D4.4 Assessment of Cloud Profile interoperability testing

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This deliverable summarises the activities in Work Package 4 around cloud standards development and certification. The document describes the six cloud standards profile workshops organised by CloudWATCH as well as details on the cloud standards profile developed by the project.

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CloudWATCH Mission

The CloudWATCH mission is to accelerate the adoption of cloud computing across European private and public organisations. CloudWATCH offers independent, practical tips on why, when and how to move to the cloud, showcasing success stories that demonstrate real world benefits of cloud computing. CloudWATCH fosters interoperable services and solutions to broaden choice for consumers. CloudWATCH provides tips on legal and contractual issues. CloudWATCH offers insights on real issues like security, trust and data protection. CloudWATCH is driving focused work on common standards profiles with practical guidance on relevant standards and certification Schemes for trusted cloud services across the European Union.

The CloudWATCH partnership brings together experts on cloud computing; certification schemes; security; interoperability; standards implementation and roadmapping as well as legal professionals. The partners have a collective network spanning 24 European member states and 4 associate countries. This network includes: 80 corporate members representing 10,000 companies that employ 2 million citizens and generate 1 trillion in revenue; 100s of partnerships with SMEs and 60 global chapters pushing for standardisation, and a scientific user base of over 22,000.

Disclaimer

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The information, views and tips set out in this publication are those of the CloudWATCH Consortium and its pool of international experts and cannot be considered to reflect the views of the European Commission.

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Executive Summary

One of the cornerstones of the Digital Agenda for Europe is the European Cloud Computing Strategy, which was adopted in September 2012. As its first key action, the European Cloud Computing Strategy will "cut through the jungle of standards". The CloudWATCH project addresses this action through a number of activities and outputs in Work Package 4 and elsewhere.

Within WP4, CloudWATCH aspired to define a number of cloud standards profiles as a technique to clarify the exact use of standards for specific use cases: An innate consequence of standards development are implementation, though individually perfectly conforming to the same (set of) standard, they may not be interoperable when connected.

Registering the gaps and needs in the current landscape, it became clear that the underpinning requirements for cloud standards profiling have not been fully met, and the scope of the planned cloud standards profiling workshops were adjusted towards raising awareness of these gaps and facilitating stakeholders towards closing them.

CloudWATCH has built upon strong connections with the scientific community and the standardisation community which were established in past funded efforts SIENA[1] and OGF-EUROPE [2]. This includes continued cooperation with OGF, SNIA, DMTF, ITU, ETSI, OASIS. Through EGI.eu the project was able to leverage the EGI Federated Cloud initiative to validate the best practices of cloud standards profile development described in Deliverable D4.2 and D4.3. The result is not only a tightly scoped, real-life cloud standard profile based on real needs, but also a spearhead of activity for stewarding the strawman profile for scientific cloud computing in Europe.

The final workshop (please see section 2.6 for further details) conducted at the end of the project, confirmed a scope within the landscape of EC-funded projects. Representing more than twenty different projects, over thirty participants from EC-funded projects, as well as SDO representatives validated and positively acknowledged the need for standards profiles, with some fine-tuning of the work presented in [D4.3].The role of standards development organisations such as IEEE, ISO/IEC, OGF, OASIS warrant a separate assessment for further actions to be taken during the funded effort of CloudWATCH2 project [2015-2017] and beyond .

To conclude, a cloud standard profile was developed throughout the lifetime of CloudWATCH and rolled-out within the framework of the EGI federated cloud & OGF OCCI. A set of standard profiles was deemed unrealistic and difficult to achieve, given the landscape. What was provided is a workable methodology for identifying cloud computing priorities to then identify standards requirements and a set of recommendations on: "How to create your own profile" which is being taken forward under CloudWATCH2.

In addition, three strawman cloud profiles were rolled-out defining needs and relevant cloud standards.

[1] http://www.sienainitiative.eu/StaticPage/About.aspx standards & Interoperability for eInfrastructure implementation initiative.[2008-2010]
[2] http://www.ogfeurope.eu/ [2007-2009]

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I. **Cloud Standards for Trusted Public Clouds for Government**
http://www.cloudwatchhub.eu/sites/default/files/Trusted_Public_Clouds_Cloud_Standards_CloudWATCH.pdf

II. **Scientific Computing**
http://www.cloudwatchhub.eu/sites/default/files/Scientific_Computing_Cloud_Standards_CloudWATCH.pdf

III. **High Perfomance Applications**
http://www.cloudwatchhub.eu/sites/default/files/HPC_Dedicated_Purpose_Applications_Cloud_Standards_CloudWATCH.pdf

EGI.eu will take forward the scientific computing profile after the end of CloudWATCH.

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1 Introduction

The CloudWATCH project has been set up to support and aid stakeholders in Europe in their processes of "moving to the Cloud". More specifically, the Digital Agenda for Europe includes the European Cloud Computing Strategy [ECCS], adopted in September 2012, which defines as its first key action to "cut through the jungle of standards"[3]. Work Package 4 of CloudWATCH implemented this action through a number of activities and outputs as follows.

- By conducting six cloud standards profile workshops, CloudWATCH addressed Standards Development Organisations (SDO) and projects funded by the European Commission (EC) to meet with the objective of developing suitable cloud standards profiles.
- Through its partner EGI.eu, CloudWATCH had access to a pan-European testbed of Cloud Management Frameworks federated into the overall European Grid Infrastructure.
- CloudWATCH analysed existing cloud service certifications and provided recommendations for greater transparency for a trusted cloud.

These actions and activities are documented in a number of project outputs, such as:

- D4.1 – Cloud certification and recommendation guidelines [D4.1],
- D4.2 – Best practices for Cloud standards profile development [D4.2],
- D4.3 – Final report on Cloud standards profile development (Update 2) [D4.3],
- D4.4 – Assessment of Cloud Profile interoperability testing (this document).

Through this action plan, the CloudWATCH project aspired to develop a number of cloud standard profiles suitable for adoption in the respective target communities.

As already discussed in D4.3, in year one of CloudWATCH it became clear to partners that establishing a set of profiles could not be wholly developed with the available resources within the Coordination and Support Action of CloudWATCH. Nevertheless, what CloudWATCH did manage to do was show a flexible and quick thinking approach to produce an output that would have a lasting legacy and that could be used by others once the project terminated.

Therefore, the project partners, particularly those significantly involved in Work Package 2 and Work Package 4, and then at a PMB level, took action and adjusted the project work plan and objectives to re-align with the state of art of eleven months ago. Instead of *developing* standards profiles as a main technical focus of Work Package 4, the scope of the workshops and outputs of Work Package 4 changed away from specific, technical work concerning the development of actual cloud standards profiles, and more towards facilitating and enabling the right stakeholders to come together and experience the "spark" of mutual understanding that is necessary to get a profile development started which can now be used for all the projects wishing to map standard profiles through the tool developed.

[3] http://ec.europa.eu/digital-agenda/en/european-cloud-initiative

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Partners approached the issue from two different angles. Firstly, instead of working with SDOs alone, the audience was dramatically widened, leveraging the Concertation meeting and project support activities conducted in Work Package 3. Different ways of conducting the workshops with much more standards consumer involvement (i.e. Cloud Service Consumers, as well as software/solution providers) were tested. First implemented in the third cloud interoperability workshop in September 2014, a public, virtual Cloud Plugfest was held together with the CloudPlugfest initiative driven by SNIA and OGF (see section 2.3 for details), and continued with the fourth and fifth workshop, and finally culminating in the sixth and last workshop where the project intentionally invited representatives from both SDOs and projects into the same workshop.

The second angle included a slight adjustment of work in Work Package 2 that culminated in developing the statistical methodology for clustering projects based on the relative importance of cloud characteristic: Deliverable 2.4 [D2.4]. Based on the results of this work, Work Package 4 has developed a methodology for deriving strawman profile documents that target the respective grouping of projects. This work has been documented in Deliverable D4.3. Finally, CloudWATCH developed a specific cloud standards profile, which is very specific in its scope and hence a reachable target within a CSA.

The following sections of this document give further detail on the outputs of this work. Section 2 provides an executive summary of the six cloud standards profiles workshops conducted during the project's lifetime, taking the shift of focus into account, and summarising the results achieved in each workshop.

Section 3 outlines a real life, production-level case study of a federation of infrastructure cloud deployments. Incepted and initiated by the European Grid Infrastructure (EGI) in 2011, it demonstrates the validity of standards-based deployment and operation of cloud services. At the same time, it may serve in certain aspects, as a blueprint for an envisioned federation of governmental public cloud services across the member states of the EU. Last not least, while it was the origin of one of the cloud standards profiles (ie. "Scientific Computing"), it just as well may be the major consumer of such a profile if finalised and published.

Section 4 discusses a real-life, specific cloud standard profile that has been developed by the CloudWATCH consortium. The result of this activity was not only producing an actual example of a cloud standards profile, but also to validate the process defined in Deliverable "Best practices for Cloud standards profile development" [D4.2] and amended in Deliverable "Final report on Cloud standards profile development" [D4.3].

Section 5 discusses a number of issues to be considered when planning to contribute to the work of standardization organizations and provides recommendations.

This deliverable concludes with final considerations of the timing for the definition and adoption of cloud standards within the cloud landscape and a series of next steps that should be considered in the future, either as part of the CloudWATCH2 project or elsewhere in other standards development activities.

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2 Cloud Interoperability Workshops

From the beginning of the project, the consortium aimed at supporting the Commission in their Cloud Computing objective "Cutting through the jungle of standards" [ECCS]. The project's strategy of achieving this goal has been in a nutshell to:

- Develop a portfolio of cloud commonplaces
- Engage with SDOs in the respective fields
- Offer a testbed for implementations with near real-life conditions

A key implementation element of this strategy is a series of workshops offered to a number of target audiences to drive results towards the three aspects listed above. Over the course of the project CloudWATCH conducted six such workshops.

Developing a **portfolio of cloud commonplaces** needs to pay attention to a number of aspects of cloud services, such as:

- **Technical interfaces.** Service consumers use many different Cloud services offered in a worldwide and uncurated marketplace. A technical interface ideally allows consumers to mix and match services providing certain functionalities with other services that consume the very same functionality facilitating freedom of choice on the consumer's side. Service providers compete in the excellence of their service delivery rather ring-fencing users into their technical solution. While this is also true for all other aspects of Cloud commonplaces it is most prevalent and obvious in technology interoperation.
- **Procedures and processes.** Looking at the cloud landscape many services require the establishment of new, or integrating existing procedures and processes with each other, mostly related to (IT) service management. While generally these are modelled after well-known best practices such as the ISO 2000 family of standards [ISO20k], ITIL [ITIL], COBIT [COBIT], and a few others, there seems consensus that harmonisation is still required.
- **Compliance and certification.** Mostly employed where data is transferred into the controlling domain of a service provider, compliance and certification criteria and processes aim to fulfil the same objective of ascertaining true and fair guardianship over the data as described and laid out in the bylaws. Many approaches exist and it is unfeasible for service providers to pursue all or even a select few of them when the business value of maintaining multiple certifications in the same field is unclear.

For each of these aspects, involving the target audience is key to success. While a large portion of stakeholder engagement is delivered elsewhere in the project (i.e. WP3, but also WP2) engagement on this level requires not only technical insight among projects, but also support and vision provided from the respective project management.

Return on Investment for not only implementing cloud standards, but also driving their support and completion, their mapping to use cases in pre-canned combinations described in profiles on these standards, requires reassurance in such effort. Therefore, having an impact and benefit in the future is key. For this, Standards Development Organisations (SDO) need to be involved early on with the right expectations.

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Over the course of the CloudWATCH project, we discovered that there is still a gap between the work and mandate of SDOs, and the efficient and fruitful engagement of uses (of bespoke standards), and projects. While the workshops originally aimed at technical advancements of standards profiles, the scope and aim of the workshops were adjusted over time to fill that very gap, which is considered as hampering the emergence of workshops and engagement of stakeholders in the intended shape.

No.	Workshop theme and objective	Co-located with
1	**Seed portfolio** Kicking off the discussion within CloudWATCH and engaged projects, it proposed a cloud standard profile strawman that eventually formed the basis of the CloudWATCH Scientific Computing strawman profile.	EGI Technical Forum, Madrid (ES), Sep 2013
2	**Use of standards in by R&I projects in FP7** Broadening information and date for analysis; explicitly engage with projects in FP7 related to cloud computing.	Concertation meeting, Brussels (BE), Mar 2014
3	**Cloud Plugfest: Interoperability state of the art** Using results from workshop 2, assess technical state of the art in interoperability.	EGI Big Data Conference Amsterdam (NL), Sep 2014
4	**Cloud Interoperability days** Addressing the interface of implementations and its user communities, this event promoted the use of interoperable solutions, and discussions on the need of profiles on the demand side.	IEEE UCC 2014 London (UK), Dec 2014
5	**Engaging with SDOs** Realising that isolated engagement with SDOs does not provide leverage, this workshop specifically invited as many SDO representatives as possible to discuss ways of collaboration.	CloudScape VII Brussels (BE), Feb 2015
6	**Structured methodology supporting CloudWATCH profiles** Bringing together SDOs and EC-funded projects to present CloudWATCH's methodology for take-up as legacy beyond the project.	n/a Brussels (BE), Sep 2015

Table 1: CloudWATCH Cloud standards profiling workshops

Table 1 provides a succinct overview of dates and places of the six workshops, and their respective goals for underpinning the project's success in "cutting through the jungle of standards".

The following subsections provide a brief overview of each workshop and highlights the most essential outcomes, which led the consortium to establish a higher-level process in establishing the profiles.

2.1 Proposing a seed portfolio

The first workshop (MS14)[4] was held at the EGI Technical Forum in Madrid in September 2013. Using the format of lighting talks many speakers were able to present their ideas and take away messages to a well-attended event. With each talk of 5 minutes being voted, a select few were awarded 10 minutes of a more detailed talk.

[4] https://indico.egi.eu/indico/sessionDisplay.py?sessionId=34&confId=1417#20130917

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A seed profile portfolio driven by the members of the EGI Federated Cloud initiative was agreed to work upon to include the following existing standards:

- Federated AAI: X.509, VO services & HTTP/1.1 profile
- Accounting: OGF UR2.0 (originated from the Grid)
- Information System: Machine-readable Cloud capabilities using OGF GLUE2
- Cloud compute: Consistent access using OGF OCCI
- Cloud Storage: Consistent access using SNIA CDMI
- Image distribution: DMTF OVF and S/MIME-based Image subscription lists

2.2 Use of standards in by R&I projects in FP7

With the first workshop already initiating a seed portfolio focusing on the technical interoperability of Cloud services, the second workshop (MS16) aimed at extending the reach to EC-funded cloud related projects from FP7 Call 8 & Call 10 and others. To this extent, the workshop was embedded into the DG CONNECT E2 concertation meeting held in Brussels in March 2014[5].

For this workshop, we asked participating projects to relay information about the existing and planned adoption of standards, and their engagement with SDOs. The material collected at this meeting comprised of more than 50 concise project briefings that formed the seed material for the analysis performed in WP2 and conducting further workshops in WP4. As a coordination and support activity, CloudWATCH also facilitated and promoted collaboration between EC-funded projects. This was successful with one highlighted outcome being the public announcement of a commitment of collaboration between some projects on standards adoption.

2.3 Cloud Plugfest: Interoperability state of the art

Digesting and processing the information collected at the second workshop needed some time, so the third workshop again focused on the technical interoperability of Cloud services. CloudWATCH collaborated with the CloudPlugfest initiative to conduct a technical interoperability workshop (MS17)[6], held in September 2014. The workshop was co-located with the larger EGI workshop on the Science Park campus, and back-to-back with the RDA plenary held earlier that week in Amsterdam.

The aim of this workshop was not only to continue advancing technical interoperability between Cloud services, but also to begin to expose the grassroots and volunteer-driven CloudPlugfest initiative to a more formalised QA approach and principles in the standards interoperability “business”.

The event was well attended and thanks to CloudWATCH’s extensive network CloudWATCH managed to make the event a global one with international participation from Greece, Czech Republic and Spain from Europe, and The United States and Brazil internationally. Five different implementations of Cloud standards were tested against each other: rOCCI (CESNET), OCCI-OS (CSIC), fOCCI (EUBrazilCC), Syn-

[5] http://www.cloudwatchhub.eu/concertation-meeting-e2-software-services-cloud-computing-towards-interoperable-european-ecosystem

[6] https://indico.egi.eu/indico/sessionDisplay.py?sessionId=3&confId=2160#20140925

CDMI (GRNET), and the CDMI reference implementation. A separate full report of the event was published on CloudWatchHub[7].

By explicitly incorporating ETSI's test case specification for interoperability tests for OCCI and CDMI the workshop was able to:

- Assess and review test case specifications
- Assess standards and detect possible issues requiring attention in future versions
- Assess implementation quality, standard compliance and level of interoperability

All three aspects are vital and important for any healthy IT-related QA process.

Results of the workshop are as follows:

- Implementations are generally OCCI compliant, but formal assessments that would allow formal certifications require a more developed and matured assessment procedure. Further discussions on-premise and post-event (e.g. during Cloud Expo Europe 2015) led to discussions on forming a worldwide Cloud Interoperability Council that might take on stewardship of impartial, neutral and fair interoperability testing.
- Several non-critical issues were found in existing standards, namely in OCCI 1.1. These were taken forward and incorporated into a revised version soon to be formally published as OCCI 1.2.
- Some test cases documented in the ETSI test specifications require a fixed and standing testing infrastructure with advanced networking equipment, or the provision of preconditions that would lead to reproducibility issues in the test results, or are impossible to conduct altogether.

All technical test results are permanently available online at http://goo.gl/kYrWT0

2.4 Cloud Interoperability days

The fourth workshop (MS19) continued the successful collaboration with the CloudPlugfest initiative in trying a new format in attracting community interest and commitment. As a venue, the UCC 2014 event[8] in London provided the perfect audience, and the workshop was well attended.

The structure of the workshop targeted consumers of cloud software, and invited technology providers and EC-funded projects to showcase and demonstrate their software, focusing on the standards-based interoperability aspect of Cloud software. CloudWatch and CloudPlugfest partnered with the PrimeurMagazine who provided media coverage for the event and an article[9].

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[7] http://www.cloudwatchhub.eu/creating-interoperable-future-clouds-3rd-cloudwatch-cloud-plugfest-and-standards-profile-workshop
[8] http://computing.derby.ac.uk/ucc2014/conference-programme/; denoted as "EGI workshop"
[9] http://primeurmagazine.com/weekly/AE-PR-03-15-81.html

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The entire event schedule is available online[10], and the videos capturing the demonstrations and featured interviews are available on the Cloud standards testing section of the CloudWatchHUB[11].

2.5 Engaging with SDOs

While the momentum in the implementing community was growing, the fifth cloud interoperability workshop (MS20) [12] focused on engaging with SDOs, with the objective of inviting as many as possible in order to discuss how and whether to join forces in furthering the standardisation of cloud computing. The workshop itself was integrated with the programme of the Cloudscape VII event held in March 2015 at the Microsoft Research Centre in Brussels.

In brief, the workshop featured participation and presentations from:

- TOSCA (OASIS) – Peter Gibbels, HP Software X-portfolio & HP Foundation Service Group
- OCCI (OGF) – Alan Sill, VP Standards, OGF & Texas Tech University, USA
- P3201 (IEEE) – David Bernstein, IEEE & Managing Director of Cloud Strategy Partners, LLC
- CDMI (SNIA) – Due to unforeseen circumstances, the speaker cancelled participation on short notice.

The major outcome of this meeting was an agreement to collaborate between IEEE P2301 and CloudWATCH in that P2301 would directly incorporate outcomes of this project into its portfolio of cloud standards. This resulted in a number of post-meeting activities that are reported in [D2.4].

2.6 Structured methodology supporting CloudWATCH profiles

The sixth cloud interoperability workshop (MS21)[13], being the last of such workshops under the auspices of the CloudWATCH project, brought together the results and outcomes of all previous workshops, the work conducted in WP2, and in other tasks in WP4. Through the numerical analysis conducted in WP2 (D2.4), which has also brought a self-assessment tool to life, WP4 was able to take the project clustering further and formulate three straw man standard profile documents that bring together standards addressing the respective needs of self assessment participants.

The entire structure of the workshop focussed on bringing together in the same room the SDOs and projects that had been identified as fitting with these straw man profiles. The workshop was an opportunity to discuss::

- Whether the assessment of project needs and capabilities was accurate, and where it needs changing
- The composition and applicability of the straw man profile identified for the respective group of projects, and potential corrections and amendments.
- Possible action plans for the future ahead.

[10] http://www.cloudplugfest.org/events/past-plugfest-agendas/december-2014-interop-event/december-2014-event-schedule
[11] http://www.cloudwatchhub.eu/4th-cloud-interoperabilitycloud-plugfest-workshop-london-dec-2014
[12] http://www.cloudwatchhub.eu/cloudwatch-cloud-standards-ready-prime-time-cloudscape-vii
[13] http://www.cloudwatchhub.eu/towards-secure-and-trusted-cloud-services-europe

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With 30 participants representing seven standards development organisations, and more than 20 EC-funded projects, this workshop achieved the required momentum and standing, as a final and stand-alone workshops organised in WP4.

While the methodologies were generally accepted as sound and applicable, as described in D2.4 and D4.3, participants felt that the NIST characteristics of cloud computing used in the gathering of information should be revised. While it is certainly agreeable that Privacy characteristics should not be subsumed under "Advanced Security" (which is a characteristic that was present in a draft version of NIST SP 800-145 [NIST-800-145]), the workshop participants made it abundantly clear that:

- NIST SP 800-145, even in a draft form, defines characteristics of *only* cloud computing, but at the same time, many more IT service characteristics are applicable that are *not* specific to Cloud computing.

This is particularly important for future work **related to profiling standards for cloud services, in that focussing only on Cloud related standards is insufficient. It is also important to take other standards into consideration that address IT service characteristics with a wider scope than cloud computing.** Under the remit of the Digital Single Market and the pursuit of open standards, this is certainly an area for further consideration. For example Service Monitoring, Privacy, and many more that were not touched upon at the workshop.

However important this may be, one may argue that part of standards profiling may be out of scope for EC funded projects that focus on cloud computing.

3 Case study: Interoperability in the EGI Federated Cloud

Throughout the life of the CloudWATCH project, EGI.eu[14] has supported the development of not only the standards profiles, but the standards testing as well, which has improved the quality of usage of standards across the infrastructure providers.

The EGI community started developing a new type of infrastructure, the EGI Federated Cloud in 2011. The system reached production level in 2014. The EGI Federated Cloud (FedCloud) is a standards-based, open cloud system as well as its enabling technologies that federate community and public cloud providers to offer a scalable computing platform for data and/or compute driven applications and services. EGI is adopting OCCI in production and its federation approach for portability of data and applications relies on OCCI and uses CDMI for cloud data management. Beyond the project, EGI has a history of working with standards organisation bodies, such as OGF, in

[14] EGI operates one of the largest, collaborative e-infrastructures in the world. EGI supports the digital European Research Area (ERA) through this pan-European infrastructure, its innovative technological building blocks, and related support teams and networks for users. All together these offer reliable ICT services which provide uniform, cost effective, user oriented and collaborative access to computing and data storage resources in more than 30 countries, from EGI's National Grid Infrastructures (NGIs). EGI's mission is to help scientists to make the most of the latest computing technologies, such as clouds, big data and grids by facilitating interactions between them and the NGIs.

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order to proactively steer standards development with real world use cases. This is currently on-going, such as through support of the EGI-Engage[15] project, and is foreseen to continue well into the future.

This section serves as a case study of the activities and motivations that underpin the emergence of cloud standards profiles and their use in reality: **It takes a significant amount of time and effort of many stakeholders to reach consensus.** The more participants, the more difficult it will be to reach consensus.

The case of the EGI Federated Cloud is interesting, in that it not only is the originating body of the CloudWATCH Scientific Computing strawman profile, but also serves as an illustrative example of the presence of prerequisites for standards development to take place, as described in deliverable [D2.4].

The following subsections will thus describe the different necessary aspects of the EGi Federated Cloud that shaped how standards are perceived, selected, and eventually profiled – as a blueprint for future cloud standard profile activities with similar impact as the EGI Federated Cloud to take place in Europe.

Section 3.4 then describes EGI's vision of how the CloudWATCH profile for Scientific Computing may be taken further into a complete end-to-end standardised federated (IaaS) Cloud solution across Europe and beyond.

3.1 Overview of the EGI Federated Cloud

Following the successful use of the EGI grid computing platform for the LHC Computing activities and other communities requiring batch-oriented High Throughput Computing, EGI investigated how to broaden the support for different research communities and their application design models by enriching the solutions being offered, whilst retaining and protecting existing functionality and investment made in EGI's production infrastructure. Virtualisation technology and the Infrastructure as a Service (IaaS) cloud service model were considered clear candidates to enable this transformation as many institutes participating in the EGI federation had already invested into virtualisation and IaaS Cloud technology through the provision of R&D private cloud resources.

A Taskforce was created to evaluate the integration of virtualised resources within the existing EGI production infrastructure, provisioning a test bed open to all research user communities and cataloguing the requirements for community facing services based on or deployed through virtualised resources. Two main design choices were made: platform agnosticism and open standards. The former allowed for retaining the expertise developed by many EGI providers in managing and deploying local cloud-based services, the latter to build on a number of on-going European and global activities that were engineering diverse open source Cloud Management Frameworks (CMF). As a consequence, every cloud provider of the EGI infrastructure was not mandated to use a specific software stack and, where open standards were not available, methods that insured broad acceptance in the e-infrastructure community were endorsed.

[15] https://www.egi.eu/about/egi-engage/

The Taskforce activity was organised in six-month phases, enabling milestones to be communicated and met before moving onto the next. These milestones alongside their overarching goals are listed below:

1. **Setup** – Identify resource and technology providers and draft the infrastructure model.
2. **Consolidation** – Engage exemplar user communities and start configuration of individual site testbeds.
3. **Federation** – Technically evolve the testbed into a federated IaaS infrastructure testbed.
4. **Preproduction** – Scope the requirements for both resource providers and core services to reach production.
5. **Integration** – Integrate new cloud specific core services into the EGI e-infrastructure and enforce the processes by which resource providers can become certified members.

The Task Force activity ensured a close working relationship with relevant technology providers, rapid communication of feedback as well as input on changes needed for deployment, and testing of the new capabilities and services. This effort also ensured that blocking issues of a non-technical nature needing to be addressed were identified by other areas of EGI (e.g. policy, operations, support, or dissemination) and that the testbed, once developed into a production-ready federated e-infrastructure, was effectively integrated into the existing EGI infrastructure. The taskforce engaged others who were already active in this technology space, enabling diversity in the resource provider community available to research through connection of commercial providers alongside traditionally academic provided resources.

The defining goal of the EGI Cloud Platform is to provide heterogeneous research communities with a single set of interfaces to a distributed collection of diverse cloud resources.

3.2 Principles of federation

As previously mentioned the EGI federated cloud developed with an underpinning set of principles that were used to guide both social and technical developments. These are listed and discussed below;

1) **Independence of resource provider** – It is clear that as we transition from the academic High Throughput Grid computing world where all resources provided were made available through public sector organisations that within the cloud computing world we have to dramatically change our philosophy. Firstly there are a large number of high quality providers of public cloud providers, many of whom are already engaging with the research community and as such are already resource providers with whom we must connect. Therefore we make no distinction in the resource provider with which we will engage, public or private, academic or commercial. The only restriction is that they will agree to support our other requirements.
2) **Heterogeneous implementation**. There can be no mandate on the cloud technology that is employed by providers. Within the commercial sector this is certainly obvious (we are likely to be small scale customers when compared to other sectors so couldn't expect to call the tune). This is also true though within the academic and public sector where we are in a number of ways 'late to the party'. Many organisations already have IaaS cloud computing

testbeds which they would want to connect to an EGI cloud activity and in multiple cases different technologies have already been chosen.

3) **Standards and validation**: To ensure that we are able to support the second implementation or software deployment principle it was decided to foster only recommended and common open standards for the interfaces and images. Though there was a temptation to start off with defacto or self defined interfaces it was clear that were we to achieve expansion in the providers we were able to engage, especially commercials that we would have to show ourselves independent of any single provider or technology.
4) **Resource integration**: Through the deployment of the High throughput Computing platform within the EGI a fully featured set of e-infrastructure independent services, which were reused. Therefore a number of non-cloud interfaces have to be integrated into the cloud management frameworks used by services. This also allows future e-infrastructure types not currently developed able to be integrated into the EGI alongside the cloud and HTC services.

3.3 Key capabilities and associated standards

The creation of the federated cloud was a requirements driven exercise with a set of individual user stories developed that described the simplest atomic functionality which allowed a targeted development or integration activity with a single goal.

User Stories	Capability	Functionality	Standards	NIST Criteria
"I want to instantiate a single existing VM image on a remote cloud."	**Virtual Machine management**	**VM Management** directly implies IaaS Cloud services employing Virtualisation	OCCI	*On-demand Self-Service*, Virtualisation
"I want to instantiate a VM instance from an image that I have created and is not on the cloud I wish to use." "I want to associate my running VM with a data set in the Cloud." "I want to take snapshots of my running VM for restart purposes."	**Data management**	Though a popular method is to utilise the Virtual Machines storage capability, reference and input data is often stored in publicly accessible repositories, requiring **Data Management** functionality and data repository integration into the VMs. This also covers all other IaaS Cloud functionalities such as VM image storage, snapshots, upload staging area etc.	OCCI, CDMI	*On-demand Self-Service*
"I want to choose on which resource provider I want to start my single VM." "I need to know about the Virtual Machine	**Integrated information system**	**Integrated information systems** provide a mechanism by which EGI user communities and providers, who consume and offer resources from a large	GLUE2	*Massive Scale*, Geographic Distribution,

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Manager (VMM) capabilities the provider offers.”		number of independent organisations, can have a complete picture of the federated infrastructure services.		
“My usage across different resource providers needs to be recorded and reported to multiple aggregators.”	**Accounting**	**Accounting** for consumed resources is a fundamental cloud capability, even within a publicly funded IT infrastructure.	OGF Usage Records	*Measured Service*
“Information relating to the availability/reliability and current status of the remote virtualised resource needs to be available to me.”	**Availability & Reliability**	**Availability** and **Reliability** are vital Key Performance Indicators (KPI) of an infrastructure, helping to build confidence in professional operations and service quality across participating resource providers.	NAGIOS[16]	*Massive* Scale, Resilient Computing
“When the status of the [VM] instance I am running changes (or will change) I want to be told about it.”	**VM & Resource state change notification**	**State change notifications for VMs and resources** allow for both reactive and proactive management of any set of services deployed on EGI’s Federated Cloud infrastructure.	Oasis AMPQ	Resilient Computing
“I want to use my existing identity, and not re-apply for new credentials to use each component of the service.”	**Integrated AAI**	**Integrated AAI** conveys the desire of users to use a single sign-on technique or technology for all e-infrastructure service access.	X.509 + VOMS	Advanced Security
“I want to use a single VM image across multiple different infrastructure providers.”	**VM Image Management**	Within a federated Cloud infrastructure, it becomes vital for the efficacy of a user’s research to ensure that there is consistency of service capability across different resource providers available.	OVF	Virtualisation

[16] NAGIOS is a de facto standard in infrastructure monitoring, not a fully specified standard as, e.g. AMQP.

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		Therefore within the cloud the users VMs must all be consistent across resources, **VM Image management** solves this problem by automating this process as much as is feasible		
"I want my VM instance to run on a resource that is suitable based on a set of policies or requirements rather than my choosing directly which resource will run it."	**Brokering**	**Brokering** enable users to automate the process of selecting a particular resource provider among a pool of potential and/or accessible resource providers, focusing on higher-level scientific problems.	OCCI	Resilient Computing
"When I deploy a VM instance on a resource I want to give it configuration information for customisation of the default template. This can only happen when it is up and running."	**Contextualisation**	**Contextualisation** is a subset of VM management in that it is the automation of the configuration of a deployed VM instance achieved automatically upon startup or during its lifetime.	OCCI	

Table 2: EGI Federated Cloud key capabilities and ancillary information

3.4 A profile for Scientific Cloud Computing

The EGI Federated Cloud is already deployed on nearly 20 academic institutes across Europe who together offer 6000 CPU cores and 300 TB storage for researchers in academia and industry. This capacity is available for free at the point of access through IaaS capabilities and interfaces that are tuned towards the needs of technologists from research and education. These technologists can define high-level platforms and environments – with the cloud terminology PaaS and SaaS systems - on top of the EGI IaaS cloud. The technologies that enable the EGI cloud federation are developed and maintained by the EGI community, and integrate open standards and open source Cloud Management Frameworks. These integrated technologies are available for institutes and communities who wish to setup their own federated cloud infrastructures.

The EGI Federated Cloud integrates the core capabilities of individual cloud deployments to enable workloads, simulations and services that may span across multiple administrative locations. The federation provides harmonised views across the individual cloud instances for end users, who are typically platform developers (PaaS, SaaS), scientific programmers, community/project coordinators and system administrators. The EGI Federated Cloud currently supports scientific communities coming from different scientific disciplines: bioinformatics, physics, earth sciences, basic medicine, arts, language and

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architecture, mathematics, computer sciences, etc. Furthermore, between 2015-2017 several research infrastructures from the ESFRI roadmap (BBMRI, EPOS, ELIXIR, DARIAH, EISCAT-3D, INSTRUCT and LifeWatch) will define and implement community-specific capabilities on this platform in the recently started H2020 EGI-Engage project. The adoption of the EGI Federated Cloud is ongoing within industry too, through early adopter SMEs from Spain, France and the UK.

The EGI Federated Cloud is based on the mature federated operations services that makes EGI a reliable resource for science. When using EGI Federated Cloud resources, researchers and research communities can count on:

- Total control over deployed applications
- Elastic resource consumption based on real needs
- Immediately processed workloads – no more waiting time
- An extended e-Infrastructure across resource providers in Europe
- Service performance scaled with elastic resource consumption
- Single sign-on at multiple, independent providers

The EGI Federated Cloud architecture is developed from high-level capabilities extracted from users' requirements taking also into account the needs and expertise of the existing heterogeneous cloud management software locally installed at EGI resource providers. The architecture tackles this by considering each local Cloud deployment as an autonomous and abstract subsystem that integrates with the federation through well-defined interfaces. Each of the identified capabilities from the user stories described above was compared to state-of-the-art cloud computing technologies, standards, protocols and APIs to identify a technology stack which can help the National Grid Initiatives and research communities to connect resources into a federated infrastructure. Open standards are employed for providing these capabilities wherever possible. Where this was not feasible, community-accepted non-standardised solutions are used. It is the responsibility of resource providers to identify and deploy the solution that fits best their individual needs whilst ensuring that the offered services implement the required interfaces. The Federated Cloud currently integrates the standard-based technological components listed in the following table:

Name of the technology	Description	What it's used for in EGI?
Open Cloud Computing Interface (OCCI)	The Open Cloud Computing Interface comprises a set of open community-lead specifications delivered through the Open Grid Forum. OCCI is a Protocol and API for all kinds of management tasks. OCCI was originally initiated to create a remote management API for Infrastructure as a Service (IaaS) model based Services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and	Virtual Machine management & Block Storage Management

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	monitoring. It has since evolved into a flexible API with a strong focus on integration, portability, interoperability and innovation while still offering a high degree of extensibility.	
GLUE Schema	The GLUE Schema is a common way of publishing information about sites and services of grid or cloud resources. GLUE is a open specification developed by the Open Grid Forum with implementations for a range of systems; the EGI Federated Cloud uses the LDAP based BDII implementation.	Information system for cloud resources
X509	User authentication is a means of identifying the user and verifying that the user is allowed to access some restricted service, particularly the sites of the EGI Federated Cloud. Public-key cryptography is a cryptographic technique that enables users to securely communicate on an insecure public network, and reliably verify the identity of a user via digital signatures. The X.509 specification defines a standard for managing digital signatures on the Internet. X.509 specifies, amongst other things, standard formats for public key certificates, certificate revocation lists, attribute certificates, and a certification path validation algorithm.	User authentication
CDMI	The Cloud Data Management Interface defines the functional interface that applications use to create, retrieve, update and delete data elements from Object-base storage in the cloud. CDMI is a flexible protocol that allows clients to discover the capabilities of the cloud storage offering and to manage containers and the data that is placed in them.	Object Storage
Usage Record, STOMP	OGF Usage records allow sites to exchange basic accounting and usage data in a common format. The EGI Federated Cloud has extended the OGF usage record to support the collection of resource usage of VMs that are sent securely via STOMP to EGI's accounting database.	Accounting
OVF, VMDK	Open Virtualization Format (OVF) is an open standard for packaging and distributing software to be run on virtual machines. VMDK (Virtual Machine Disk) is a open file format that describes the disks used in virtual machines. OVF with VMDK disks are	VM Image management

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	the recommended and supported formats in EGI's VM Image management tools.	

Table 3: A strawman scientific cloud computing profile for EGI Federated Cloud

Users of the EGI Federated Cloud are scientists working in many fields, who can benefit of a flexible environment for running their workloads. Also, the EGI cloud is suitable to projects aiming to provide services and platforms to the scientific community.

4 Interoperability testing by example: Resource Templates profile

Over the course of the project, CloudWATCH addressed standards profiles on a number of occasions:

- D4.2 "Best practices for Cloud standards profile development", section 3
- D4.3 "Final report on Cloud standards profile development", section 3

Among those, Deliverable 4.2 provides the most comprehensive description of the entire process. As a case study and means of validation of the process described in D4.2, this section will trace the activities outlined in the Project proposal and D4.2.

The work conducted in the EGI Federated Clouds initiative mostly predates the CloudWATCH project. However, this profile specification fell within the CloudWATCH project timeframe itself, and has informed and influenced the work of this project. As such, the work described here is entirely embedded in the overarching processes and activities as studied and summarised in section 3.

4.1 A bird's eye view on the profile development process

In a nutshell, the process comprises of three phases described in more detail in D4.2 (see also Figure 1)

1. **Phase 1 – Collect relevant material.** Arguably somewhat pre-profile definition work, it is nonetheless important to compile a solid foundation of use cases, and technical requirements. If applicable, a portfolio of target standards (implemented, scheduled, or candidate) should be added to the dossier.
2. **Phase 2 – Develop the (Cloud) standard(s) profile.** There are variations of how to conduct the actual work. Formally, developing a standards profile does not require a chaperoning Standards Development Organisation (SDO). However CloudWATCH strongly recommends engaging with SDOs in this phase due to the extensive knowledge of their members in the technique, process and formal language of standard-defining specifications – and a profile on standard specifications is one of the most technical documents present.
3. **Phase 3 – Disseminate and deploy.** In a formal/theoretical setting, the final phase of developing a profile specification comprises of editorial clean up, and publication accompanied by implementation and deployment in the production infrastructure. However, in practice this phase often runs in parallel to phase 2 – or even has preceded phase 1: Particularly in grass-roots situations where independent implementations arrive at the same interpretation of the standard specification, implementations exist before stakeholders even consider formalising these into a common profile.

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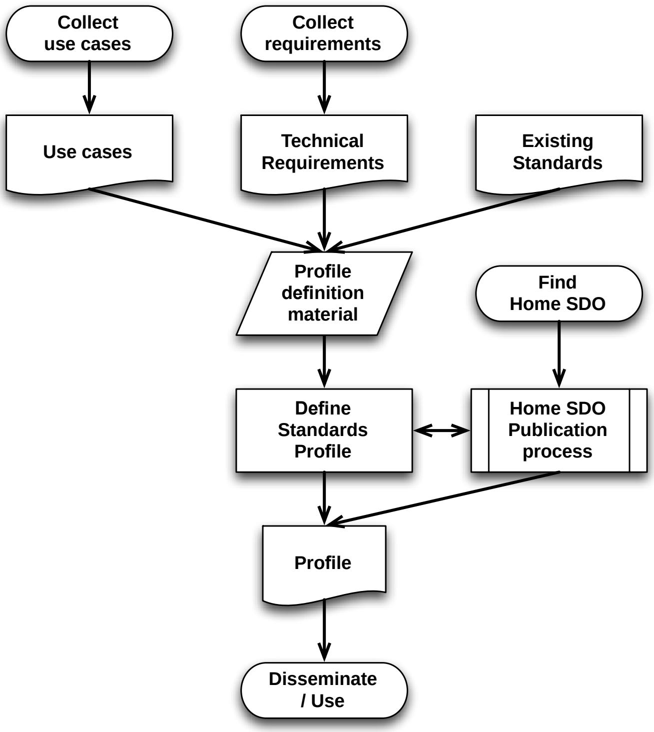

Figure 1: Overview of the standards profile development process

A more detailed view and recommended techniques is provided in D4.2, focusing on the first two phases of the overall process:

PHASE 1

- Application domain description
    - Stakeholder analysis
    - Use Case collection
        - Methodology
        - Use case acquisition
        - Outcomes, conclusions and recommendations
- Understanding the current standardisation landscape
    - Resources
    - Gap analysis

PHASE 2

- Profile definition
    - Roadmap
    - Stakeholder analysis, again
    - Approaching and collaborating with relevant SDOs

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4.2 Defining the OCCI 1.2 Resource Template Profile

4.2.1 Stakeholder analysis

Within the EGI Federated Clouds activity, all relevant stakeholders are already present and active.

- **Resource providers.** They deploy an IaaS cloud management framework such as OpenStack, OpenNebula, etc. and expose the configured resources to researchers and scientists locally, nationally, in Europe, and worldwide. They are all interested and engaged in the idea of providing a consistent, federated research computing infrastructure that is homogenised through heavily focusing on interoperable and standards-compliant access interfaces on all levels.
- **Technology Providers.** Ultimately, Resource Providers are responsible for delivering a CMF deployment adhering to the standards and interface requirements imposed by the EGI Cloud federation. Some Resource Providers implement and maintain the integration code themselves, but most delegate this to (an)other Resource Provider (such as CESNET, the Czech NREN) or FCTSG (member of the Spanish CESGA). Other Technology Providers include external and EGI members that integrate EGI operational services (e.g. Monitoring, Accounting, and others) or additional services that user communities may employ, such as Brokering services (e.g. COMPSs, Slipstream, and others), Portal applications and many others. What they all have in common is that the EGI Federated Cloud infrastructure provides an attractive market segment, which is worth engaging with.
- **Service Consumer.** The consumers of the EGI Federated Cloud infrastructure are often researchers using portal applications, and other services that façade the IaaS access level in favour of focusing on the most prevalent use cases and usage scenarios of the federated Cloud infrastructure. The users are not involved directly but by proxy that are technologically very adept and versed. While the end users are almost never concerned, they are interested in a continuously available infrastructure at their disposal. Their proxies however need to be able to provision infrastructure beyond their own assets in a very flexible manner with minimal transition cost. Consistent and interoperable access interfaces are a key driver to attain this goal.

4.2.2 Use case collection

Most use cases in the EGI Federated Cloud are technical, sourced directly from EGI's engaged user communities. The EGI Federated Cloud activity provides several angles of interaction and collaboration. Fortnightly conference calls among key stakeholders associated with working groups aligned with capabilities of the EGI Federated Cloud ensure constant and vibrant exchange of ideas and knowledge. Where necessary, representatives are tasked with outreach to relevant stakeholders; a key body within EGI is the User Community Support Team (UCST) that takes on many of these tasks. Also, consultation of the EGI Executive Board, and EGI Council is conducted via the support and participation of the EGI Strategy and Policy Team. Most use cases are actually sourced by interviewing stakeholders.

In this particular case, the EGI Federated Cloud already implements OCCI 1.1 for managing Virtual Machines images and instances. OCCI provides users with a CRUD-type interface for VM images and instances, which allows for ultimate flexibility in how users achieve their objectives. However, this has

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some shortfalls, which EGI wished to alleviate while accommodating a popular user community request:

1. User Communities use resource templates to optimise application performance *within* the VM instance as some applications are memory-intensive while others are CPU-intensive (or have other resource consumption profiles)
2. Resource Providers use templates to achieve optimal VM instance scheduling, hence resource utilisation, which in turn drives down cost for the provider and customer.
3. Resource Providers wish to promote the use of certain resource templates by providing discount on the resource consumption price.
4. User Communities wish to use resource templates that are discounted, for optimising the capital expenditure on their research project.
5. EGI wishes to ensure continuity and adherence to its Cloud federation principles of standards-based access, and consistency in its operation and offering.

4.2.3 Resources & Gap analysis

EGI was already implementing OCCI 1.1 at the point of discussing the way ahead of satisfying the use cases summarised above, and a change of standards is not lightly taken or implemented.

While many CMFs offer the use of resource "templates" or "flavours" allowing for consuming pre-defined combinations of underlying resources such as RAM, scratch storage, virtual CPUs, and others, using pure OCCI 1.1 commands, a user would have to issue several sequential commands in achieving the same result, causing unnecessary network traffic and application performance penalties.

Since the initial affected portfolio of standards and Standards Development Organisations was clear from the beginning (i.e. OCCI, and OGF) the most pressing resource considerations revolved around operational services within EGI to satisfy the entire list of use cases. Use cases 1 and 2 above may be satisfied through a change of the user-facing interfaces only (i.e. OCCI 1.1 implementations), use cases 3 and 4 required a change in the operational infrastructure, specifically the integration of CMFs with EGI's accounting solution: Not only are CMFs required to report the actual use/application of a given resource template to the accounting system, they also must record the timestamps of engaging and disengaging of any resource template. The accounting solution in turn needed to be extended to harvest such information and aggregate in an appropriate way for the billing departments to calculate the correct charges, but also for users to check their current consumptions. This required the change of a second standard used in the EGI infrastructure: Usage Record 2, also originating from OGF. Lastly, to satisfy use case 5, the proposed solution had to ensure (i) standards are employed wherever possible, (ii) resource templates would be defined in a consistent way across the EGI cloud federation, and (iii) a core set of common resource templates would be available, under identical names, across the entire EGI cloud federation.

4.2.4 Profile document roadmap

EGI is involved on many levels with OGF; in fact EGI is represented in both working groups stewarding "OCCI" and "Usage Records" (UR), both hosted by OGF. Therefore, the level of influence and impact on both existing standards were ensured. Eventually EGI decided to separate the activities concerning OCCI and UR as, UR version 2 was in the process of being developed at the time, and any changes

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proposed in time might be included in the final standard, without the need of defining a profile document. OCCI 1.1, on the other hand, was already finished and implemented, and although several other shortcomings of the OCCI 1.1 specifications were already recorded, conversations around an update of the specifications were in a very early stage. As a consequence, the *profile strawman* document comprised solely of proposed interpretations and extensions of the OCCI 1.1 family of specifications.

4.2.5 Approaching and collaborating with relevant SDOs

Since only standards specifications were affected that originated from within OGF, it was appropriate to approach OGF. Through its longstanding relationship this was in fact agreed upon within days, and work could commence.

EGI decided to coordinate the development and delivery of the necessary changes to OCCI and UR through technical work in the working groups, and synchronise their progress via the regular EGI Federated Cloud conference calls. In practice, the OCCI working group oversaw the profile development adhering to the OGF processes (e.g. document formats, choosing the right standardisation track) as well as providing technical expertise for the technical details of the profile document itself. The help of the OCCI WG was considered invaluable in reviewing many internal drafts of the document and checking for consistency and compliance with the base specifications.

Eventually, the OCCI WG decided on how it would proceed with publishing a revised version of the OCCI family of specifications. Compiling a backwards-compatible minor revision of OCCI in the 1.2 version allowed EGI to develop a profile with a unique property as follows:

- Common standards profile specifications define exactly which versions of base specifications they apply to.
- By coincidence, being originally developed on top of OCCI 1.1 the near-final draft version was well in time to be considered for inclusion in OCCI 1.2.
- Applying necessary editorial changes allowed the WG to include the profile document into the OCCI 1.2 family of specifications
- The EGI-originated OCCI resource template profile will form an integral part of the OCCI 1.2 specification
- At the same time, the profile is applicable to the OCCI 1.1 family of specifications.

Eventually, the profile specification was formally incorporated into the OCCI 1.2 family of specifications. At the time of writing, the OGF mandatory phase of public comments has finished, and a final version of the OCCI 1.2 specifications is currently being written by the main authors.

5 Recommendations for contributing to standards development

The development of standards (or, with regard to the focus of this document, standards profiles) is necessarily a consensus driven process that requires a framework of strict processes and codices to make sure that stakeholders can adequately express their interests. This includes rules for the production of standard documents, with regard to timelines, inclusion of material, and resolution of comments. Research projects or innovative SMEs, on the other hand, usually do not employ strict

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procedures beyond their reporting (deliverable) structure and quality assurance measures. If important content become available, it can usually be published after a comparable quick review by the project's consortium or the SMEs management board.

The conflicting modus operandi of innovative enterprises and projects and SDOs results in many cases in a failure to influence the development of standards, simply because formal procedures are not followed.

To provide an example, a number of research projects and organisations with interest in standardization has been provided input to the current work of ISO/IEC JTC 1/SC 38 (Cloud Computing and Distributed Platforms), in many cases without any impact due to (a) providing material without indicating what the subcommittee is expected to do with it (i.e., ignoring rules on introduction of material into ISO/IEC JTC 1 standards), (b) not establishing or utilizing a formal liaison with SC 38 or acquiring the endorsement of on of the national bodies contributing to SC 38, and (c) failure to provide input as on-time-contribution to .SC 38 plenary meetings (i.e., ignoring the timeline of SC 38).

Hence, it is crucial for research projects and SMEs that intend to initiate the development of standards profiles or contribute to it to make sure that material is presented to SDOs in a way that allows SDOs to take it actually into account. As a first step, it is necessary to understand how standards are developed. For instance, IEEE-SA uses a process comprises seven steps as described in Table 4 below.

#	Step
1	**Securing Sponsorship**
An IEEE-approved organization must sponsor a standard. A sponsoring organization is in charge of coordinating and supervising the standard development from inception to completion.	
2	**Requesting Project Authorization (Within 6 month of the first decision to initiate the project)**
To gain authorization for the standard a Project Authorization Request (PAR) is submitted to the IEEE-SA Standards Board. The New Standards Committee (NesCom) of the IEEE-SA Standards Board reviews the PAR and makes a recommendation to the Standards Board about whether to approve the PAR.	
3	**Assembling a Working Group**
After the PAR is approved, a working group of individuals affected by, or interested in, the standard is organized to develop the standard. IEEE-SA rules ensure that all Working Group meetings are open and that anyone has the right to attend and contribute to the meetings.	
4	**Drafting the Standard**
The Working Group prepares a draft of the proposed standard. Generally, the draft follows the IEEE Standards Style Manual that sets guidelines for the clauses and format of the standards document.	
5	**Balloting**
Once a draft of the standard is finalized in the Working Group, the draft is submitted for Balloting approval. The IEEE requires that a proposed draft of the standard receive a response rate of 75% (i.e., at least 75% of potential ballots are returned) and that, of the responding ballots, at least 75%	

approve the proposed draft of the standard. If the standard is not approved, the process returns to the drafting of the standard step in order to modify the standard document to gain approval of the balloting group.	
6	**Review Committee**
After getting approved, the draft standard, along with the balloting comments, are submitted to the IEEE-SA Standards Board Review Committee (RevCom). The RevCom reviews the proposed draft of the standard against the IEEE-SA Standards Board Bylaws and the stipulations set forth in the IEEE-SA Standards Board Operations Manual. The RevCom then makes a recommendation about whether to approve the submitted draft of the standard document.	
7	**Final Vote**
Each member of the IEEE-SA Standards Board places a final vote on the submitted standard document. In some cases external members are invited to vote. It takes a majority vote of the Standards Board to gain final approval of the standard. In general, if the RevCom recommends approval, the Standards Board will vote to approve the standard.	

Table 4: IEEE-SA standards development process

The example exhibits a number of issues to be take into account:

- Understanding the structure of the standardization organisation to be addressed. As seen in the cases of IEEE-SA (step 3), a new working group is assembled for each standardization project. Other standardization organisation employ a more rigid structure where new projects are assigned to existing working groups if possible. In these cases, the introduction of a new working group is a time and resource intensive process that will be initiated only after extensive discussions leading to a strong consensus in favour to it.
- Identification of parties that are allowed to initiate a new standardization project (including the development of standards profiles). IEEE-SA requires sponsoring by an IEEE-approved organisations, while ISO/IEC JTC 1 requires the submission of a new work item proposal supported by at least five national bodies contributing to the relevant sub-committee.
- Moreover, a research project or SME that likes to contribute to standards development has to determine which commitments are required (e.g., membership fees, personal attendance at meetings, commitments with regard to taking responsibility as document editor and working group convenor).
- Understanding the timeline of development. New standardization projects cannot be initiated at any time (in many cases, a formal meeting is required to approve such a project, hence proposals have to follow the meeting schedule of the responsible sub-group within the SDO to be addressed), comments have to be provide on ballots (and cannot be provided between the end of the balloting period and the associated comment resolution meeting, etc.). Short term research projects in particular have to evaluate if it is possible for them to contribute meaningfully to standardization within the projects duration at all. In many cases, so that measures to continue with the standardization work after the project's finalization have to be in place.
- Understand the formal ways in which material can be introduced into standards. Most SDOs provide templates for commenting on existing material and to introduce new one. Using these

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templates is mandatory, sending an informal contribution (e.g., a report on a certain topic) to be taken into account by the standards development group will most likely have no impact.

Table 5 below provides a list of URIs where procedures of various SDOs can be found.

SDO	URI
OGF	https://www.ogf.org/documents/GFD.152.pdf
OASIS	https://www.oasis-open.org/policies-guidelines/tc-process#standApprovProcess
IEEE	http://standards.ieee.org/about/sasb/audcom/baseline_sponsor_2013.doc, see also https://en.wikipedia.org/wiki/IEEE_Standards_Association#Standards_and_the_IEEE_Standards_Development_Process
SNIA	http://snia.org/sites/default/files/TWG_PnP_4_3.pdf
DMTF	http://schemas.dmtf.org/process/DSP4014_1.1.0/
W3C	http://www.w3.org/2014/Process-20140801/#Reports
ISO/IEC JTC 1	http://isotc.iso.org/livelink/livelink/fetch/2000/2122/4230450/9482942/JTC_1_Supplement_%28pdf_version%29.pdf?nodeid=9484244&vernum=-2

Table 5: SDO standardisation process resources

Beyond following the formal requirements of standardisation work imposed by the SDO to be addressed, a number of additional issues have to be taken into account:

- Almost all SDOs are driven by industry. It is true even for SDOs which are organized in a different way (such as ISO/IEC JTC 1, where the "unit of consensus" are the national bodies). Hence, projects or SDOs that like to propose a new standardization project, the definition of a standards profile, or even the contribution of material to a standard under development should understand the interests of other contributing industrial players first, and if possible acquire the support a sufficient number of these players (this becomes even more complicated in ISO/IEC JTC 1 where national interests are mixed with industrial ones).
- Not all material can be standardized, a certain maturity that at least implies industrial application is required. Having existing products ready, or potential reference implementations, is a suitable way to motivate industrial relevance.
- A research project should evaluate its own interest on the development of a standard or standards profile. As said before, standardization is drive by material interests (e.g., industrial exploitation). Hence, spending time and resources on standardization work must be motivated by concrete exploitation plans of the project or its consortium.

6 Conclusions and next steps

Over the course of the 2-year project, a number of conclusions must be drawn for Work Package 4.

Tracking the various cloud computing technologies and services, a continuous supply of services are entering the "Gartner Hype Cycle pipeline" while other, longer existing services are advancing through the various stages. Picking a few cloud technologies and service models, and comparing their progression from 2013[17] to 2015[18] illustrates the dilemma of the CloudWATCH project. Limiting ourselves to the general-purpose service models IaaS, PaaS and SaaS, in 2013 SaaS was “Climbing the Slope” towards the plateau, while IaaS was plummeting towards the trough and PaaS, which was already beyond the peak, was about to plummet as well. Fast-forwarding to 2015 SaaS progression has slowed down compared to IaaS, with which it has now caught up. Both are climbing the slope towards the Gartner plateau. PaaS is still sliding down to the trough with its niche and sustainability options yet to be found.

Broadly, this is echoed in the work and environment Work Package 4 has worked on over the last two years. Broadly speaking, Work Package 4 needed to ask, and eventually answer the question: “When is it the right time to push for standardisation (in the cloud computing landscape?” The question whether or not to standardise was asked many times, and discussed even more often, at all kinds of meetings and opportunities within and even more beyond CloudWATCH. Without doubt, opinions increase to diverge with increasing numbers of participants in those events. However, the question of *when* to standardise goes a step further in implying standardisation not being challenged at all.

From CloudWATCH’s point of view, the Gartner Hype Cycle provides good indication of when to begin thinking of standardisation, and when this may be an utter waste of time: At the NetFutures 2015[19] event in Brussels related to the Digital Single Market, CloudWATCH asked the question of *when* to standardise for the first time, and made it a prominent discussion topic, by provocatively mapping the Gartner Hype Cycle to standardisation for the first time. At that time, CloudWATCH thought of starting the standardisation activities when technologies and services are “Sliding into the Trough” according to Gartner.

As a consequence, it would not make sense to discuss standardisation at an earlier point in time, and discussions at various CloudWATCH and related events (e.g. Cloudscape VII, CloudWATCH concertation events) confirm that observation. At the same time, however, *profiling* standards would have to take place at an even later stage than anticipated at the time of assembling the CloudWATCH project.

This is clearly an impediment to the original CloudWATCH objectives and outputs – conversely, we think it a valid statement to say that *CloudWATCH was and continues to be ahead of its time*. Had the project and Work Package 4 not experienced these issues, the outputs that have now been produced instead would not likely to have taken place.

Instead, the project’s current position is more refined in that standardisation should happen when services and technologies are “Climbing the Slope” and are close to “Entering the Plateau”, in other words, they transit into commodities, where identification of sustainable and prevailing technologies make it worthwhile spending the effort on standardisation.

Profiling on standards, however, should be considered much earlier than it often is at the moment. Instead of emerging a few years after underlying standards, profiling should be an integral part of

[17] https://www.gartner.com/doc/2573318/hype-cycle-cloud-computing-
[18] https://www.gartner.com/doc/3106717/hype-cycle-cloud-computing-
[19] http://netfutures2015.eu/programme/cloud-as-an-enabler-for-digital-single-market/

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standardisation activities and used as a technique to reach consensus hence standard publication much earlier: Profiles could be used constructively as a tool to reconcile diverging use cases in one common standard, while detailing the differences in a profile document straight away.

This concept is in its early stages, and has at times been referred to as "DevOps for Standards" (e.g. Alan Sill, President OGF) in order to reconcile the long standing objections to standardisation due to its long time frames and it is catching up with technology.

In the late phase of the first project year, CloudWATCH was in the decision making process about how to respond to these observations. The result manifested in adjusted work outputs for Work Package 2 and Work Package 4; by taking a few steps backwards and redirecting effort into underpinning groundwork for profile development to emerge.

The scope of the remaining workshops conducted by Work Package 4 were tweaked (see section 2 for more details) to accommodate and satisfy, pragmatically the new direction. Work Package 2 developed a methodology to reliably cluster projects with similar cloud computing characteristics with repeatable results to sue in the future as well. [D2.4]

Work Package 4 picked up the results of this clustering methodology; building on the published best practice methodology for standards profile development published in [D4.2] it complemented this process with a methodology on developing strawman profile documents in [D4.3].

The result of this strategic change in the project is obvious.

Through more focused work with Standards Development Organisations (SDO), the outputs of WP2 and WP4 are of high interest to the IEEE P2301 working group which is addressing a similar space. IEEE P2301 is very interested in adopting the statistical methodology developed in [D2.4] and use it for its work, and the work presented in [D4.3] will make its way into future IEEE P2301 publications.

Moreover, the final workshop (see section 2.6) confirmed the spot-on scope within the landscape of EC-funded projects. Representing more than twenty different projects, a good thirty participants from EC-funded projects as well as SDO representatives outspokenly validated and positively acknowledged the need for standards profiles, even though some of the work presented in [D4.3] would need further elaboration before technical details can be discussed and developed.

6.1 Next steps

The work conducted in the CloudWATCH project and particularly in WP4 so far has significantly progressed the awareness for cloud standards profiles and has positioned the process to conduct further cloud standard profiles in a methodological manner. But it is not yet completed: Through introducing a variety of workshop structures the CloudWATCH consortium as represented in the CloudWATCH2 project is now in a position to tally the workshops exactly to the needs of the community: A mix of facilitating Cloud Interoperability events (continued to be co-organised with the

Cloud Plugfest initiative[20]) and workshops in the style of MS21 will address the Technology & Techniques, and the Concertation & Coordination aspects of convergence in CloudWATCH2.

[20] http://www.cloudplugfest.org/

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D4.2 CloudWATCH deliverable 4.2 "Best practices for Cloud standards profile development", June 2014

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Document Log

DOCUMENT ITERATIONS		
V1	First draft	Michel Drescher, EGI.eu
V2	Second draft	Michel Drescher, EGI.eu
V3	Third draft	Michel Drescher, EGI.eu, David Wallom, UOXF
V4	Fourth draft	Michel Drescher, EGI.eu, David Wallom, UOXF, EGI Federated Clouds Task Force
V5	Fifth draft	EGI Federated Clouds Task Force
V6	Sixth draft	Michel Drescher, EGI.eu
V7	Seventh draft, including section 5.	Peter Deussen, FOKUS
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