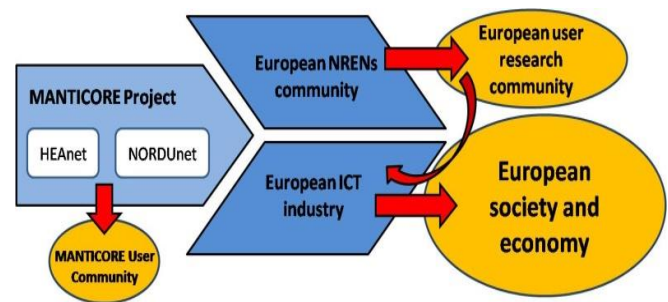


1 Publishable summary

Context and Objectives

IP Network as a Service (IP Network Service) is seen as a key enabler of the flexible and stable e-Infrastructures of the future. The research and industrial communities have been developing for the last years tools that provide Bandwidth on demand (BoD) in the form of control plane systems such as IETF GMPLS or G2MPLS from the Phosphorus project or as management provisioning systems such as AUTOBAHN from GN3, Harmony from PHOSPHORUS, and G-Lambda from KDDI R&D labs., NTT, NICT and AIST. All these tools provide high bandwidth pipes to researchers but it requires that researches have to be physically part of the infrastructure which in many cases is not achievable with secure high bandwidth links with routing integrity. One of the ways of efficiently solving this problem is to create a logically separated IP network (on top of dedicated high capacity links), by using separate instances of virtualized routers, or a combination of both, and dedicating it to the virtual research community. In order to maximize the flexibility and convenience of this IP Network Service, the users of the virtual community should be able to modify some of the parameters of their IP network by themselves (such as the addressing, dynamic routing protocols, routing policies or quality of service).



The main objective of the Mantychore FP7 project is to allow NRENs to provide network services to the research communities they serve through the main tool implemented by the project, the OpenNaaS framework. The service implemented in the project is an IP Network Service. OpenNaaS enables the NRENs to manage and operate the IP Network Service and has been deployed individually over the e-Infrastructure of each NREN in the consortium (HEAnet and NORDUnet) as a pre-operational service.

The rest of the objectives have been achieved focusing in three main aspects: (i) designing and demonstrating a set of use cases to validate the project outcomes, (ii) implement an open source approach to the project management and software implementation and (iii) to analyse the socio-economic impact that the project targets.

Mantychore Use Cases

The Mantychore FP7 project has reflected the applicability of IP Networks as a Service through the implementation of five specific use cases that span through different research communities. Three of these use cases, the core ones, are deployed as Service Activities. Initially, three research communities benefited from the IP Network Service: the Danish Health Data Network, the British Advance High Quality Media Services and the Irish NGI effort.

- **UHD Applications** – The deployment of next generation multimedia applications is a bandwidth intensive challenge that requires flexibility to adjust the network, independently of the underlying physical infrastructure. The group from University of Essex (which moved to University of Bristol later on) led this use case, which involved Glasgow and Cardiff sites.
- **Virtual CPE** – The management of CPE demarcation is an area where network virtualization can provide several advantages, saving equipment costs and expert

intervention while providing enhanced flexibility. UNI-C's group (which moved to DeIC-DTU) and HEAnet led this use case.

- **Distributed and Private Cloud** – Being able to aggregate local computing infrastructure with remote resources (both commercial clouds and federated sites) has a huge impact for research centres. **GIOC (Trinity College of Dublin, Irish NGI)** and NORDUnet led this use case.

Additionally, two Research Activities supported the project use cases:

- **Marketplace** – This use case investigated and designed algorithms and procedures in order to allow automatic request matching over a pool of available network resources. University of Essex/University of Bristol led this use case.
- **Zero-Carbon emission virtual infrastructures** - In collaboration with the GreenStar Network project (CANARIE, Canada), this use case accommodated requirements in order to adapt the network resources to the needs of energy driver cloud management.

Open Source Project Management

One of the main achievements of Mantychore has been the adoption of an open source approach to its software prototype (i.e. OpenNaaS) following an iterative process to drive the project. This approach has proven successful both in order to ensure proper information availability inside the project and for collaborating with other research activities.

The iterative approach, following a consortium-wide SCRUM implementation, allowed the incorporation of user feedback as early as possible in the service development process. In order to do so, releases of the software powering the service were available each month. Each month, a dialog between the NRENs and the end-users was established, so requirements were correctly prioritized and clarified, ensuring the best investment and focus on the development effort. Publicly accessible and updated user manuals¹, bug reporting and feature roadmap allowed third parties to approach and try the software with minimum hassle. This methodology improved the work leveraged from the MANTICORE II project, since some of the functionalities were technologically upgraded in order to fit the more strict requests by the Mantychore project users.

Beyond the software development methodology, and always striving for openness, the Mantychore project conducted its day-to-day discussions on an open mailing list, where external individuals could observe and join the discussion. All deliverables, meeting minutes and activities information can be found on the open wiki space².

Socio-economic impact

The economic benefits that MANTYCHORE brings are numerous and can be differentiated depending on the type of user being addressed:

- **NRENs'** (National Research and Education Networks) and **Commercial telecom operators**: MANTYCHORE tools offer a way to reduce OpEx and CapEx thanks to the MANTYCHORE virtualisation tools by providing a novel IP network as a Service.

¹ <http://confluence.i2cat.net/display/OPENNAAS/OpenNaaS+Documentation>

² <http://confluence.i2cat.net/display/MANTECH/Home>

- **Virtual Research Communities and development community:** MANTYCHORE allows them to manage their own e-Infrastructure and access to the OpenNaaS inclusive community which will provide available resources for those interested in deploying and researching network virtualization based services.
- **Final users:** Mantychore expects to reduce the Internet services cost. This reduction can be carried by the definition of a new business model which is currently opening new topics in the future internet issue: the decoupling of the current Internet Service Provider (ISP) in two roles: Infrastructure Provider and Service Provider. The first one manages the physical infrastructure, while the second one deploys network protocols and offers end-to-end services. This decoupling would channel Service Provider as a new source of revenue in the market of ICT (Information and Communication Technologies) as an agent that would increase competition in the market for network infrastructures and consequently, reduce the Internet services cost.

These set of main socio-economic benefits are based on a new business approach. This strategy, besides defining a set of measures and processes, follows an open service innovation approach that makes sure it is focused on the business/research use of the project results. Open innovation³ is “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively”. Mantychore strategy will increase the impact and demonstration of the Mantychore services and the OpenNaaS toolset while accelerating the time required delivering innovations/services to the community/market.

The socio-economic impact of Mantychore is considering its novel service offering, NaaS; and the exploitation plan for the OpenNaaS open source implementation, which will provide a LGPL version 3 licensing for the main body and an ASFv2 for the additional plug-ins.

Moreover, Mantychore has signed a MoU agreement with ERINA+ to enhance the Mantychore socio-economic studies. The main objective of ERINA+ is to evaluate the impact of e-Infrastructure funded projects through the deployment of an effective socio-economic methodology as well as proposing, by the end of the project, a proactive self-assessment methodology.

Final Results

The project results has been differentiated in two main groups. In one hand, the IP network services deployed at the NRENs and research communities, which take the name of the project itself. In order for NRENs and operators to be able to deploy and operate these innovative NaaS offerings, an appropriate toolset has been created. With such goal in mind, Mantychore FP7 builds on the foundation of MANTICORE I and II projects, an IP Networks as a Service middleware knowledge. The new software is named **OpenNaaS**⁴.

The second year of the project has been used to implement the abovementioned use cases and to finalize all the development activities planned for the project lifetime. The final results are sound and demonstrate the feasibility and viability of the Mantychore services and OpenNaaS solutions as has been proven by the achieved performance and the impact that these outcomes have had in the research community.

³ <http://www.openinnovation.net/books/>

⁴ <http://www.opennaas.org/>

Mantychore

The Mantychore FP7 project serves a user community that uses and takes benefit of Mantychore FP7 services offered by the NRENs.

User groups have determined the activities that they perform using Mantychore FP7 services. Those activities considered more relevant, have been summarized in an evaluation report at the end of the project describing how Mantychore FP7 services have been useful for its research activities (Deliverable D1.4). As Mantychore FP7 deployment is a pre-operational activity with real users, it has been mandatory to receive feedback from them to improve the Mantychore FP7 services and correct the bugs that could appear. The bug correction procedures have not been considered a pilot phase but rather an evaluation that has helped determine whether the Mantychore FP7 services are useful for each particular research community. When the pre-operational phase is successful, the service can be role-out on an operational level to a large community. Each user group will perform different activities and use Mantychore FP7 services for different goals. The diversification of research activities in the Mantychore FP7 project has allowed a better evaluation of the outcomes.

Three research end-user groups have formed the initial user community in Mantychore FP7, where each user group represents a core use case that will use the Mantychore FP7 services for its own interests. These three user groups include the Danish HDN (Health Data Network), the British UHDM (Ultra High Definition Media) group, and the Irish NGI network. An important effort has been dedicated to increase the provider (NREN, commercial) and user community, contacting new research groups and presenting them the available project ideas and results. The project has already received positive feedback from several NRENs, virtual communities and research projects.

OpenNaaS

The biggest part of the Mantychore FP7 efforts are centred in building and refining the toolset that allows network virtualization services to be deployed. As of now, this toolset allows to see a domain's network infrastructure as a set of resources and capabilities. These resources are abstracted from concrete virtualization technologies and vendor details. This is a prerequisite for building rich network intelligence orchestration on top of it, as required by the NaaS approach.

OpenNaaS has born as a project neutral software project, with an inclusive community and available resources for those interested in deploying and researching network virtualization based services. The software is released⁵ with a dual GPL/ASF licensing schema that ensures that while the platform will remain open and consistent, commercial derivatives can be built on top. This open schema allows trust to be built on the platform, as NRENs and commercial network operators can rely on the continuity, transparency and adaptability of the platform.

OpenNaaS is not a tool meant to be used in isolation. On the contrary, with an eye on versatility and smooth integration, OpenNaaS offers a powerful remote command line, as well as web-service interfaces. This web-service interface will offer the possibility to both build a GUI and integrate it with existing middleware applications already deployed in the virtual organizations.

⁵ Software available at: <https://github.com/dana-i2cat/opennaas>

Several plugins for OpenNaaS are being developed inside the Mantychore FP7 project. These plugins cover Routers, Optical Switches, IP Networks and Bandwidth on Demand resources. Beyond that, other resources are being created in parallel projects, leveraging the same core components and bringing reusability across distinct research efforts. In that sense, OpenNaaS has created a huge interest in the research community as a platform for providing virtualized network services and infrastructure management. Extensions to OpenNaaS are being implemented to increase its potential while the projects benefit from a stable platform where to experiment and demonstrate new functionalities and architectures. An example of this are the developments that are happening in the OFERTIE project that are extending the OpenNaaS platform to build an SDN compliant solution based on the OpenFlow protocol.

Therefore, the impact that OpenNaaS is having in the research community is even beyond the initial assumptions and its development and continuity seems guaranteed.

Activities performed

Some of the main activities performed by the project have been:

- Development of the OpenNaaS in Mantychore. With OpenNaaS network operators are able to partition their physical infrastructures into virtual networks based on user/application requirements, and offer them as infrastructure services to users. OpenNaaS provides a tool set for on-demand provisioning of network resources.
- OpenNaaS has been implemented as an open source tool providing on-demand provisioning of network resources and has been developed and opened to the community
- A web client application has been developed in order to facilitate the management of vCPE instances.
- Support for different platforms and devices has been implemented, such as OpenStack or Quagga.
- Definition of a detailed plan on how Mantychore will perform its dissemination and liaison function, and how it will work with standards bodies and commercial/NREN companies to look for exploitation models has been delivered (Deliverable D2.5).
- Some of the contributions to standard development are done in parallel through the active liaison with other projects (Deliverable D2.5).
- Mantychore has established strategic liaisons with other projects: GN3, GEYSERS and GSN.
- The Mantychore user's manual is available at the open wiki. It is continuously updated. The OpenNaaS website, Twitter, Facebook and YouTube account have been used and updated to help users and improve the dissemination of the platform.
- A set of external users have shown their interest on Mantychore: GSN, Stratuslab, CLARIN, Masaryk University, OSAeml, SURFnet, NTUA, JUNIPER, Univ. of Gent and Delft University of Technology.
- An agile methodology to gather user requirements is in place and active along the project.
- Specific equipment for the Mantychore's services deployment has been deployed and tests have been performed on different user communities.
- A study, design and evaluation of a number of algorithms for the implementation of a Marketplace mechanism have been delivered and evaluated by means of simulation.
- The GSN and Mantychore subset of a Euro GSN Networks have been interconnected and Virtual Environments have been interchanged between sites without loss of data. This has been demonstrated at several GSN / CANARIE Reviews. A chapter of a book was written between both projects and accepted in the FIA book.
- Five usecases have been designed, implemented, deployed, tested and demonstrated showcasing the NaaS capabilities.

- The outcomes of Mantychore have been disseminated in conferences, workshops, exhibitions and other events promoting its results in the research community.