	May 16 - 19, 2022
18	Luca Barsellotti, Faris Alhamed, Juan Jose Vegas Olmos, Francesco Paolucci, Piero Castoldi, Filippo Cugini	CNIT, NVIDIA	Introducing Data Processing Units (DPU) at the Edge	2022 International Conference on Computer Communications and Networks (ICCCN)	July 25 - 27, 2022
19	Simon Rommel; Bruno Cimoli; Idelfonso Tafur Monroy	TUE	The Role of Opto- Electronic Co- Integration for 6G Systems and Networks	2022 30th Telecommunicat ions Forum	Nov 15 -16, 2022
20	Carlos Rubio Garcıa, Oumayma Bouchmal, Catalina Stan, Panagiotis Giannakopoulos, Bruno Cimoli, Juan Jose Vegas Olmos, Simon Rommel and Idelfonso Tafur Monroy	TUE	Secure and Agile 6G Networking – Quantum and Al Enabling Technologies	23rd International Conference on Transparent Optical Networks (ICTON)	Jul 2 - 3, 2023
21	Alexander Grebenchukov, Hui Liu, Gleb Nazarikov, Bruno Cimoli, Simon	TUE	Prospects of Chip- Based Multi-Protocol Quantum Key	23rd International Conference on Transparent	Jul 2 - 3, 2023

#	Authors	BRAINE Partner	Title	Conference	Publication Date
	Rommel, and Idelfonso Tafur Monroy		Distribution Transceivers	Optical Networks (ICTON)	
22	Catalina Stan, Simon Rommel, Juan José Vegas Olmos, and Idelfonso Tafur Monroy	TUE	Computation offloading in beyond 5G/6G networks with edge computing: implications and challenges.	20th International Conference on Distributed Computing and Artificial Intelligence (DCAI)	July 12 – 14, 2023
23	Alessandro Rivitti, Roberto Bifulco, Angelo Tulumello, Marco Bonola, Salvatore Pontarelli	NEC	eHDL: Turning eBPF/XDP Programs into Hardware Designs for the NIC	ACM International Conference on Architectural Support for Programming Languages and Operating Systems	Mar 23, 2023
24	P. Szántó, T. Kiss, K.J. Sipos	BME	FPGA accelerated DeepSORT object tracking	ICCC 2023	June 12-14, 2023
25	B. Scherer, J. Lazányi, B. Kardos, Á. Radics	BME, PCB	Distributed supervision of an edge micro datacenter	ICCC 2023	June 12-14, 2023
26	G. Rouaze, E. M. Minazzo, J.B. Marcinichen, J.R. Thome, F. Buining	JJC, HIRO	Thermal-Hydraulic Characterization of Thermosyphon Cooling System for Highly Compact Edge Microdatacenter. Part I: Design and Experiments	INTERPACK 2023	Oct 24-26, 2023
27	E. M. Minazzo, G. Rouaze, J.B. Marcinichen, J.R. Thome, F. Buining	JJC, HIRO	Thermal-Hydraulic Characterization of Thermosyphon Cooling System for Highly Compact Edge Microdatacenter. Part II: Solver Validation	INTERPACK 2023	Oct 24-26, 2023
28	Sean Ahearne, Ahmed Khalid, Martin Ron, Pavel Burget	Dell, CTU, FS	An Al Factory Digital Twin Deployed Within a High Performance Edge Architecture	CEC Workshop 2023	Oct 10, 2023
29	M. F. Silva, A. Sgambelluri, A. Pacini, F. Paolucci, A. Green, D. Mascarenas, and L. alcarenghi	SSSA	Confidential Detection of Multiple Failures in Optical Networks: an Experimental Evaluation	OFC 2023	March 5 - 9, 2023
30	Venkateswarlu Gudepu, Venkatarami Reddy Chintapalli, Luca Valcarenghi, Koteswararao Kondepu	SSSA	Exploiting Drift Detection Techniques for Next Generation Radio Access Networks	COMSNETS	Jan 3 - 8, 2023
31	Venkateswarlu Gudepu, Bhavani Pappu, Tejasri Javvadi, Riccardo	SSSA	Edge Computing in Micro Data Centers for Firefighting in	ICECCME	Nov 16 -18, 2023

#	Authors	BRAINE Partner	Title	Conference	Publication Date
	Bassoli, Frank H.P. Fitzek, Luca Valcarenghi, D V N Devi, Koteswararao Kondepu		Residential Areas of Future Smart		
32	Alessandro Pacini, Davide Scano, Luca Valcarenghi, Andrea Sgambelluri, Alessio Giorgetti	SSSA	Enabling event-based hierarchical synchronization in SDN ONOS clusters	SDN/NFV 2022	Nov 14 -16, 2022
33	Adam Flizikowski, Md Arifur Rahman, and Md Munjure Mowla	IS-Wireless	Workload Prediction of Virtualized RAN in the Edge Micro Data Center: An Experimental Progress	IEEE CSCN	Nov 6 - 8, 2023

Table 3.3 Dissemination activities: journal publications

#	Authors	BRAINE Partner	Title	Journal	Publicati on Date
1	Marco Spaziani Brunella, Giacomo Belocchi, Marco Bonola, Salvatore Pontarelli, Giuseppe Siracusano, Giuseppe Bianchi, Aniello Cammarano, Alessandro Palumbo, Luca Petrucci, Roberto Bifulco	NEC, CNIT	hXDP: Efficient Software Packet Processing on FPGA NICs	Communications of the ACM	Aug, 2022
2	Francesco Paolucci, Andrea Sgambelluri, Moises Felipe Silva, Alessandro Pacini, Piero Castoldi, Luca Valcarenghi, Filippo Cugini	SSSA, CNIT	Peer-to-peer disaggregated telemetry for autonomic machine-learning- driven transceiver operation	Journal of Optical Communications and Networking	July, 2022
3	Afra Dömeke, Bruno Cimoli, Idelfonso Tafur Monroy	TUE	Integration of Network Slicing and Machine Learning into Edge Networks for Low- Latency Services in 5G and beyond Systems	Applied Sciences	June, 2022
4	Carlos Rubio Garcia, Simon Rommel, Sofiane Takarabt, Juan José Vegas Olmos, Sylvain Guilley, Philippe Nguyen, Idelfonso Tafur Monroy	TUE, SIC, NVIDIA	Quantum-Resistant Transport Layer Security	Computer Networks	May, 2023
5	Pérez Santacruz, J., Meyer, E., Budé, R. X. F., Stan, C., Jurado-Navas, A., Johannsen, U., Tafur Monroy, I. & Rommel, S.	TUE	Outdoor mm-wave 5G/6G transmission with adaptive analog beamforming and IFoF fronthaul	Scientific Reports	Aug, 2023
6	Moises Felipe Silva, Andrea Sgambelluri, Alessandro Pacini,	SSSA, CNIT	Confidentiality- preserving machine learning algorithms for	Journal of Optical	July 3, 2023

#	Authors	BRAINE Partner	Title	Journal	Publicati on Date
	Francesco Paolucci, Andre Green, David Mascarenas, and Luca Valcarenghi		soft-failure detection in optical communication networks	Communications and Networking	
7	Scano, Davide and Giorgetti, Alessio and Paolucci, Francesco and Sgambelluri, Andrea and Chammanara, Javad and Rothman, John and Al- Bado, Mustafa and Marx, Edgard and Ahearne, Sean and Cugini, Filippo	CNIT, SSSA, DELL, LUH, DELL, ECC	Enabling P4 Network Telemetry in Edge Micro Data Centers With Kubernetes Orchestration	IEEE Access	Feb, 2023

Table 3.4 Dissemination activities: workshops/ short course organized.

#	Date	Person/Partner	Title
1	Nov 29, 2022	CTU	Open days NCI4.0 in Testbed for Industry 4.0
2	Nov 23, 2022	CTU	T-mobile's events for industrial partners
3	June 22, 2022	CTU + NCP4.0	Award for Industry 4.0
4	Oct 09, 2023	C. Sreenan (UCC)	ICNP
5	Feb 02, 2023	CTU	Industry 4.0 a/vs Maintenance 4.0
6	March 20 -21, 2023	CTU + NCP4.0	Technology Literacy
7	May 31,2023	CTU + NCP4.0	NCP4.0 Open day in Testbed
8	June 1, 2023	CTU + NCP4.0	AI open days

Table 3.5 Dissemination activities: given talks/ panels

#	Authors	BRAINE Partner	Title	Event /Place	Date
1	J. Thome (chair)	JJC	Two-phase Cooling of Electronics	IEEE ITherm 2022	June 1, 2022
2	J. B. Marcinichen (panelist)	JJC	Two-phase Cooling of Electronics	IEEE ITherm 2022	June 1, 2022
3	F. Cugini	CNIT	Towards a converged computing, networking, and optical solution at the edge	ONDM 2021	May 16 - 19, 2022
4	CJ Sreenan	UCC	Network-Centric Healthcare	Digital Heath Summer School	June 09, 2023

Table 3.6 Industrial Dissemination activities: Meetings with business units and commercialstaff of industry

#	BRAINE Partner	Location	Title	Participants
1	Sean Ahearne	DELL Offices/virtual	BRAINE Presented at TeX - Internal Dell Conference	All Dell Products & Operations
2	Sean Ahearne	DELL Offices/virtual	Summarized reports of BRAINE results for consumption by relevant BU's	Dell global R&D BU, Manufacturing BU, Edge BU, Telco BU
3	Sean Ahearne	DELL EMC Manufacturing facility, Ovens, Cork, Ireland	Deployment of BRAINE platfrom prototype for testing by manufacturing BU by Mustafa Al- bado	Manufacturing BU
4	Antonino Albanese	Italtel Offices	Presentation of BRAINE Use Cases to the Business Unit Telco and Media to evaluate business opportunity in 5G private networks.	BU executives
5	Roberto Bifulco	NEC HQ in Tokyo	Presentation of networking technologies developed in BRAINE	Management board, BU executives

#	BRAINE Partner	Location	Title	Participants
			to the NEC managament board and BUs' vice presidents	
6	Antonino Albanese	Italtel Offices/Virtual	Presentation of BRAINE to Business Unit Telco and Media and discussion about business opportunities	BU executives, engineers
7	Martin Ron	FS office	Discussions about UC deployment opportunities	Sales executives, IT department managers
8	Thomas Nørgaard	Comcores offices	Promoting O-RAN LowPHY solution with selected customers.	Sales executives, CEO/COO
9	Sean Ahearne	DELL Offices/virtual	Meetings with Edge BU to discuss exploitable output from BRAINE and desired features from Edge BU customers	Dell Edge BU, Sean Ahearne, Ahmed Khalid, Mustafa Al-bado
10	Marc Fleuren	Helder offices	Discussing market potential with selected potential customers	Fred Buining (HIRO)
11	Sean Ahearne	DELL Offices/virtual	Meetings with Project Alvarium team to discuss integration of Alvarium features in an edge environment and future exploitation with BRAINE components	Dell project Alvarium team, Sean Ahearne, Ahmed Khalid, Mustafa Al-bado
12	Sana Fateh	Synano office	Regular discussions on BRAINE technical progress and upcoming dissemination opportunities	Synano R&D team
13	F. Civerchia	SMA offices	UC2 and MEC platform progress updates	5G/Edge computing Business Unit, CEO
14	Adam Flizikowski	IS-Wireless offices (Piaseczno)	regularly discussing BRAINE progress with top management and sales executives (on weekly meetings as well as ad-hoc meetings).	Sales executives, CEO/COO
15	Hans Ehm	IFX (virtual)	regular discussions on BRAINE progress with Innovation Department	Supply Chain Principals, Innovation Managers
16	Fred Buining	HIRO Offices, Hospital offices	Implementing Braine platform as part of operating room of the future	Sales executives, CEO/COO

Table 3.7 Industrial Dissemination activities: Demonstration of prototypes and talks at industry-dominated events

#	BRAINE Partner	Location	Title	Authors	Date
1	IFX	5th Supply Chain Innovation Summit	Challenges and Solutions in Complex Supply Chains	H. Ehm	June 9 - 10, 2022
2	(FS)	MSV Brno	Application Motif Discovery on Industrial Edge	Martin Ron	Oct 4 – 7, 2022
3	IFX	Insdustry-Academic Collaborations in Semiconductor Manufacturing	Panel by MASM at Winter Simulation Conference	H. Ehm	Dec 12, 2022
4	IFX	Automotive Logistics & Supply Chain	Panel on "From Crisis Management to Supply Chain Resiliency" by Semi	H. Ehm	March 23, 2023
5	HID	TU Delft, Industrial Design Engineering, Human-Centred Artificial Intelligence	Demonstration of enclosure solution and project methodology	Marc Fleuren	March 23, 2023

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3.2. Synergies with other projects

During the project several formal and informal meeting with other projects were organized, In particular, the meetings meeting with ASSIST-IoT on Jan. 14, 2022 and FRACTAL on March 10, 2022 must be mentioned.

The project ASSIST-IoT ("Architecture for Scalable, Self-*, human-centric, Intelligent, Secure, and Tactile next generation IoT) (https://assist-iot.eu/) is a EU H2020 ICT-56-2020 funded research project which aims at design, implementation and validation of an open, decentralized reference architecture, associated enablers, services and tools, to assist human-centric applications in multiple verticals.

The meeting included a BRAINE presentation, an ASSIST-IoT presentation, an ASSIST-IoT Open Call description and topics of interest, and a Q&A session. A capture of the meeting is reported in Figure 2.



Figure 2: BRAINE-ASSIST-IoT meeting

The project FRACTAL ("Cognitive Fractal and Secure Edge Based On Unique Open-Safe-Reliable-Low Power Hardware Platform Node") (https://fractal-project.eu/) is receiving funding from the ECSEL Joint Undertaking (JU) under grant agreement No 877056. The meeting dealt with possible sinergies between BRAINE and FRACTAL for joint activities and future proposal submissions. A follow-up meeting is planned in June 2022.

3.3. Standardization Dissemination

BRAINE' partners have participated to several standardization topics, security and cryptography, distributed computing, ontology for industrial applications, telecommunications, and of course, Edge related standards.

Standardization bodies and industrial associations we are working with are ISO/IEC, ETSI, NIST, Open RAN (O-RAN) Alliance, Open Grid Alliance and 5G-PPP, 3GPP, W3C/NFDI4Ing and we are also (modestly) contributing to open-source standard implementation projects.

On Security standardization at **ISO**, Secure-IC (SIC) has worked in 2022 on **ISO 17825** standard as lead editor. Work concerns standardization of side-channel evaluation methodology. Side-channels are security vulnerabilities, weakness or robustness measurement of implementation of cryptographic algorithms. Research involving several

partners done in WP4 and tested in WP5 were used to be foundation, evidences and examples for ISO 17825.

Then in 2023, Secure-IC has been pushing the novel version from DIS to FDIS (i.e., Draft to Final Draft) stage.



ISO/IEC JTC 1/SC 27/WG 3 N 2307

ISO/IEC JTC 1/SC 27/WG 3 "Security evaluation, testing and specification" Convenorship: UNE Convenor: Bañón Miguel Mr

ISO/IEC JTC 1/SC 27/WG 3 Recommendations, Virtual (via Zoom) April 04th – 8th, 2022

This standard normalizes methods to analyses and detected side-channel vulnerabilities on cryptographic modules. It is foreseen that the document will be accepted as an international standard at next WG3 meeting.

This novel edition considers the case of false positives, and has been shown suitable to evaluate PQC (Post-Quantum Cryptography) as well. Secure-IC is the main editor, after former lead editor (from USA NIST) retired.

In 2021, SIC (Pr Sylvain Guilley) did participate to 63rd **ISO/IEC JTC1/SC27/WG3** meeting (25-28 oct 2021) and submitted a new resolution for the Working Draft (WD) of standard. Recently, SIC has also participated to the "Information security, cybersecurity and privacy



protection — Verification of Cryptographic Protocols" working group of ISO/IEC JTC 1/SC 27/WG 3 meeting being held in 2022, April 4th. Area of contribution will be "Evaluation Methods and Activities for Cryptographic Protocols (WG 3 N2290)" and "Evaluation Methods and Activities for Protocol Implementation Verification (WG 3 N2291)".

In 2023, Secure-IC has been launching two international standards drafting at ISO/IEC JTC1/SC27/WG3 on "Cryptographic Protocols Verification".

With the increasing need for connectivity and vulnerability management, new cryptographic protocols are being developed. It is important to evaluate them from a theoretical manner and also, to evaluate their implementations. Those are the goals of the novel parts 2 and 3 of **ISO/IEC 29128**.

The main editor is Ritu-Ranjan Shrivastwa from Secure-IC. SIC (Secure-IC, Dr Sylvain Guilley) was rapporteur for ISO/IEC 29128-2/3 at ISO meeting (79th Meeting, Redmond, Washington, USA; April 17th – 21st, 2023).

ISO/IEC JTC 1/SC 27/WG 3 Recommendations

79th Meeting, Redmond, Washington, USA

April 17th - 21st, 2023

All recommendations are approved UNANIMOUSLY unless otherwise noted.

WG Recommendation 1. Acceptance of minutes

ISO/IEC JTC 1/SC 27/WG 3 recommends accepting the minutes of ISO/IEC JTC 1/SC 27/WG 3 of the 78th virtual meeting, October 3rd – 6th 2022, in document WG 3 N2409.

WG Recommendation 2. Appointment of the Drafting Committee

ISO/IEC_ITC_1/SC_27/WG_3_recommends_annointing_Kwangwoo_Lee_Mike_Grimm_and

Reference: WG Recommendation 4 "Approval of Project Editors/Co-Editors" from ISO/IEC JTC 1/SC 27/WG 3 recommendations (79th Meeting, Redmond, Washington, USA; April 17th – 21st, 2023).

Regarding Post-Quantum Cryptography, Secure-IC also attended to the ISO/IEC JTC 1/SC 27/WG 2 "Cryptography and security mechanisms" meeting in April in Redmond.

We report that it has been initiated an international standardization of 3 post-quantum key encapsulation mechanisms (KEM), namely Classic McEliece, FrodoKEM and Crystals-Kyber, and inclusion in **ISO/IEC 18033- 2**.



ISO/IEC JTC 1/SC 27/WG 2 N 3254

ISO/IEC JTC 1/SC 27/WG 2 "Cryptography and security mechanisms" Convenorship: JISC Convenor: Yoshida Hirotaka Dr



Justification for Initiating an Amendment tof ISO/IEC 18033-2

At **ETSI** (European Telecommunications Standards Institute), activities of SIC has included a conference on Quantum Safe Cryptography (at ETSI Quantum Safe Cryptography Technical Event), with acknowledgement to the BRAINE project.

ISW (IS-Wireless partner) was analyzing activities of ETSI related and relevant to the BRAINE developments, and especially the ENI (Experimental Networked Intelligence) workgroup.

Still at ETSI, Dell is setting up the following subject to be addressed:

- ETSI CYBER/5G-PPP Security WG: Secure data management at the edge
- ETSI CYBER/OASIS KMIP: Key management solutions
- ETSI MEC: Edge node orchestration and collaboration

Then, Dell's involvement in T6.3 primarily revolves around the standardization efforts concerning cutting-edge technologies for data management, privacy, and cryptography. A number of contributions are noted below:

1. ETSI CYBER/5G-PPP Security WG: Secure Data Management at the Edge

- **Problem:** One of the challenges faced by the 5G-PPP revolves around managing vertical SLAs and ensuring compliance with data regulations.
- **Dell's Solution:** Within the BRAINE project, Dell has been instrumental in developing key components, notably the SLA Broker and the Data Lifecycle Manager, to tackle these challenges.
- **Engagement with EU Standards:** Dell is actively engaging with prominent EU standards groups such as GAIA-X. The intent is to help define an international framework that addresses data privacy, management, and sharing.
- **Project Alvarium & LF-EDGE Foundation:** Further establishing its commitment, Dell is a foundational member and contributor to Project Alvarium. This initiative, in collaboration with the LF-EDGE foundation, seeks to establish a trusted Data Confidence Fabric (DCF) at the Edge.

2. ETSI CYBER/OASIS KMIP: Key Management Solutions

- **Evaluation:** Dell undertook a comprehensive assessment of Post-Quantum Cryptography (PQC) solutions during the BRAINE project. This was synchronous with ETSI's own evaluations.
- **Findings:** Dell's analysis highlighted that the PQC solutions, CRYSTALS-Kyber, CRYSTALS-Dilithium, Falcon, and SPHINCS+, possess merits tailored to specific user requirements. It's noteworthy that these PQC algorithms were officially standardized by NIST in July 2022.

3. ETSI MEC: Edge Node Orchestration and Collaboration

- **Contribution:** Dell has successfully culminated its contributions to the ETSI MEC standard, evidenced by the ETSI TR 103 747.
- Details of the Contribution: This standard involves Core Network and Interoperability Testing (INT/WG AFI); Federated GANA Knowledge Planes (KPs) for Multi-Domain Autonomic Management & Control (AMC) of Slices in the NGMN® 5G End-to-End Architecture Framework.
- **Design & Implementation:** Dell has significantly contributed to various technological facets within this standard, including Software Defined Networking, Network Function Virtualization, Service Orchestration, and platform Cognition.

At **NIST**, (US **N**ational Institute of **S**tandards and **T**echnology) SIC submitted an answer to the call for "Masked Circuits for Block-ciphers" for PQC (Post-Quantum Cryptography).

Regarding the **Open RAN (O-RAN) Alliance**, ISW, as a member of this organization, has followed the ORAN standards and especially the specifications prepared within the WG3 (nearRT-RIC).

ISW interests were mainly related to following the E2 interface and the specification of the non-standard information exchange. It was done in relation to the key performance measurements (KPM) that is delivered to the nearRT-RIC via the E2 interface.

Key performance metrics are crucial to the task T3.3 for performance metrics collection in order to populate the model data. Thanks to the proper collection of the performance metrics, it would be possible to expose such measurement towards xApps (on the north bound interface) and potentially also use it as inputs to the MEC servers in the future.

IS-Wireless was active in various plug-fests related to integration via ORAN interfaces for the 5G RAN. We have participated in various integration activities in order to assure our radio stack is best tuned to the edge architecture of EMDC node.

Regarding the **AIOTI (Alliance for Internet of Things Innovation)**, IS-Wireless (who is an alliance member) was tightly following the work of the Alliance in the task-force related to edge computing gaps analysis for an IoT. ISW has been investigating the key directions that are seen as enablers towards 6G (like digital twin, blockchain). These techniques and mechanisms will be supporting the future edge-based systems.

As a reminder, AIOTI mission is to lead, promote, bridge and collaborate in IoT & Edge Computing and other converging technologies research and innovation, standardization and ecosystem building providing IoT deployment for European businesses creating benefits for European society. We co-operate with other global regions to ensure removal of barriers to development of the IoT & Edge Computing market, while preserving the European values, including privacy and consumer protection.

For **Open Grid Alliance** and **5G-PPP** activities, VMW (VMWare) who is a founding member of the Open Grid Alliance, together with Dell, is following the work of the Alliance as its strategic reference for development. Towards the 5G-PPP, VMW is participating in one more initiative, the 5GASP (https://www.5gasp.eu/) EU project to help SMEs in reaching edge-facilities for easier certification of net appliances; standardization there is yet to take place and would love if we could align these efforts further if relevant.

Regarding activities with the **W3C standardization**, the main actor in the BRAINE consortium is IFX (Infineon) with interest in Web-Based Ontologies. More precisely, IFX is interested in investigation and efforts towards standardizing Digital Reference as Semantic Web based ontology representing semiconductor supply chains and supply chains containing semiconductors. Therefore, IFX is closely following and applying NFDI4Ing Terminology (Digital Reference Ontology) and pronounces further spread of the conceptual basis in parallel funded project efforts, such as CoyPu project (Cognitive Economy Intelligence Platform for the Resilience of Economic Ecosystems) for instance.

Digital Reference (DR) is a generic tool developed at Infineon Technologies AG, representing the semiconductor supply chain (and supply chain containing semiconductors) in a holistic ontology. This knowledge graph is a directed labeled graph in which the labels have well-defined meanings. It represents a collection of interlinked descriptions of entities – objects, events or concepts. Digital Reference puts data in context via linking and semantic metadata. DR as semantic web-based representations is complemented by more granular, application-specific ontologies (such as for UC05 in Arrowhead Tools). Moreover, the wireless communication sub-ontology as part of the Digital Reference serves as knowledge representation for edge computing capabilities, i.e., a link to BRAINE. Besides that, DR comes with a framework for data unification, integration, analytics and sharing. The current version can be accessed at: https://w3id.org/ecsel-dr.



The idea is that Digital Reference is a semantic representation, in other words a digital twin, of the whole semiconductor industry and of supply chains containing semiconductors, representing supply chain networks, digital production and product lifecycle management in particular. It consists of almost 1000 connected classes and is subject to continuous development to reflect the changing environment of the industry. Digital Reference can be understood by humans and computers. Digital Reference has been created as an outcome of the Productive 4.0 project. This project was launched in 2017 and was completed in 2020. Currently, Digital Reference is being further developed as part of the SC3 project and other funded projects,

where sub-ontologies are refined and developed.

Regarding the structure, each part of the Digital Reference represents processes of some particular area of the semiconductor industry.

Finally, regarding **open-source standards** implementation projects, MLNX (Mellanox) provided contribution to public implementation of OpenSSL (TLS tx, TLS sendfile, TLS rx functions).

4. Communications

Communication activities focused on disseminating the project results to the public and outside the scientific community strictly related to the BRAINE project. The main instruments to implement these activities are the project website and social media. An additional instrument are wider public publications and white papers. The other actions, unforeseen at the time of the project proposal submission, were put in place, such as Communication Talks delivered online (i.e., YouTube).

Project website was successfully maintained, and 27K unique visits were achieved. Social media and the Project YouTube channels were successfully maintained. Even in this case the initiatives to boost communication and reach a wider audience were executed, such as the "Ask BRAINE" webinars through the project YouTube channels.

More details on the single communications activities are reported in the following sections.

Communication Output	Target Indicator (overall)	Achievement
magazine/newsletter articles – wider public publications	5	25
White papers	5	2
Project website promotion	3000 visits/year	21K
Social media presence	Established groups in at least 2 networks (e.g., LinkedIn, Twitter); evidence of engagement with target audience, demonstrated via comments, sharing of regular updates.	LinkedIn, Twitter, Instagram successfully maintained and improved dissemination

Table 4-1 Communication activities

Website

The BRAINE website analytics were continuously monitored during the project duration. The most significant statistics include overall unique visitors and views. Along with that referring domain including Google, Twitter, Instagram, LinkedIn etc.

We monitored the statistical parameter of project website (<u>www.braine-project.eu</u>) using 'SmarterStats business analytics' tool. The screenshot of traffic trend is, shown in Figure 2, depicts that the website has reached 83K views and total of 51K visits during the last year of the project.



Traffic Trend

braine-project.eu 30/09/2022 - 12/10/2023

Traffic Trend

30/09/2022 - 12/10/2023 ---- Page Views --- Visits 25.000 20.000 15.000 10.000 5.000 0 Q3 2022 Q4 2022 Q1 2023 Q2 2023 Q3 2023 Q4 2023 Visits Hits Bandwidth Date **Page Views**

Q3 2022	0	0	0	0,0 MB
Q4 2022	24.460	11.082	92.160	2.170,5 MB
Q1 2023	18.449	13.570	95.195	1.576,0 MB
Q2 2023	19.516	14.314	62.893	1.055,7 MB
Q3 2023	18.475	11.282	56.517	982,4 MB
Q4 2023	2.334	1.288	9.519	173,0 MB
Total	83.234	51.536	316.284	5.957,6 MB

Figure 3: SmarterStats business analytics tool stats

Figure 3 reports the number of visualizations divided per month during the last year of the project. The new visits per quarter reached more than 2K views with peaks and valleys during different times of the year. Thus, the project website is effective in terms of dissemination and received visit during the complete duration of the project.



Visitors Trend

braine-project.eu 01/10/2022 - 02/11/2023



Figure 4: Number of views per quarter (Year3).

Instagram

BRAINE's Instagram profile (<u>https://www.instagram.com/braine_project/</u>) has reached 162 followers and 63 posts until M43 of the project as shown in the screenshot captured in Figure 4. During this year, the posts were mostly related to the development of BRAINE project and for the advertisement of seasonal school, research activities under the framework of BRAINE project.



Figure 4: Latest posts on Instagram profile

Twitter

Twitter account (<u>https://twitter.com/BraineProject</u>) has reached 173 followers till M43. In Figure 5, we present the screenshot of latest tweets and respective statistics. During this year, most of the posts were related to the development of BRAINE project and also for the advertisement of seasonal school, research activities under the framework of BRAINE project.



Figure 5: Twitter and respective statistics.

LinkedIn

The project LinkedIn page (<u>https://www.linkedin.com/company/braineproject/</u>) has reached 199 followers by the end of the project. During the last year the project gained twenty (20) followers. Figure 6 highlights the follower behavior during the last year of the project. Followers are not only within the project consortium but also outside the consortium, such as Brazil and Pakistan.



Figure 6: Statistical analysis related to followers of LinkedIn profile.

YouTube

During Year3 BRAINE <u>YouTube channel</u> (Figure 7) reached 52 subscribers with 1.5K viewing count. Figure 7 highlights the statistics of different videos uploaded on BRAINE Youtube channel. Among them, the most viewed videos are:

- 1. BRAINE Project. An introduction (172 views).
- 2. OFC 2021 Demo Zone (152).
- 3. WP4 User-oriented utilization of the edge (103 views).
- 4. Use Case 4 Industry 4.0. SC2 Semiconductor Supply Chain (90 views).
- 5. Ask BRAINE Artificial Intelligence in Edge Computing (276 views).

An important instrument that BRAINE exploited for communication through the YouTube channel, unforeseen during the proposal preparation and to counter-balance the COVID-19 negative impact on dissemination during the initial years of project, is the organization of panel series in live streaming: **"Ask BRAINE"**. An example is the panel on "Artificial Intelligence in Edge Computing (March 2021) that is the second most viewed video and during the livestream has reached a peak of concurrent views of 28 streams and received 276 unique viewers since it was published. Similarly, "Telemetry and Monitoring at the Edge" received 339 unique viewers since uploading.

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Figure 7: Youtube channel and analytical analysis of the channel.

Communication Talks and other actions

During the project, several press releases were issued to raise awareness about the project. Moreover, the list of white papers is given in *Table 4-2* and other communication activities in term of press release and all the news articles are given in Table 4-3. BRAINE project participated in several public events listed in Table 4-4.

#	Partners	Title	Site/Journal
1	Martin Ron FS	Quality Control by Motif Discovery Application Project BRAINE	https://www.factorio.cz/post/br aine-motif-discovery- whitepaper?lang=en
2	Sana Fateh, T.Donepudi, A. Korobko SYN	Effect of Nanoparticle Depositions on Surface Wettability for Boiling Heat Transfer	Online, company website: http://business.synano- cooling.com/about-us/

#	Partners	Title	Site/Journal	Date
1	РСВ	PCIe Switching	https://www.youtube.com/ watch?v=D6vVdt1j1sY	Feb 22, 2023
2	PCB	Edge server 48V Power distribution	New Tech Events - Tel Aviv	Nov 7-10, 2022
3	СОМ	SPRINT AHEAD IN 5G: START WITH A COMPLETE RADIO PLATFORM	O-RU Radio Platform Analog Devices	Jan 12, 2022
3	COM (Analog Devices)	SPRINT AHEAD IN 5G: START WITH A COMPLETE RADIO PLATFORM	https://www.analog.com/en /applications/technology/sd r-radioverse-pavilion- home/o-ru-radio- platform.html	Jan 12, 2022
4	COM (Analog Devices)	Analog Devices Announces Complete Radio Platform for 5G O- RAN Ecosystem	https://www.analog.com/en /about-adi/news- room/press- releases/2021/3-25-2021- analog-devices- announces-complete- radio-platform-5g-o-ran- ecosystem.html	March 25, 2021
5	UCC	BRAINE Project Consortium will help to position Europe at the forefront of the intelligent edge computing field	UCC website www.ucc.ie/en/compsci	Oct 27, 2022
6	WI3	5G, intelligenza artificiale e big data per le smart city: il progetto H2020 Braine	https://www.is- wireless.com/news/is- wireless-joins-braine- consortium/	Jan 20, 2021
7	SSSA	INTELLIGENZA ARTIFICIALE: SANT'ANNA DI PISA IN PROGETTO UE H2020 BRAINE	https://www.9colonne.it/26 3380/intelligenza- artificiale-sant-anna-di- pisa-in-progetto-ue-h2020- braine#.XwXIjXUzZhE	July 08, 2023
8	ITL	Italtel è partner del progetto BRAINE	https://www.italtel.com/it/it altel-is-part-of-braine/	June 04, 2022
9	SSSA	CITTA' INTELLIGENTE, SMART HOSPITAL, ROBOTICA E INDUSTRIA 4.0	https://www.santannapisa.i t/it/news/citta-intelligente- smart-hospital-robotica-e- industria-40-da-edge- computing-il-nuovo- approccio	July 07, 2020
10	SSSA	La Scuola Superiore Sant'Anna di Pisa nel progetto Braine	http://www.pisatoday.it/cro naca/progetto-braine- scuola-superiore- santanna-pisa.html	July 08, 2020
11	SSSA	Città smart, robotica, industria 4.0: Sant'Anna partner del progetto "Braine"	https://www.lanazione.it/pi sa/cronaca/sant-anna- robotica-braine-1.5301341	July 08, 2020
12	SSSA	5G, il prototipo implementato grazie all'istituto Tecip della Sant'Anna	https://www.gonews.it/202 0/07/08/5g-sant-anna-pisa/	July 08, 2020
13	SSSA	SMART CITY, TELEMEDICINA, ROBOTICA E INDUSTRIA 4.0: LA SANT'ANNA PARTNER DI 'BRAINE'	https://www.intoscana.it/it/t ecnologia/articolo/tecip- brain/	July 08, 2020

Table 4-3 Commun	ication activities: p	oublications/Maga	zine/Newsletter/Videos

14	SSSA	Ricerca, progetto Ue "Braine" per nuovi orizzonti edge computing	https://it.finance.yahoo.co m/notizie/ricerca-progetto- ue-braine-per-nuovi- orizzonti-edge- 095920812.html	July 08, 2020
15	SSSA	Ricerca, progetto Ue "Braine" per nuovi orizzonti edge computing	http://www.askanews.it/sci enza-e- innovazione/2020/07/08/ric erca-progetto-ue-braine- per-nuovi-orizzonti-edge- computing- pn_20200708_00081/	August 08, 2020
16	СОМ	Analog Devices Announces Complete Radio Platform for 5G O- RAN Ecosystem	Analog Devices Announces Complete Radio Platform for 5G O- RAN Ecosystem Analog Devices	March 25, 2021
17	SSSA	AI, Big Data, 5G: il progetto europeo H2020 "BRAINE" e il nuovo approccio alle architetture di rete	https://www.youtube.com/ watch?v=ZZ1n7EYT5FI&t =60s	July 07, 2020
18	Martin Ron (FS)	Quality Control by Motif Discovery Application	https://www.factorio.cz/pos t/braine-motif-discovery- whitepaper?lang=en	Mar 1, 2022
19	СОМ	ADI: 3.5GHz O-RAN O-RU Testing with Keysight DU Emulator	https://www.youtube.com/ watch?v=D6vVdt1j1sY	June 18, 2021
20	HID	Explanatory video about the eject tool		Oct 11, 2021
21	Comcores	Part 1: Opening the 5G Radio Interface - White Paper on O-RAN	https://www.design- reuse.com/articles/48029/a ccelerating-5g-virtual-ran- deployment.html	July 13, 2020
22	Comcores	Part 2: Opening the 5G Radio Interface - White Paper on O-RAN	https://www.design- reuse.com/articles/48289/o pening-the-5g-radio- interface.html	May 20, 2020
23	ITA TEL	Moving data processing from cloud to edge	https://research.italtel.com/ moving-data-processing- from-the-cloud-to-the- edge/	Dec 17, 2020
24	HIRO+ PCBD+HI D	Power density and efficiency drive scalable, high-performance edge computing	https://www.vicorpower.co m/resource-library/case- studies/hiro	Feb 01, 2022

Table 4-4 Communication activities: public events

#	Author	Partners	Title	Event
1	L. Valcarenghi, S. Fichera, J.C. Borromeo	SSSA	Star Trek (5G)SOSIA: an app transforms you in the Stat Trek physician	BRIGHT - European Researcher Night 2021
2	L. Valcarenghi	SSSA	5G for mobile health	Internet Festival 2021
3	C. Sreenan	UCC	Innovating for people, prosperity, planet (Panel)	it@cork TechFest
4	C. Sreenan	UCC	ADVANCE Summer School	ADVANCE Summer School

5	C. Sreenan	UCC	Research Overview	Workshop at Nokia Bell Labs
6	I. Tafur Monroy	TUE	Towards mass deployable QKD systems	Holland High Tech Event 2021
7	I. Tafur Monroy	TUE	Eindhoven Testbed	Quantum Delta Community Gathering
8	I. Tafur Monroy	TUE	The role of photonics in 6G systems	Benelux RF Conference
9	L. Valcarenghi	SSSA	Edge computing for sustainable development goals	Internet Festival 2022
10	Marcus Nordström	MAI	BRAINE UC2	Smart City Expo 2022
11	СТО	СТИ	Open Houses	
12	СТU	СТИ	Researcher's Night	BRIGHT - European Researcher Night 2022

5. Conclusion

This report outlined the project's work by WP6 to assist and to support BRAINE in terms of Communication, Dissemination, Collaboration and Standardisation. We provided the statistics and summary of all the activities carried out during the period of the project. Despite the COVID-19 pandemic during the initial period of the project, BRAINE dissemination and communication activities progressed well.

During the last year, the main dissemination activities were focused on multiple aspects including academic and industrial dissemination in terms of scientific publications. Thanks to the availability of BRAINE 1.0 components and solutions, industrial dissemination increased during Year 2 and Year 3. Indeed, demonstration of prototypes and talks at industry-dominated events were eleven and meeting with business units and commercial staff of industry are thirty-two at the end of project. In terms of publications, during the third year, the number of conference publications overcame the target of 20 per year with 36 accepted papers and it adds to the total count of sixty-seven conference publications. Apart from that, the number of journals were the double of the target with the total of twentyfour journal publications in Q1 and Q2 of the Scimago ranking (https://www.scimagojr.com/). Total of twelve talks and public events were conducted to spread the information and awareness of the project.

For what concerns communication activities, the project attracted a lot of attention both through the website and social media evident through the statistical parameter given in the form of graphs and tables by SmartStats tool. Several newsletter and magazine articles (twenty-five in total) were published during the period of the project and listed in tables.

For what concerns standardisation activities, BRAINE partners participated to the activities of Standardization bodies and industrial associations, such as ISO/IEC, ETSI, NIST, Open RAN (O-RAN) Alliance, Open Grid Alliance and 5G-PPP, 3GPP, W3C/NFDI4Ing and we are also contributing to open-source standard implementation projects.