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UNICORE

UNICORE: A Common Code Base and Toolkit for Deployment of Applications to Secure and Reliable Virtual Execution Environments

Horizon 2020 - Research and Innovation Framework Programme

D6.5 Final Report on Communication and Dissemination Activities

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Abstract

The goal of the EU-funded UNICORE project is to develop a common code-base and toolchain that will enable software developers to rapidly create secure, portable, scalable, high-performance solutions starting from existing applications. The key to this is to compile an application into very light-weight virtual machines – known as unikernels – where there is no traditional operating system, only the specific bits of operating system functionality that the application needs. The resulting unikernels can then be deployed and run on standard high-volume servers or cloud computing infrastructure.

This deliverable reports on the achievements of the UNICORE project during the whole project for what concerns the activities of communication and dissemination executed by the Consortium.

Target Audience

The target audience for this document is **public**.

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Impressum

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Executive Summary

The UNICORE project has developed tools to enable lightweight virtual machines (VM) development to be as easy as compiling an app for an existing operating system (OS), thus unleashing the use of the next generation of cloud computing services and technologies. With UNICORE toolchains for unikernels, software developers will be able to easily build and quickly deploy lightweight VM starting from existing applications. During its Year 3, the UNICORE Consortium continued to work along the following main streams of actions to achieve its expected impacts:

- **Publications in top academic conferences**, which continued at a great pace despite the impact of lockdown measures due to pandemic;
- **Open-source development and community building**, which focused on consolidating the ongoing developments for UNIKRAFT, improving the site for the toolchain (<https://unikraft.org>) and continuing engaging with the FOSS community interested in unikernels;

The dissemination and communication strategy followed in Year 3 (+ 3 months extension) continued to focus on the presentation of the core UNICORE concepts and solutions for Linux kernels and security in top-tier scientific forums and international conferences. The communication campaign followed the scientific publication stream and generated awareness in the large network of industry and academia connected to the Consortium about the research progress. Key results achieved by the project in Year 3 (+3 months 2022) can be summarized as follows:

- **15** scientific papers published to relevant conferences and important events;
- **14** UNICORE/Unikraft presentations given in well-known international events;
- **1** public unikraft tutorial given (ASPLOS 2022);
- Number of UNICORE's website **users increased 112.41%** in 2021 (2,961 vs 1,394 in 2020);
- Continued a significant presence on socials: 180 followers on Twitter with 46 published tweets with **29,598 impressions, 863 engagements**, 119 link clicks, 76 retweets, 194 likes and 12,675 user profile clicks;

The achieved results confirm a good progress on all the KPIs set by the project despite the hard times due to COVID-19 lockdown measures.

If we consider the full period (2019-22), key results achieved can be summarized as follows:

- **30** scientific papers published to relevant conferences and important events;
- **51** UNICORE/Unikraft presentations given in well-known international events;
- **3** public unikraft tutorials given;
- Since 2019, the website data has obtained **5,295 unique visitors that viewed 18,044 pages** and loaded an average of 2.21 pages per session;
- The project video published in the project YouTube channel got **414 views** since November 2019;
- Significant presence on socials: 406 published tweets with **150,915 impressions in total, 2,202 engagements**, 476 retweets, 235 likes, and 22,097 user profile clicks.

UNICORE progress on communication and dissemination is shown below (see Fig. 1.1). In addition to these activities, a final press release is being written to present results and the use cases.

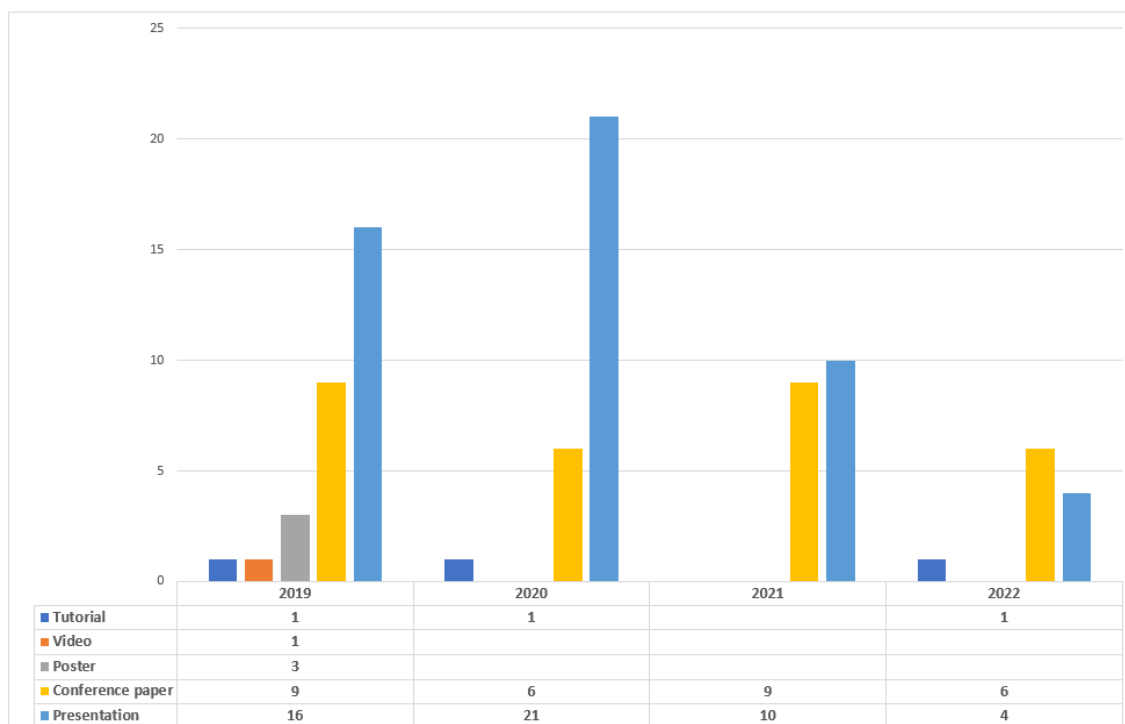


Figure 1.1: UNICORE dissemination log (2019-2022)

List of Authors

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1 Introduction

This document reports on the achievements of the entire UNICORE project (Jan 2019-March 2022) for all the communication and dissemination executed by the Consortium.

In addition, Year 3 and the 3 Months extension in 2022 are explained as well, as no deliverable has been submitted for this period. The document is organized in two main chapters corresponding to different types of activities as follows:

- Chapter 2 reports on the dissemination and communication and public activities undertaken jointly by the Consortium and individually by the partners for the whole project and, in some cases, breaking down information into periods.
- The conclusions in chapter 3 summarize the key relevant aspects and results of the Consortium in terms of impact and achievements.

2 Communication and Dissemination Activities

2.1 Scientific Publications

The following publications occurred since the beginning of the project. Several papers have been distinguished and are highlighted in bold:

2019

1. Osterlund, S., Koning, K., Olivier, P., Barbalace, A., Bos, H. and Giuffrida, C., 'kMVX: Detecting Kernel Information Leaks with Multi-variant Execution', 24th ACM International Conference on Architectural Support for Programming Languages and Operating Systems, April 13th April 17th, Providence, RI, USA. DOI: <https://doi.org/10.1145/3297858.3304054>
LINK: https://download.vusec.net/papers/kmvx_asplos19.pdf
2. Cojocar, L., Razavi, K., Giuffrida, C. and Bos, H., 'Exploiting correcting codes: On the effectiveness of ECC memory against rowhammer attacks', **BEST PAPER AWARD, 2019** IEEE Symposium on Security and Privacy (SP), May 20-22 2019, San Francisco, CA, US.
DOI: <https://doi.org/10.1109/SP.2019.00089>
LINK: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8835222>
3. Van Schaik, S., Milburn, A., sterlund, S., Frigo, P., Maisuradze, G., Razavi, K., Bos, H. and Giuffrida, C., 'RIDL: Rogue In-Flight Data Load', **INTEL BOUNTY REWARD, 2019** IEEE Symposium on Security and Privacy (SP), May 20-22 2019, San Francisco, CA, US.
DOI: <https://doi.ieeecomputersociety.org/10.1109/SP.2019.00087>
LINK: <https://www.ieee-security.org/TC/SP2019/papers/588.pdf>
4. Kuenzer, S., Santhanam, S., Volchkov, Y., Schmidt, F., Huici, F., Nider, J., Rapoport, M. and Lupu, C., 'Unleashing the power of unikernels with unikraft', 12th ACM International Conference on Systems and Storage - SYSTOR'19, Haifa, Israel June 03 - 05, 2019.

DOI: <https://doi.org/10.1145/3319647.3325856>

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5. Nider, J., Rapoport, M. and Bottomley, J., 'Address space isolation in the linux kernel', 12th ACM International Conference on Systems and Storage - SYSTOR'19, Haifa, Israel June 03 - 05, 2019. DOI: <https://doi.org/10.1145/3319647.3325855>
LINK: <https://dl.acm.org/doi/10.1145/3319647.3325855>
6. van der Kouwe, E., Heiser, G., Andriessse, D., Bos, H. and Giuffrida, C., 'SoK: Benchmarking flaws in systems security.', 4th IEEE European Symposium on Security and Privacy, June 17-19, 2019 in Stockholm, Sweden.
DOI: <https://doi.org/10.1109/EuroSP.2019.00031>
LINK: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8806739>
7. Constantin, I., Patachia, C., Patrascu, C., Avadanei, A., Nitorescu, L., 'Threat Classification in Current Communication Infrastructures', 11th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), pp. 1-6, 27-29 June 2019, Pitesti, Romania.
DOI: <https://doi.org/10.1109/ECAI46879.2019.9042079>
LINK: <https://ieeexplore.ieee.org/document/9042079>
8. Hong, S., Frigo, P., Kaya, Y., Giuffrida, C. and Dumitra, T., 'Terminal Brain Damage: Exposing the Graceless Degradation in Deep Neural Networks Under Hardware Fault Attacks', 28th USENIX Security Symposium, Aug 14-16, 2019 Santa Clara, CA, USA.
DOI: <https://arxiv.org/abs/1906.01017>
LINK: <https://www.usenix.org/system/files/sec19-hong.pdf>
9. Pawlowski, A., van der Veen, V., Andriessse, D., van der Kouwe, E., Holz, T., Giuffrida, C. and Bos, H., 'VPS: excavating high-level C++ constructs from low-level binaries to protect dynamic dispatching', 35th Annual Computer Security Applications Conference, ACSAC 2019, Dec 9-13 2019, San Juan, Puerto Rico. DOI: <https://doi.org/10.5281/zenodo.3523939>
LINK: <https://dl.acm.org/doi/10.1145/3359789.3359797>

2020

10. Enes Gkta, Kaveh Razavi, Georgios Portokalidis, Herbert Bos, and Cristiano Giuffrida. 2020. Speculative Probing: Hacking Blind in the Spectre Era. In Proceedings of the 2020 ACM SIGSAC Conference on Computer and Communications Security (CCS 20), November 9-13, 2020, Virtual Event, USA. ACM, New York, NY, USA, 15 pages.
DOI: <https://doi.org/10.1145/3372297.3417289>
LINK: https://download.vusec.net/papers/blindside_ccs20.pdf
11. Koschel, J.; Giuffrida, C.; Bos, H.; and Razavi, K. TagBleed: Breaking KASLR on the Isolated Kernel Address Space Using Tagged TLBs. In 2020 IEEE European Symposium on Security and Privacy (EuroS&P3), 2020, pp. 309-321.
DOI: 10.1109/EuroSP48549.2020.00027
LINK: https://download.vusec.net/papers/tagbleed_eurosp20.pdf
12. Frigo, P.; Vannacci, E.; Hassan, H.; van der Veen, V.; Mutlu, O.; Giuffrida, C.; Bos, H.; and Razavi, K. TRRespass: Exploiting the Many Sides of Target Row Refresh. In 2020 IEEE Symposium on Security and Privacy (SP), San Francisco, CA, USA, 2020, pp. 747-762. Best Paper Award, Pwnie Award for Most Innovative Research.
DOI: <https://doi.org/10.1109/SP40000.2020.00090>
LINK: https://download.vusec.net/papers/trrespass_sp20.pdf
13. Kurth, M.; Gras, B.; Andriess, D.; Giuffrida, C.; Bos, H.; and Razavi, K. NetCAT: Practical Cache Attacks from the Network. 2020 IEEE Symposium on Security and Privacy (SP), San Francisco, CA, USA, 2020, pp. 20-38. **Intel Bounty Reward, Pwnie Award Nomination for Most Innovative Research.**
DOI: <https://doi.org/10.1109/SP40000.2020.00082>
LINK: https://download.vusec.net/papers/netcat_sp20.pdf
14. Gras, B.; Giuffrida, C.; Kurth, M.; Bos, H.; and Razavi, K. ABSynthe: Automatic Blackbox Sidechannel Synthesis on Commodity Microarchitectures. In NDSS, February 2020.
LINK: https://download.vusec.net/papers/absynthe_ndss20.pdf

15. S. Santhanam et al., "Towards Highly Specialized, POSIX -compliant Software Stacks with Unikraft: Work-in-Progress," 2020 International Conference on Embedded Software (EMSOFT), 2020, pp. 31-33.

DOI: [10.1109/EMSOFT51651.2020.9244044](https://doi.org/10.1109/EMSOFT51651.2020.9244044)

LINK: <https://ieeexplore.ieee.org/document/9244044>

2021

16. Felipe Huici: Unikraft: Fast, Specialized Unikernels the Easy Way. In EuroSys '21: Proceedings of the Sixteenth European Conference on Computer Systems, April 2021, pp. 376–394. DOI: <https://doi.org/10.1145/3447786.3456248>

LINK: <https://dl.acm.org/doi/10.1145/3447786.3456248>

17. Hugo Lefeuvre: FlexOS: Making OS Isolation Flexible. In HotOS '21: Proceedings of the Workshop on Hot Topics in Operating Systems, June 2021, pp. 79–87.

DOI: <https://doi.org/10.1145/3458336.3465292>

LINK: <https://dl.acm.org/doi/10.1145/3458336.3465292>

18. Giuffrida, C.; Borrello, D.; Cono, D.; Querzoni, L: Constantine: Automatic Side-Channel Resistance Using Efficient Control and Data Flow Linearization. In CCS '21: Proceedings of the 2021 ACM SIGSAC Conference on Computer and Communications Security, November 2021, pp. 715–733.

DOI: <https://doi.org/10.1145/3460120.3484583>

LINK: <https://www.sigsac.org/ccs/CCS2021/conference-program.html>

19. Ragab, H.; Barberis, E.; Bos, H.; and Giuffrida, C.: Rage Against the Machine Clear: A Systematic Analysis of Machine Clears and Their Implications for Transient Execution Attacks. In USENIX Security, August 2021. **Distinguished Paper Award, Intel Bounty Reward, Mozilla Bounty Reward, Pwnie Award Nomination for Most Innovative Research, Pwnie Award Nomination for Best Privilege Escalation Bug, Pwnie Award Nomination for Best Client-Side Bug, Pwnie Award Nomination for Epic Achievement, CSAW Best Paper Award Runner-up .**

LINK: <https://bibbase.org/network/publication/ragab-barberis-bos-giuffrida-rageagains>

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20. de Ridder, F.; Frigo, P.; Vannacci, E.; Bos, H.; Giuffrida, C.; and Razavi, K.: SMASH: Synchronized Many-sided Rowhammer Attacks From JavaScript. In USENIX Security, August 2021. **Pwnie Award Nomination for Most Under-Hyped Research, Best Faculty of Science Master Thesis Award.**
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21. Bhat, K.; van der Kouwe, E.; Bos, H.; and Giuffrida, C.: FIREstarter: Practical Software Crash Recovery with Targeted Library-level Fault Injection. In DSN, June 2021.LINK:<https://bibbase.org/network/publication/bhat-vanderkouwe-bos-giuffrida-firestarterpracticalsoftwarecrashrecoverywithtargetedlibrarylevelfaultinjection-2021>
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24. Jung, A.; Lefeuvre, H.; Rotsos, D.; Olivier, p.; Oñoro-Rubio, D.; Huici, F.; Niepert, M.: 2021. Wayfinder: towards automatically deriving optimal OS configurations. Proceedings of the 12th ACM SIGOPS Asia-Pacific Workshop on Systems. Association for Computing Machinery, New York, NY, USA, 115–122.
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LINK: <https://arxiv.org/pdf/2112.06566.pdf>
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LINK: https://download.vusec.net/papers/dupefs_fast22.pdf

Technical reports and pre-prints

1. Enis Ceyhun Alp, Cristina Băescu, Pasindu Tennage, Noémien Kocher, Gaylor Bosson, and Bryan Ford: Efficient Deterministic Execution of Smart Contracts. EPFL Working Paper, March 2022.

LINK: <https://infoscience.epfl.ch/record/292907?&ln=en>

2.2 Participation to Talks/Posters/Panels/Webinars/Workshop

Tutorials

2019

1. Simon Kuenzer, 'Unikraft: Unikernels Made Easy', FOSDEM 2019, Brussels (BE), 2-3 Feb 2019.

LINK: https://archive.fosdem.org/2019/schedule/event/unikraft_made_easy

VIDEO: https://video.fosdem.org/2019/AW1.121/unikraft_made_easy.webm

Industry events

2019

1. C. Lupu, 'Is the Hypervisor the New Kernel?', EuroSys, Doctoral Workshop, 25-28 March 2019, Dresden, Germany.
2. Kuenzer, S., Santhanam, S., Volchkov, Y., Schmidt, F., Huici, F., Nider, J., Rapoport, M. and Lupu, C., 'Unleashing the power of unikernels with unikraft', 12th ACM International Conference on Systems and Storage - SYSTOR'19, Haifa, Israel June 03 - 05, 2019.
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DOI: <https://doi.org/10.1145/3319647.3325855>
4. J. Guijarro, 'UNICORE Project: Unikernel Power', OpenNebula Techday, 8 May 2019, Barcelona, Spain.

- LINK: https://www.slideshare.net/CSUC_info/unicore-project-unikernel-power
<https://opennebula.io/wrap-up-of-techday-barcelona-8may19>
5. L. Mathy (speaker), F. Huici, 'Unikraft: Unikernels for NFV', The 3rd Future Network Development Conference, Nanjing, China.
 6. X. Peralta, 'Another Step Beyond Containers', Jornadas Técnicas RedIRIS, 28/30 May 2019, Sevilla, Spain.
LINK: <https://tv.rediris.es/es/jjtt2019/video/5ce6bb06cc464677048b45b7>
 7. Cristian Patachia & Orange CEO, 'UNICORE Presentation by Orange', Digital Assembly, 13-14 June 2019, Bucharest Romania.
LINK: <https://ec.europa.eu/digital-single-market/events/cf/digital-assembly-2019/programme.cfm?id=465>
 8. S. Santhanam, S.Kuenzer, F. Huici, 'Building DPDK Unikernel with Unikraft', DPDK Summit 2019, Shanghai, China.
LINK: <https://www.youtube.com/watch?v=lfjCz0wV7hs&list=PLo97Rhbj4ceIppqgEWAc6nWfaIuldgDH5h&index=8&t=0s>
 9. Alexandre Chartre, Mike Rapoport, James Bottomley, Joel Nider, 'Kernel Address Space Isolation', Linux Plumbers, 9-11 September 2019, Lisbon, Portugal.
LINK: <https://www.linuxplumbersconf.org/event/4/contributions/277/>
VIDEO: https://www.youtube.com/watch?v=rp_WawkcHeU
 10. Mike Rapoport, 'Memory management bits in arch/*', Kernel Summit, 9-11 September 2019, Lisbon, Portugal.
LINK: <https://linuxplumbersconf.org/event/4/contributions/550>
VIDEO: <https://www.youtube.com/watch?v=KGaEiTBvJOA>
 11. Mike Rapoport, James Bottomley, 'Address Space Isolation for Container Security', Linux Plumbers, 9-11 September 2019, Lisbon, Portugal.
LINK: <https://www.linuxplumbersconf.org/event/4/contributions/431>
VIDEO: https://www.youtube.com/watch?v=rp_WawkcHeU

12. Mike Rapoport, James Bottomley, 'Address Space Isolation inside Linux Kernel', Open Source Summit Europe, 28-30 October 2019, Lyon, France.
LINK: <https://sched.co/TPGq>
13. Mike Rapoport, 'Boot Time Memory Management', Embedded Linux Conference Europe, 28-30 October 2019, Lyon, France.
LINK: <https://sched.co/TLEU>
VIDEO: <https://www.youtube.com/watch?v=NP7wU7A218k>
14. Mike Rapoport, James Bottomley, 'Address Spaces for Namespaces', Linux Security Summit Europe, 31 October - 1 November 2019, Lyon, France.
LINK: <https://sched.co/TynJ>
VIDEO: <https://www.youtube.com/watch?v=CrsLqYjmq4&list=PLbzoR-pLrL6rF8E5yyknJzrVQaHeYszTR&index=17>

2020

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LINK: https://archive.fosdem.org/2020/schedule/event/kernel_address_space_isolation
VIDEO: https://video.fosdem.org/2020/K.1.105/kernel_address_space_isolation.webm
16. Constantin, I. Cloud Cyber Security Course. Orange Education Program, Technical University of Iași, Alexandru Ioan Cuza University of Iași. Romania (RO), 8 April 2020.
LINK: https://profs.info.uaic.ro/~springschool/Presentations/2020/Day1/OEP_CLOUD_CYBER_SECURITY.pdf
17. Constantin, I. Cloud Cyber Security Course. Orange Education Program, Ovidius University of Constanta. Romania (RO), 6 May 2020.
18. Constantin, I. Mobile Devices Security. Orange Education Program, Polytechnic University of Bucharest, ETTI. Romania (RO), 11 May 2020.

19. Huici, F., Kuenzer, S., Santhanam, S. Unikraft Weather Report. Xen Developer & Design Virtual Summit 2020, Bucharest, Romania (RO), 6 July 2020.
LINK: <https://xen2020.sched.com/event/baWR/keynote-session-unikraft-weather-report-felipe-huici-sharan-santhanam-nec-laboratories-europe-gmbh>
20. Constantin, I. Mobile Devices Security Course. Orange Education Program, Polytechnic University of Bucharest, ETTI. Romania (RO), 17 July 2020.
21. Constantin, I. Cloud Cyber Security Course. Orange Education Program, Polytechnic University of Bucharest, ETTI. Romania (RO), 20 July 2020.
22. Rapoport, M. Address Space Isolation in the Linux Kernel. Open Source Tech Conference 2020. Online, 10 August 2020.
LINK: <https://ostconf.com/en/materials/2835>
23. Rapoport, M., Bottomley, J. Memfd Secret Memory Areas. Google Linux Kernel Exchange. 13 August 2020.
24. Rapoport, M. Memory Management Bits in arch. Linux Plumbers Conference 2020. Online, 25 August 2020.
LINK: <https://linuxplumbersconf.org/event/7/contributions/666>
25. Rapoport, M. Restricted Kernel Address Spaces. Linux Plumbers Conference 2020. Online, 27 August 2020.
LINK: <https://linuxplumbersconf.org/event/7/contributions/660>
26. Constantin, I. Cybersecurity in the New Reality. CIO Council Romania Virtual Summit. Online, 16 Sept. 2020.
LINK: <https://www.cioconference.ro>
VIDEO: <https://www.youtube.com/watch?v=5PwLWTvGpGk>
27. Huici, F. Towards Highly Specialized POSIX-compliant Software Stacks with Unikraft. International Conference on Embedded Software (EMSOFT). Online, 20 Sept. 2020.
DOI: <https://doi.org/10.1109/EMSOFT51651.2020.9244044>

- LINK:<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9244044&isnumber=9244012>
28. Huici, F. Towards Highly Specialized POSIX-compliant Software Stacks with Unikraft. Linaro Virtual Connect 2020. Online, 22 Sept. 2020.
LINK: <https://connect.linaro.org/resources/lvc20/lvc20-107>
29. Huici, F., Santhanam, S. Extremely Fast and Efficient NFV with Unikraft. Open Source Summit. Online, 29 Sept. 2020.
LINK:<https://osseu2020.sched.com/event/eE18/extremely-fast-and-efficient-nfv-with-unikraft-sharan-santhanam-nec-laboratories-europe-gmbh>
30. Constantin, I. 5G Toolbox: The Instrument of the Future. CERTCON10, The New Global Challenges in Cyber Security. 22 Oct. 2020.
LINK: <https://cert.ro/certcon10/agenda/#agenda>
31. Constantin, I. Constientizarea si mitigarea amenintarilor actuale. Doing Business Webinar. 16 Nov. 2020.
32. Orange Business. Orange Business Internet Security Report, 3rd edition. 2020.
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33. Kuenzer, S. Cut your Cloud Computing Costs by Half with Unikraft. Linux.com. 15 Dec. 2020.
LINK:<https://www.linux.com/news/cut-your-cloud-computing-costs-by-half-with-unikraft>
- 2021**
34. Simon Kuenzer, 'Severely Debloating Cloud Images with Unikraft'. FOSDEM, 06 February 2021.
LINK: https://fosdem.org/2021/schedule/event/vai_cloud_images_unikraft
VIDEO:https://video.fosdem.org/2021/D.virtualization/vai_cloud_images_unikraft.webm

35. Xavier Peralta, 'Unikernels in Practice: A UNICORE Serverless Use Case', H-Cloud Technical Community Event, 23 March 2021.
LINK: <https://www.h-cloud.eu/event/h-cloud-technical-community-event>
36. Felipe Huici, 'Unikraft Weather Report', Xen Summit, 25 May 2021.
LINK: <https://xen2021.sched.com/event/jAEm>
37. Felipe Huici, 'It's Time to Debloat the Cloud with Unikraft', USENIX LISA, 1 June 2021. LINK: <https://www.usenix.org/conference/lisa21/presentation/huici>
VIDEO: https://youtu.be/L_HHEsxpY
38. Mike Rapoport, 'Consolidating representations of the physical memory', Linux Plumbers Conference, 20 September 2021, virtual.
LINK: <https://lpc.events/event/11/contributions/987>
VIDEO: https://www.youtube.com/watch?v=pQ_Goasu3jM
39. Mike Rapoport, 'Direct Map Management', Linux Plumbers Conference, 24 September 2021.
LINK: <https://linuxplumbersconf.org/event/11/contributions/1127>
VIDEO: <https://www.youtube.com/watch?v=egC7ZK4pcnQ>
40. Mike Rapoport, James Bottomley, 'Restricted Address Spaces for Container Security', Open Source Summit 2021, 28 September 2021.
LINK: <https://sched.co/IAOV>
VIDEO: <https://www.youtube.com/watch?v=FCWbWC2K3P0>
41. James Bottomley, Mike Rapoport, 'Analysing and Improving the Security Properties of Secret Memory', Linux Security Summit 2021, 1 October 2021.
LINK: <https://sched.co/ljRf>
VIDEO: <https://www.youtube.com/watch?v=asqtqD0D3IY>
42. Alexander Jung, 'Deploying Unikernels in Production with Kubernetes', KubeCon + CloudNative North America 2021, October 11-15 2021.
LINK: <https://kccncna2021.sched.com/event/IV2y/deploying-unikernels-in-product>

ion-with-kubernetes-alexander-jung-lancaster-university

VIDEO: https://www.youtube.com/watch?v=cV-xawN9_cg

43. Costin Lupu, 'Cloning Unikernels on Xen', XenSummit '21, May 25-28 2021.
LINK: <https://xen2021.sched.com/event/jAME/cloning-unikernels-on-xen-costin-lupu-university-politehnica-of-bucharest>

2022

44. Simon Kuenzer, Marc Rittinghaus, 'Debugging and Monitoring in Unikraft. Everything beyond print', FOSDEM, 5 February 2022.
LINK: <https://fosdem.org/2022/schedule/event/skuenzer>
VIDEO: <https://video.fosdem.org/2022/D.microkernel/skuenzer.webm>
45. Alexander Jung, 'Massive Unikernel Matrices with Unikraft, Concourse and More. How Unikrafts builds many permutations of unique unikernels', FOSDEM, 6 February 2022.
LINK: https://fosdem.org/2022/schedule/event/massive_unikernel_matrices_with_unikraft_concourse_and_more
VIDEO: https://video.fosdem.org/2022/D.cicd/massive_unikernel_matrices_with_unikraft_concourse_and_more.webm
46. Cezar Crăciunoiu, Unikraft Performance Monitoring with Prometheus, FOSDEM, 6 February 2022.
LINK: <https://fosdem.org/2022/schedule/event/unikraft>
47. Hugo Lefeuvre; Jan Tobias Muehlberg: Rethinking the OS for Isolation Flexibility with FlexOS. In FOSDEM, February, 2022.
LINK: https://fosdem.org/2022/schedule/event/tee_flexos
VIDEO: https://video.fosdem.org/2022/D.trusted-hardware/tee_flexos.webm

Academic events

2019

48. Gauthier, G., Soldani, C. and Mathy, L., 'UNICORE: A toolkit to automatically build unikernels', Grascomp Doctoral Day, 22 November 2019, Namur, Belgium.

LINK:https://orbi.uliege.be/bitstream/2268/244842/2/gauthiergain_gdd2019_slides.pdf

49. S.Kuenzer, 'Unikernels Made Easy with Unikraft', 14th Workshop on Virtualization in High-Performance Cloud Computing (VHPC'19), Frankfurt Germany.

LINK: <https://vhpc.org>

2020

50. Kuenzer, S. Unikraft A Unikernel Toolkit. 15th Workshop on Virtualization in High-Performance Cloud Computing. Online. 25 June 2020.

LINK: <https://vhpc.org>

51. Kuenzer, S. Specialized and Secure Unikernels with Unikraft. Herbstreffen 2020 in Aachen - GI Fachgruppentreffen Betriebssysteme. 24 Sept. 2020.

LINK:<https://www.betriebssysteme.org/aktivitaeten/treffen/2020-aachen/programm>

2.3 Demonstrations, Hackathons and Tutorials

During the KOM in Haifa, NEC organized a demo on Unikraft for the rest of technical partners as a part of the technical introduction to the project.

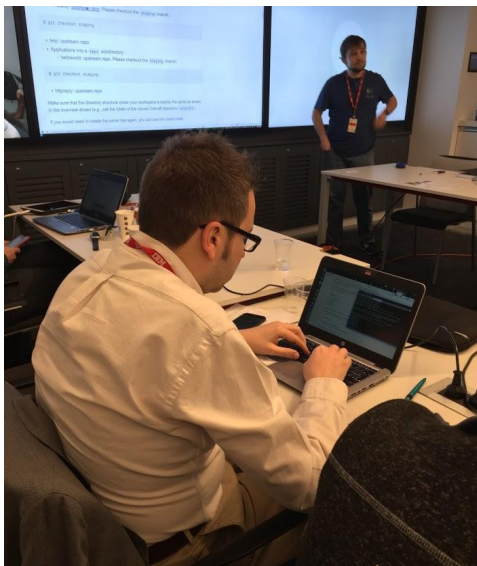


Figure 2.1: Demo on Unikraft during the KOM

Moreover, with the occasion of the face to face plenary meetings, a couple of Coding Days were organized also.

The first one took place in Bucharest (Romania), at the UPB facilities on 26 June 2019, jointly with the first F2F general meeting.

The second coding day was organized before the technical and admin meetings also, on 12 November 2019 in Barcelona (ES), and it was a starting point for porting the use-cases to Unikraft.

In 2020 (September 24th), UNICORE project partners held several technical presentations and an integration meeting virtually with the aim of making progress in the use cases. Partners involved in software development activities (NEC, Vrije Universiteit Amsterdam, University of Liege, University Politehnica of Bucharest and IBM) gave a presentation on kraft and how it works, memory deduplication and the current status of the toolchain, and Dafny scheduler, among other topics, with the participation of 25 people.



Figure 2.2: Second coding day in Barcelona (2020)

This way partners working to show UNICORE's applicability to a wide range of areas (cloud computing, telecom operators, home automation/IoT and smart contracts) received the latest update on technical progress and could solve doubts related to the deployment of the use cases.

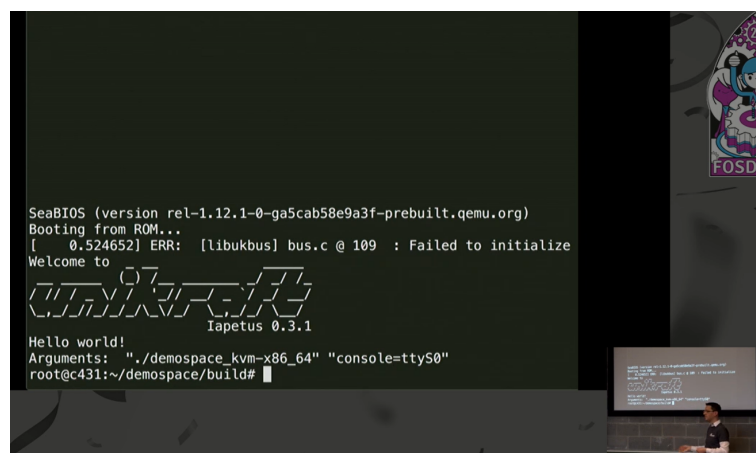


Figure 2.3: Public Unikraft tutorial by Simon Kuenzer (NEC Labs) at FOSDEM 2020

Moreover, UNICORE gave one public Unikraft tutorial (FOSDEM 2020) by Simon Kuenzer (NEC Labs) to update the Unikraft open source project to the audience, reviewing all the achievements and shedding light into recent project directions: binary compatibility (Linux

ABI), support for a wide range of compiled and interpreted languages (e.g., web assembly, Go, Python, Ruby, etc.), enhanced safety features, and the ability to seamlessly produce images ready to run as extremely lean VMs, containers, or directly on bare metal. The goal under this tutorial was to make clear that Unikraft will represent a step forward towards wider adoption of unikernels beyond the research community. UNICORE also gave a Unikraft tutorial (ASPLOS 2022) by Razvan Deaconescu, Alexander Jung, Hugo Lefeuve, Vlad Bădoiu, Cristian Vijelie and Pierre Olivier, to present Unikraft, a unikernel SDK aiming for extreme specialization (see Fig. 2.4). The tutorial consisted of a short presentation/demo of 10-15 minutes followed by practical work to be done by each attendee on their allocated remote machine. Trainers from the Unikraft community provided instructions and support during the tutorial.



Figure 2.4: Pierre Olivier (University of Manchester) during his talk at ASPLOS 2022

In addition to these activities, a Unikraft tutorial to help users to build a unikernel is available on the UNICORE website (<https://unicore-project.eu/tutorials>) and the Unikraft team provides and stimulates also a forum (<https://unikraft.org/community>) for public discussions (on Discord, <https://discord.com/invite/RG5ZQGKxyW>) and shares all the public

development and management on GitHub (<https://github.com/unikraft>), where they use guidelines for development and maintenance to ensure the creation of high quality code.

The Unikraft community organizes a weekly hackathon aiming to both help contributors with their work and to get open source contributions to the Unikraft project. Summary of results are presented in a public repository of meeting notes, together with notes from other community meetings (<https://github.com/unikraft/meeting-notes/tree/staging/hackathons>).

2.4 Workshops

Unikraft held the Unikraft Summer of Code, a Unikernel and library Operating Systems workshop organized by members of the Unikraft community including professors, lecturers, PhD and MSci students from University POLITEHNICA of Bucharest, Lancaster University, Manchester University, University of Liège and industry partners NEC Labs Europe GmbH. This was a free two week event. Different topics were included, such as building unikernels, benchmarking, debugging, porting applications, virtualization and platform specifics.

All the videos are available on Youtube (<https://tinyurl.com/playlistUSoC>) and materials can be found on a dedicated site (<https://usoc21.unikraft.org>) and on github (<https://github.com/unikraft/summer-of-code-2021>).

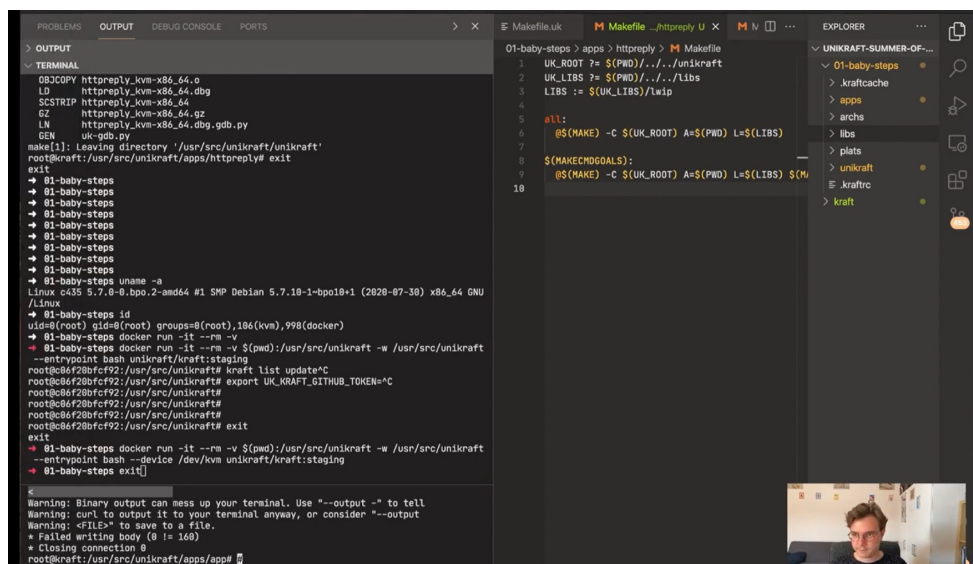


Figure 2.5: Alexander Jung during his talk at USoC 2021

After the success of this Summer of Code, Unikraft has been accepted as an organization for Google Summer of Code 2022 (GSoC'22), a global online program focused on bringing new contributors into open source software development.

GSoC Contributors work with an open source organization, such as Unikraft, on a 12+ week programming project under the guidance of mentors. The goals of this program are to motivate developers to begin participating in open source software development; to help open source projects bring in new developers into their communities; to give new contributors exposure to real world open source software development scenarios (testing, version control, software licensing, etc.) and to create more open source code for everyone. Participants will be able to discuss potential projects, ask questions directly and try out tutorials and exercises to get more familiar with the project.

All the info about the Unikraft GSoC is available on a dedicated webpage: <https://summerofcode.withgoogle.com/programs/2022/organizations/unikraft>. Instructions for students are available on the GitHub organization page: <https://github.com/unikraft/gsoc22>

2.5 Collaborations with Other Projects

A few of the Unikraft components (e.g., support for the lwip stack) were developed under the auspices of the H2020 5GCity project, which has as main goal to create a cloud-like, multi-tenant neutral host infrastructure provided by smart cities/municipalities so that third-parties can deploy smart city verticals without having to incur major investment costs up-front. Unikraft is used to provide strongly isolated, virtualized functionality at low cost.

In the framework of European initiatives, UNICORE collaborates with the Horizon Cloud Coordination and support Action project, H-CLOUD (<https://www.h-cloud.eu>), which leads coordination and support activities for the consolidation and growth of the Cloud Computing research and innovation community in Europe. A representative of UNICORE is part of the Horizon Cloud Communication Task Force that meets monthly to follow up news and activities.

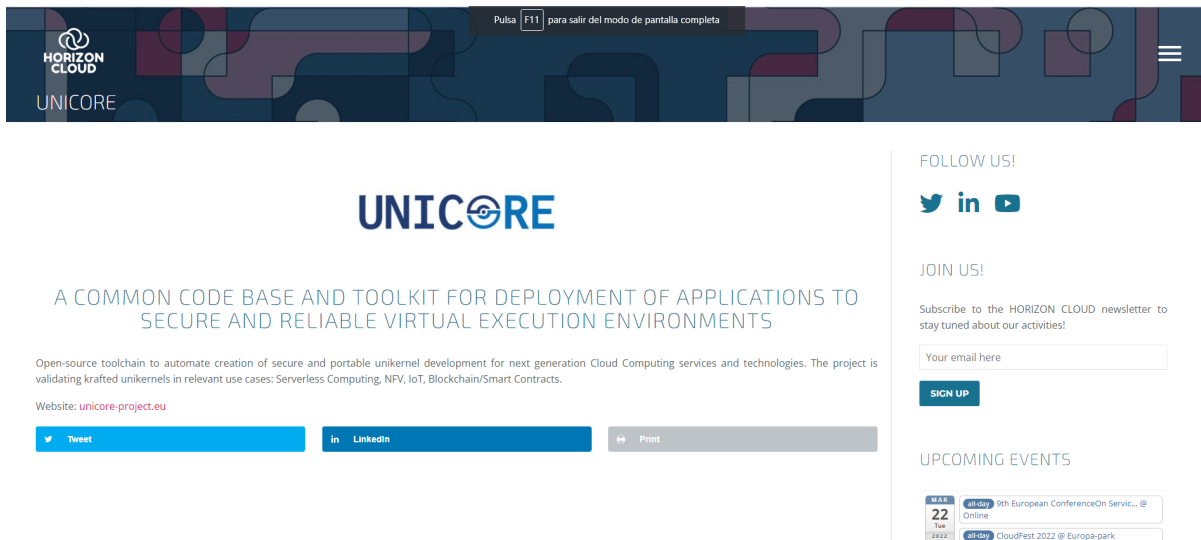


Figure 2.6: UNICORE is a member of H-CLOUD communication task force

Among others, the H-CLOUD Technical Community Event has been organized, where Cloud Computing projects funded under the European Union's Horizon 2020 Research and Innovation Programme, as well as other stakeholders from the Cloud ecosystem, presented technical outcomes of their Cloud projects.

As a representative of UNICORE, Xavier Peralta presented the session "Unikernels in Practice: A UNICORE Serverless Use Case". In Xavier's presentation, benefits and characteristics of unikernels were explained, as well as the use case. The presentation concluded with a demonstration on how the serverless images converter works.

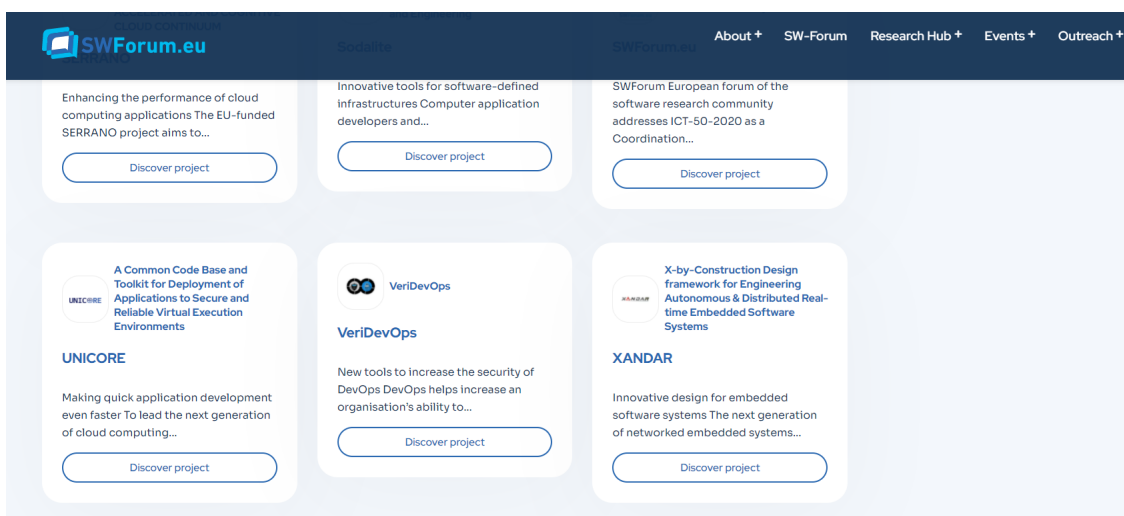


Figure 2.7: UNICORE joined SWForum.eu to increase awareness about the project

UNICORE joined also the European forum of the software research community SWForum.eu (see Fig. 2.7), that aims to create a self-sustainable online forum that facilitates and encourages both researchers and practitioners as well as projects in software, digital infrastructure and cybersecurity to create intersections of expertise and a multidisciplinary approach to research and innovation.

2.6 Communications via UNICORE website

The UNICORE website (www.unicore-project.eu) is online from the end of February 2019, after the KOM. Standard web traffic analysis tools (provided by Google) have been used to track the number of visitors and relative metrics during website lifetime. During Year 3, the UNICORE's website traffic within January 2021-December 2021 increased. Number of users grew 112.41%, with 2,961 unique visitors in 2021 vs 1,394 in 2020. These users viewed 6,865 pages in 2021 (4,798 in the previous period).

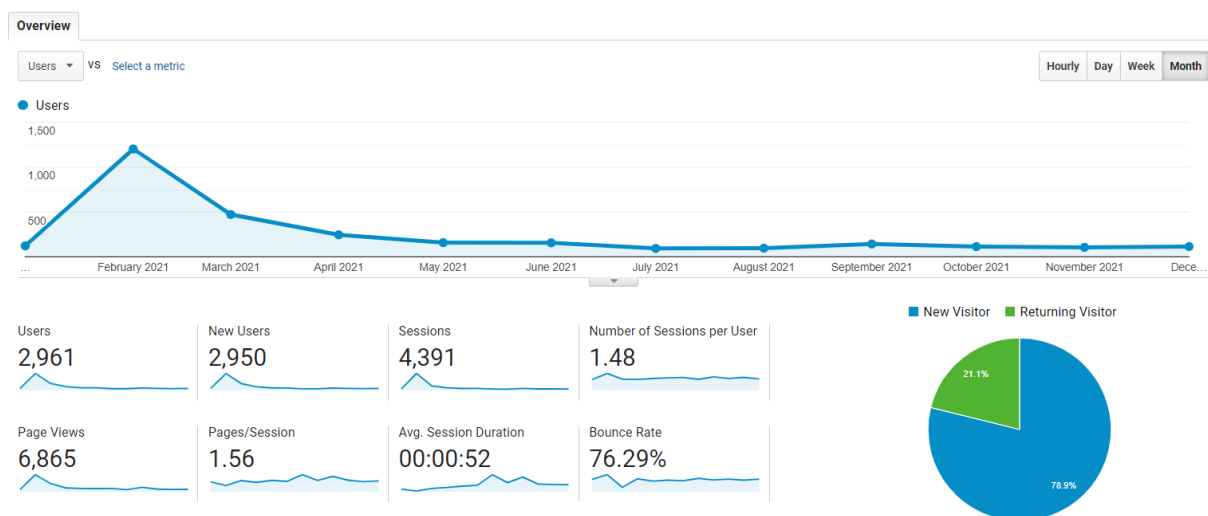


Figure 2.8: UNICORE's website overview from Jan-Dec 2021

The following figure shows the most visited pages within the specified range date (2021), being UNICORE's homepage website the one registering more views.

Page Title ?	Page Views ? ↓	Unique Page Views ?	Avg. Time on Page ?
	6,865 % of Total: 100.00% (6,865)	5,709 % of Total: 100.00% (5,709)	00:01:33 Avg for View: 00:01:33 (0.00%)
1. (not set)	2,728 (39.74%)	2,363 (41.39%)	00:00:09
2. UNICORE	1,553 (22.62%)	1,158 (20.28%)	00:01:22
3. What's UNICORE about? – UNICORE	261 (3.80%)	245 (4.29%)	00:02:01
4. News – UNICORE	166 (2.42%)	111 (1.94%)	00:01:08
5. Use cases – UNICORE	164 (2.39%)	132 (2.31%)	00:01:10
6. Consortium – UNICORE	147 (2.14%)	135 (2.36%)	00:01:35
7. Use Cases – UNICORE	142 (2.07%)	103 (1.80%)	00:03:22
8. Events – UNICORE	120 (1.75%)	86 (1.51%)	00:02:14
9. Unikernels and toolchains – UNICORE	108 (1.57%)	96 (1.68%)	00:01:50
10. Deliverables – UNICORE	102 (1.49%)	98 (1.72%)	00:01:08

Figure 2.9: Top ten most visited pages on UNICORE's website in 2021

Since the webpage was available in 2019 (February 28th), the website data has obtained 5,295 unique visitors in total that represents an average of 1.55 sessions per user, as shown in Fig.2.10. These users viewed 18,044 pages and loaded an average of 2.21 pages per session on the UNICORE website. Time spent per session on UNICORE lengths 02:03 minutes.

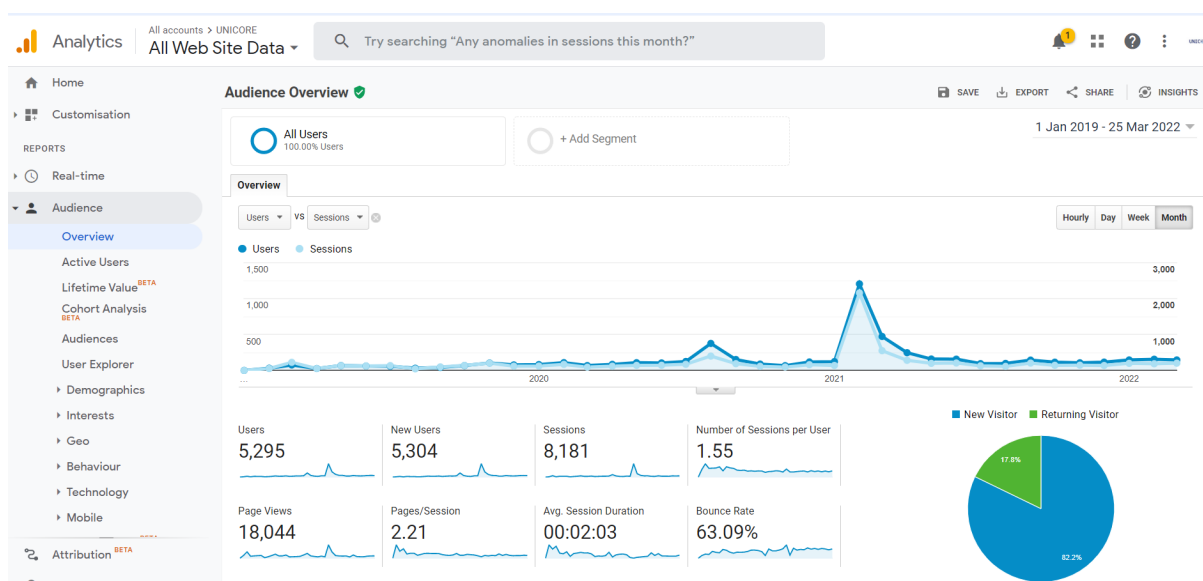


Figure 2.10: UNICORE's website overview from February 2019 - March 2022

Users reached the website from organic search (58.1%), followed by direct traffic (28.8%), referral (8.4%) and social (4.6%).

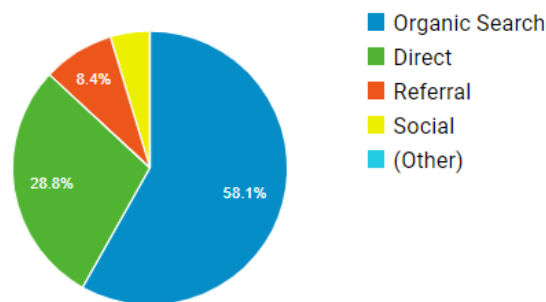


Figure 2.11: Distribution of traffic by acquisition

In regards to social traffic, it's important to note that 92.25% of it came via Twitter, becoming the main source of traffic from social networks for the UNICORE website.

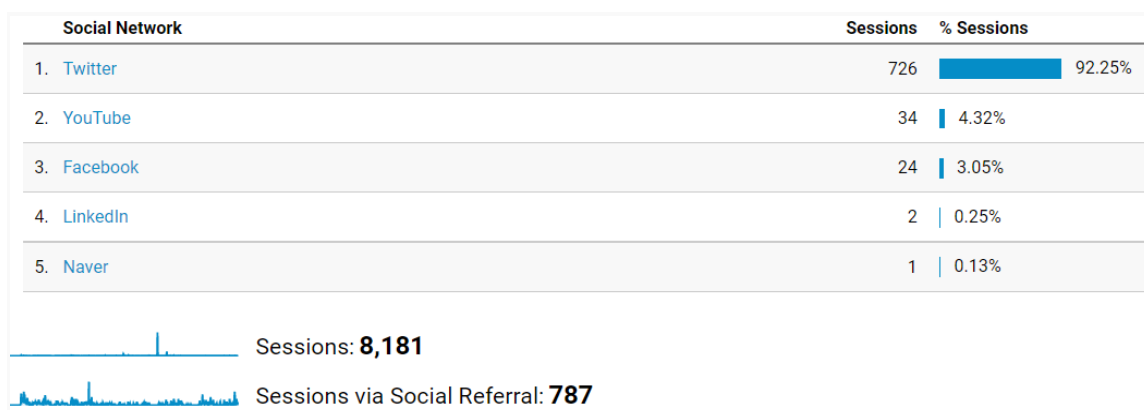


Figure 2.12: Percentage of sessions by Social Network

2.7 Communications via Social Networks

UNICORE is present in five social platforms: Twitter, LinkedIn, SlideShare, Youtube and Zenodo.

2.7.1 Twitter

A Twitter account (https://twitter.com/unicore_project) is used to give visibility to the project activity and to interact with other users and stakeholders.

During January-December 2021 this social network has registered the following data: 46 published tweets with 29,598 impressions in total, 863 engagements, 119 link clicks, 76 retweets, 194 likes, and 12,675 user profile clicks. In 2022, Twitter registered the following data: 15 tweets with 11,139 impressions, 459 engagements, 50 retweets, 116 likes, and 8,727 user profile clicks.

In reference to the overall project, from February 2019-March 2022, this social network registered the following data: 406 published tweets with 150,915 impressions in total, 2,202 engagements, 476 retweets, 235 likes, and 22,097 user profile clicks.

The most popular tweets usually refer to conferences in which members of UNICORE have participated with a talk or paper, but also to highlight aspects of the project such as use cases. TOP 3 tweets by engagement are shown in Fig. 2.13.

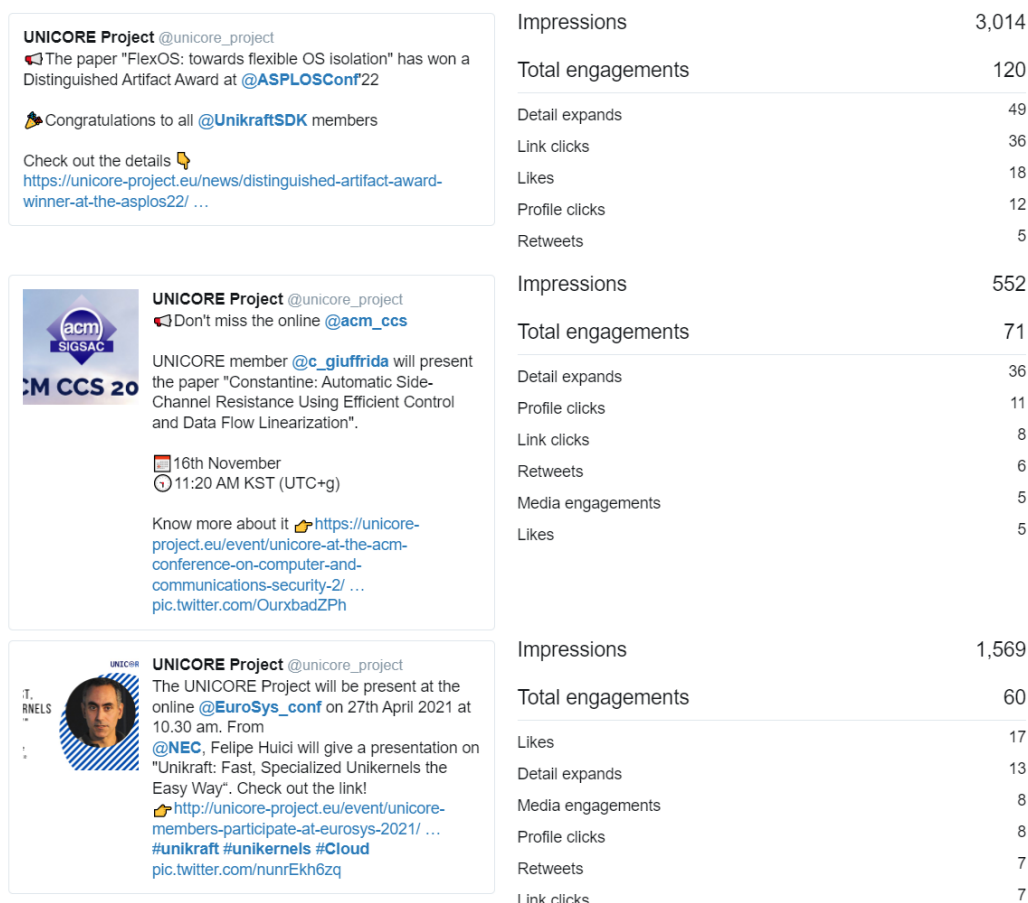


Figure 2.13: The Distinguished Artifact Award at ASPLOS got the TOP 1 in engagement

2.7.2 LinkedIn

A LinkedIn group (<https://www.linkedin.com/groups/8752067>) is available to connect up and build interactions around UNICORE. The UNICORE LinkedIn group had 20 members by the end of March 2022. In addition, LinkedIn has been used also to provide information through the page <https://www.linkedin.com/company/unikraft-sdk>.

2.7.3 SlideShare

The UNICORE Project Technical Overview is available on SlideShare from the beginning of the project, with more than 200 views. This communication channel has been used to give access to presentations when they were not available on other sources. Due to the pandemic situation, most conferences have been online and presentations have been available on the Conference website. These links have been included in UNICORE's news section, instead of using our own SlideShare. The SlideShare account is available at https://www.slideshare.net/UNICORE_project.

2.7.4 YouTube

Since its publication in November 2019, the video of the UNICORE project 'Facing a DevOps era using unikernels with UNICORE' has registered 414 views.

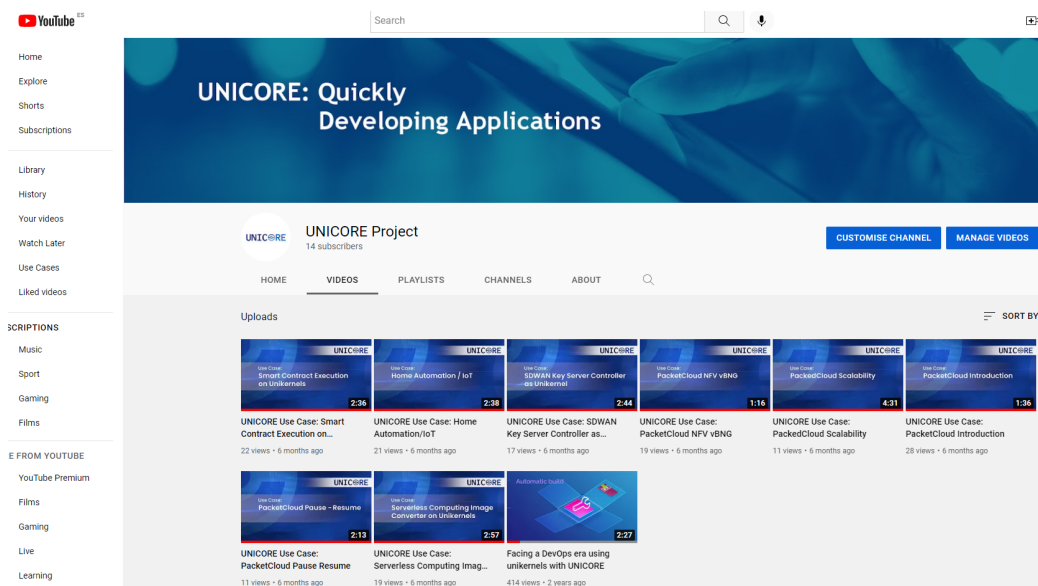


Figure 2.14: YouTube includes the project's presentation and the use cases

A playlist on Youtube ([UNICORE Project - YouTube](#)) provides access to 8 videos to present the use cases. Since the videos were available 6 months ago, they have registered 150 views. Also VUSEC has a playlist with 25 videos (demos and presentations) related to the UNICORE project (<https://tinyurl.com/VUSEC-UNICORE-Playlist>).

2.7.5 UNICORE community in Zenodo

The Zenodo account (<https://zenodo.org/communities/h2020-unicore-eu>) contains 18 publications in open access: the UNICORE technical presentation, the brochure and 16 deliverables, with 994 views and 1,191 downloads, distributed as follows:

N.	Publication	Views	Downloads
1	UNICORE Project - Technical presentation	84	77
2	D2.2 API Design	50	58
3	D2.1 Requirements - Initial	125	112
4	D4.1 Design & Implementation of Tools for Unikernel Deployment	86	124
5	UNICORE: A Common Code Base and Toolkit for Deployment of Applications to Secure and Reliable Virtual Execution Environments	50	44
6	D2.4 API Design - Intermediate	44	82
7	D3.2 Security, Safety and Validation Support Definition	39	39
8	D6.2 Data Management Plan	85	60
9	UNICORE Project - Technical Presentation	20	19
10	D5.1 Deployment Plan, Requirements and Business Cases	68	81
11	D2.3 Platform Requirements - Final	83	198
12	D3.3 API, Library and Security Primitives Implementation - Initial	41	47
13	D4.2 Design & Implementation of Tools for Unikernel Deployment - Intermediate	46	36
14	D5.2 Initial Deployment	52	46
15	D6.3 Report on Communication and Dissemination Activities and Exploitation Plans - Initial	46	63
16	D6.4 Report on Communication and Dissemination Activities and Exploitation Plans - Intermediate	35	29
17	D1.7 Innovation Strategy Report	19	60
18	D2.5 Platform Integration	21	16
TOTAL		994	1,191

Figure 2.15: List of publications on Zenodo, including views and downloads

3 Conclusions

This deliverable reported results of communication and dissemination activities carried out during Year 3 (+ 3 months extension) and for the whole period of the UNICORE project also.

Impacted by the COVID-19 lockdown measures, the Consortium continued to build a relevant impact based on the available project results. Apart from continuing dissemination of UNICORE scientific results in top level international conferences and journals, UNICORE scientific publications have been distinguished in some of them: Best paper award and Intel Bounty Reward in 2019 IEEE Symposium on Security and Privacy; Best Paper Award and Pwnie Award for Most Innovative Research in 2020 IEEE Symposium on Security and Privacy; Intel Bounty Reward in 2020 IEEE Symposium on Security and Privacy; Distinguished Paper Award, Intel Bounty Reward, Mozilla Bounty Reward and CSAW Best Paper Award Runner-up in 2021 USENIX Security and Intel Bounty Reward in 2022 USENIX Security, among others.

Twitter has been a showcase to give visibility to these awards, and thus the research behind, and has generated many interactions (measured in engagement) from researchers, other projects and forums on software, cloud, security.

Social networks, along with specialized newsletters and forums, are being used to publicize a final press release that it's being written and are disseminated by all partners using all their own communication channels in the last days of the project.

3.1 Progress on UNICORE's KPIs

Based on KPIs identified in the UNICORE Description of Action, the progress achieved by the consortium during Year 3 (and including previous years) is summarized in the following Table 3.1.

Table 3.1: Progress on Dissemination KPIs

Activity	KPIs	Cumulative Results
Industrial events (exhibitions and congresses)	<ul style="list-style-type: none"> ● number of events attended ● size of audience ● number of impacts (real interest in UNICORE) 	<ul style="list-style-type: none"> ● 43 industry-driven events ● 500+ attendees on avg ● <45 interested in unikernels
Academic events (workshops and conferences)	<ul style="list-style-type: none"> ● number of events attended/organized ● size of audience ● number of impacts (real interest in UNICORE) 	<ul style="list-style-type: none"> ● 31 scientific events/conferences ● 300+ attendees on avg ● >45 interested in unikernels
Scientific publications	<ul style="list-style-type: none"> ● number of accepted (peer-reviewed) papers in journals 	<ul style="list-style-type: none"> ● Year 1: 9 conferences papers ● Year 2: 6 conferences papers ● Year 3: 9 conferences papers
Website	<ul style="list-style-type: none"> ● positive trend in visitor numbers/month 	<ul style="list-style-type: none"> ● Year 1: 542 users and 5,208 page views ● Year 2: 1,394 users and 4,798 page views ● Year 3: 2,961 users and 6,865 page views
Social media	<ul style="list-style-type: none"> ● increasing number of followers and impact 	<ul style="list-style-type: none"> ● Year 1: 60 followers and 28.8K impressions ● Year 2: 17 followers on Twitter with 51 published tweets with 19,905 impressions, 658 engagements, 68 retweets, 137 likes ● Year 3: 46 published tweets with 29,598 impressions, 863 engagements, 76 retweets, 194 likes
Press releases	<ul style="list-style-type: none"> ● at least 3 press releases (at the beginning, when major project results are available and at the end of the project) ● published by all consortium partners in their countries 	<p>Press releases were postponed to Year 3 due to their poor penetration into the target UNICORE stakeholder communities. Socials and news on websites, as well as Blogs on UNIKRAFT website achieve a better impact.</p> <p>A final press release will be distributed through H-CLOUD and SW-Forum.eu projects and other partner communication channels.</p>
Advertising materials	<ul style="list-style-type: none"> ● 1 short video explaining benefits of UNICORE ● number of video visualizations 	<p>1 video with 414 since its publication in November 2019.</p> <p>8 videos about the use cases with 150 views since September 2021.</p>