

Context-Aware Cloud Topology Optimisation and Simulation

Dissemination & Collaboration Report & Newsletter

Deliverable 2.3.3

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Due date: 30/09/2016 Delivery date: 23/10/2016



This project is funded by the European Union under grant agreement no. 610711

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Dissemination Level

Х	PU	Public
	PP	Restricted to other programme participants (including the Commission Services)
	RE	Restricted to a group specified by the consortium (including the Commission Services)
	СО	Confidential, only for members of the consortium (including the Commission Services)

Version History

Version	Date	Change	Author
0.1	27/09/16	First draft (update of D2.3.2)	Claire Stewart (FLEX)
0.12	10/10/16	FZI updates incorporated	Claire Stewart (FLEX)
0.13	10/10/16	QUB publications added	Claire Stewart (FLEX)
0.14	10/10//1t6	DCU UPDATES	Claire Stewart (FLEX)
0.15	11/10/2016	UULM & UMU updates – web & soc med stats added editing notes	Claire Stewart (FLEX)
0.16	12/10/16	Updated UULM sections	Athanasios Tsitsipas (UULM)
0.17	16/10/16	Deleted out of date events, add pics of merch and website, edit and add to conclusion, impact, website reporting	Claire Stewart (FLEX)
0.18	17/10/2016	Update of impact reporting, event impact, addition of Twitter stat	Al Innes (FLEX)
0.19	18/10/2016	Updates	Al Innes (FLEX)
0.20	19/10/2016	Addressed comments, fixed publications, fixed format for tables Event Impact Assessment	Athanasios Tsitsipas(UULM), Jörg Domaschka (UULM)
0.21	19/10/2016	Fixed formatting of sections, updated introduction and conclusion text	Al Innes (FLEX)
0.22	19/10/2016	Fully fixed formatting	Jörg Domaschka (UULM)
0.23	20/10/2016	Added publication and accept FZI updates	Athanasios Tsitsipas(UULM)
0.24	23/10/2016	Final style check	Jörg Domaschka (UULM)
1.0	23/10/2016	Finalisation	Jörg Domaschka (UULM)

EXECUTIVE SUMMARY

This deliverable will provide an update on the CACTOS Dissemination and Collaboration Report laid out in D2.3.2. It marks the final report of the CACTOS project concerning dissemination.

Firstly, the objectives, intentions and targeted impact of CACTOS dissemination activities are presented, followed by the current dissemination strategy that the consortium is following in order to reach these goals.

The strategy that was followed by the consortium throughout the project is outlined, followed by a breakdown of each partner's individual efforts.

Beyond the strategic elements, practical measures taken are detailed, including the current status of the CACTOS website and social media presences as well as other tools used including publications, blogs, videos, guides, poster, factsheet and flyers.

The final section contains information concerning the specific activities each partner has undertaken in order to disseminate the project and its outcomes, as well as the efforts each partner has made towards collaboration with others.

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I. INTRODUCTION

Dissemination of the CACTOS project results to core target audiences is critical to the success of the project. In order to obtain and sustain an impactful dissemination process, annual reporting will be essential to make sure that results and feedback are correctly gathered, assessed and incorporated into the project dissemination strategy. In this way the strategy is a responsive and sustainable entity that is continually flexible to the market that CACTOS is working in.

This deliverable will be the final iteration of this process to be submitted in M36, CACTOS' final reporting period.

1. DISSEMINATION AND COLLABORATION OBJECTIVES

a) **OVERVIEW**

Dissemination of project results was aimed at targeting research communities, industry and potential partners and customers on CACTOS.

A primary challenge of the CACTOS project was to achieve broad consensus about the concepts developed by the project across both the scientific and industrial communities – a challenge in which dissemination was crucial.

Details of CACTOS innovations were widely disseminated in the research community and key stakeholders via numerous strategically targeted channels.

This report outlines those methods, actions and the results. It represents both an update on D2.3.1 and D2.3.2 for the third reporting period, and an end-of-project round-up of dissemination activity.

For consortium-wide strategy and individual partner roles, refer to dissemination plans outlined in full in D2.3.2.

b) Key Areas

The CACTOS strategy covers four main areas of dissemination activity and three main areas of collaboration: Summarised below are the outcomes for each type of activity.

• Scientific dissemination. The consortium has identified the major events where the project results can be disseminated. The main conferences for dissemination are listed in below.

There has been considerable dissemination by academic partners through scientific papers and presentations, reaching a large number of academics internationally and leading to interest, collaboration activities and further research opportunities.

 Internal dissemination (seminars, technical meetings, WP activity, mobility exchanges, etc.) will be constantly running throughout the project. Besides articles and conference presentations, factsheets and posters will disseminate the CACTOS approach in scientific meetings worldwide.

<u>As well as very well-received poster presentations, FLEX has held numerous internal</u> meetings, and QUB's internal discussions have led to a proposed spin-off company.

 Dissemination in Data Centre Managers Events and Associations. Members are engaged in the relevant communities such as DMTF (UULM), NESSI (UMU) and others. Potential contributions from CACTOS are related to the WBEM and Monitoring Standards of DMTF.
 Specific potential contributions to CAMP were investigated to ensure parallel relevance of CACTOS development.

<u>This activity has led to a high level of awareness in the industrial sphere of Data Centre</u> <u>management – a key target for exploitation activities.</u>

- Dissemination to the public and dissemination materials
- Horizontal collaboration at European project level. Horizontal activities will include collaboration with on-going FP7 projects (in particular in the area of Cloud Computing but also the Data Centre community at large in terms of energy efficiency and programming models). As stated in the State of the Art section B1.2 of the DoW, CACTOS will benefit from the previous direct participation of its members in related recent and on-going projects, and this will definitely help find relevant synergies and exchange of knowledge.

Dissemination of CACTOS info has led to constructive communications between CACTOS partners and other projects – CACTOS partners have formed a collaborative project with the PaaSage project consortium which will be funded by H2020 – MELODIC

 Horizontal collaboration at partner level. The activities will include collaboration with partners outside of the CACTOS consortium. This allows identifying synergies, eliciting further valuable additional requirements, community building, and knowledge exchange.

This activity has led to a new research project between UULM, UMU and DCU, funded by H2020, taking CactoOpt, CactoSim, and VMI OpenStack in particular forward (RECAP). It has also been a direct contributory factor in the instigation of collaborative cloud platform bwCloud with participation by UULM.

Dissemination activities have contributed directly to collaborations with Google, UMass, EventMap spin-out with QUB, and MSCG spin-out with DCU, and strong potential interest from a large German cloud provider, ExaInformatics and FlexiScale. (see D2.5.3 for these outcomes).

 Vertical collaboration with other initiatives in order to raise awareness of CACTOS results in the community. The consortium commits to participating with the appropriate resources to coordination and collaboration activities organized by the European Commission at unit and directorate level.

The CACTOS consortium have collaborated vertically across a wide range of events, conferences and EU ICT community activities – achieving widespread awareness over the course of the project term and with continuing life through new EU funded projects to take innovations forward. Academic partners have been able to attract research talent and CACTOS features in several ongoing academic research actions, with more on the horizon following the conclusion of the funding period.

II. CACTOS IMPACT

The following table, first introduced in the DoW, lays out the critical areas for CACTOS project dissemination. It sets out: the goals for the dissemination strategy; the Target Quantity to be obtained by M36, and the Quantity Achieved at M36.

Dissemination Goal	Target Quantity (M36)	Quantity achieved (M36)		
Publications (Scientific Target Group)				
Papers at scientific conferences	15	29– full information available in		
appearing in proceedings		section 3.2		
Publications (Technically interested community at large)				
CACTOS White papers	2	1 + 1 to be released in November		
Press Releases	4	5 <u>Target exceeded.</u>		
Web Site visits	800 p.a. with 1/3 spending more than 2 minutes on the site	1000+ views This is explored in detail in section 3.1.a <u>Target met</u> Average time on site overall – 2.06 minutes.		
Social Media Presence	Established groups in at least 2 networks (e.g. LinkedIn, Twitter) with bi-weekly updates	Active on 4 social media sites. This is explored in detail in section 3.2 <u>Target met</u>		
Industrial				
Meetings with Business Units/Commercial Staff within the industrial partners organisations	At least one every 6 months	1 (NMI) 4 internal meetings (flexiOPS) <u>6 monthly target met.</u>		
Demonstrations of the prototypes at an industry dominated event	3	1. Cloud Expo Europe 2015(11- 12 March 2015, London)		
		2. ICT 2015 (20 – 22 October, 2015, Lisbon)		
		3. ISC High Performance 2016 (19- 22 June 2016, Frankfurt)		
		As a result, we have opened a CACTOS testbed for a large German cloud operator and signed a memorandum of understanding (22 July 2016) In addition an agreement with the IT department of a large German manufacturer has been reached and signed (16 September 2016).		
Collaboration		1. Coo Cookien VIII for fronth on dot 11		
bi-lateral collaboration with another project working in the field established	inteasured by existing exchange of knowledge and/or models or implementations. CACTOS is designed to achieve its goals standalone so target is 0 but collaboration and exploiting synergies is a clear CACTOS target	regarding collaboration plans.		

Joint publication, workshop or	1	6
standardisation attempt with		Target exceeded.
another group (industrial or		
research) in order to increase		
visibility		

III. ONLINE PRESENCE

1. CACTOS WEBSITE

Our chief web presence for CACTOS is the website (<u>www.cactosfp7.eu</u>). This site serves as an online 'hub' for the CACTOS project, and is the main focus that other dissemination efforts point to audiences towards.

In D2.3.2, an account of website development and ongoing plans to update content were outlined, carried out by FLEX.

The website achieved targets for traffic as well as impressive numbers for downloads of CACTOS documentation, info and publications, outlined below.

a) WEBSITE ANALYTICS

Traffic from CACTOS partners has been removed from the following figures, in order to provide an accurate measurement of the external reach of the website.



June 2016 site statistics

In June 2016, the CACTOS website received 234 sessions (visits). These sessions came from 174 unique users, who registered 472 unique page views.

July 2016 site statistics



In July 2016, the CACTOS website received 199 sessions (visits). These sessions came from 158 unique users, who registered 509 unique page views.



August 2016 site statistics

In August 2016, the CACTOS website received 171 sessions (visits). These sessions came from 119 unique users, who registered 323 unique page views.



September 2016 site statistics

In September 2016, the CACTOS website received 127 sessions (visits). These sessions came from 98 unique users, who registered 283 unique page views.

M36 Website Analytics Summary



Sessions (visits) across the total period Sept 2015-16 totaled 1,141, which exceeds our target of 800 visits per year by 42%.

Other key points from web analytics

- The average session duration across the period for all visitors is 2 mins 16 secs.
- A significant minority of visitors (12.6%) spent between 3 to 30+ minutes on the site.
- An additional 7.5% of users spent between 1-3 mins on the site (2mins+ breakdown not available).
- Around 20% of visitors spent 1min+ on the site in total



How did visitors find us?

Only 1.6% of website visitors came directly from social media sources – however our organic search (40.5% of visits) show that our SEO was good and our direct and referral stats show that people found the site through other communicated means, such as newsletters, blogs and partner websites, conference websites etc.

Geographic profile of users

Country 🕑		Acquisition				
		Sessions 🕐 🗸 🗸	% New Sessions	New Users 🕐		
		1,141 % of Total: 100.00% (1,141)	64.50% Avg for View: 64.50% (0.00%)	736 % of Total: 100.00% (736)		
1. 🏭	United Kingdom	282 (24.72%)	52.84%	149 (20.24%)		
2. 🔳 (Germany	268 (23.49%)	36.94%	99 (13.45%)		
3. 💻	United States	84 (7.36%)	97.62%	82 (11.14%)		
4. 🔯	Brazil	68 (5.96%)	100.00%	68 (9.24%)		
5. 💵	Ireland	46 (4.03%)	30.43%	14 (1.90%)		
6. 🍱	India	29 (2.54%)	86.21%	25 (3.40%)		
7. 🔚	Sweden	27 (2.37%)	48.15%	13 (1.77%)		
8. 📕	Belgium	24 (2.10%)	45.83%	11 (1.49%)		
9. 🔳	Iran	22 (1.93%)	100.00%	22 (2.99%)		
10.	Italy	20 (1.75%)	75.00%	15 (2.04%)		

The majority of visitors came from UK or Germany – a significant portion from US and Brazil with the remaining visitor profiles comprising a diverse spread of other locations worldwide.

b) WEBSITE UPDATES

Tools and codes as well as user and installation guides for CACTOS tools were added to the website – with distinct sections for users and developers.

Tool & Code Downloads

CACTOS For Users:

Take advantage of CACTOS, and utilize the below artifacts in your data centre. Please note, as an on-going project, some artifacts are only available as nightly builds.

Artifact	Toolkit	Description	Download (Stable)	Download (Nightly Snapshot)	Documentation
CACTOS Chuckwa Agent Package	CACTOS Runtime Toolkit	Identifies the infrastructure and provide periodic updates, e.g. load measurements.	Chukwa Incubating src 0.5.0		Usage and installation instruction from Apache website
Hadoop Runtime Package	CACTOS Runtime Toolkit	Stores historical data on the infrastructure for further analyses.	Hadoop 2.6		As provided by Apache Website. Official instrutions
Runtime Management OpenStack Package	CACTOS Runtime Toolkit	The Runtime Toolkit facilitates optimisation of a data center configuration by offering a set of algorithms for initial placement and migration of virtual machines. The Runtime Toolkit is fully integrated with the OpenStack platform.		Nightly x86 Win Nightly x86 Linux	
Runtime Management FCO Package	CACTOS Runtime Toolkit	The Runtime Toolkit facilitates optimisation of a data center configuration by offering a set of algorithms for initial placement and migration of virtual machines. The Runtime Toolkit is fully integrated with the FCO platform.			
Runtime Model Updater Package	CACTOS Runtime Toolkit	Updates the infrastructure models.		Win32 x86 Binary Linux x86 Binary Nightly	CactoScale Guide
Runtime Model Storage Package	CACTOS Runtime Toolkit	Stores the infrastructure models for a data centre.			Documentation and Installation Guide
Runtime Model	CACTOS	Stores the infrastructure models for a data centre.			

c) DOWNLOADS CACTOS WEBSITE

The website as a primary platform for information and discovery of CACTOS tools and guides has registered a healthy level of tracked downloads of tools, guides, articles and documentation. With a total of 8289 downloaded items, this considered alongside website traffic suggests that a high proportion of visitors to the website are downloading multiple items of this kind.

Document title	Total Downloads		
D7.3.2 Validation Goals and Metrics	120		
D5.2.2 CACTOS Toolkit Version 2	142		
D4.4 Integrated Data Collection and Analysis Frameworks	110		
D7.4.1 Validation and Result Analysis	254		
D6.2 Preliminary results from optimisation models			
validation and experimentation	254		
D5.4 Evaluation Methodology for the CACTOS Runtime and			
Prediction Toolkits	274		
D5.3 Operational Small-Scale Cloud Testbed Managed by			
the CACTOS Runtime Toolkit	260		
D5.1 Model Integration and Supporting Tooling	279		
D4.3 Parallel Trace Analysis	266		
D4.1 Data Collection Framework	275		
D3.3 Extended Optimization Model	280		
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CACTOS Flyer	188		
Factsheet	134		
IEEE CloudCom 2014 – The CACTOS Vision of Context-			
Aware Cloud Topology Optimization and Simulation	126		
CactoScale Poster	167		
CactoOpt Poster	133		
CactoSim Poster presented at SOSP 2014	128		
CACTOS Press release – Flexiant	211		
CACTOS Press Release - Umea University	167		
CACTOS Press release – Dublin City University	159		
CACTOS Press release – FZI (German)	153		
CACTOS Press release FZI (English)	166		
'Meet CactoScale' Demo Video	161		
'Meet CactoOpt' Demo Video	161		
'Meet CactoSim' Demo Video	215		
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D2.1 Project Website	272		
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D2.3.1 Dissemination & Collaboration Report & Newsletter	347		
D3.1 Prototype Optimization Model	277		
D4.2 Preliminary Offline Trace Analysis	282		
D5.2.1 CACTOS Toolkit V1	317		
D7.3.1 Validation Goals and Metrics	260		
D4.1 Data collection framework	580		

D5.1 Model Integration and Supporting Tooling	272
TOTAL DOWNLOADS	8289

2. BLOGS

The consortium contributed to the monthly rolling blog schedule, administered by FLEX, to keep the website up to date with news and communication the latest developments and updates about CACTOS tools and innovations.

LADT - CactoScale's Lightweight Tool for Anomaly Detection

Published on May 26, 2016 by Sakil Barbhuiya

CactoScale's data analysis functionality includes LADT, which is a lightweight anomaly detection tool for Cloud data centres. LADT uses rigorous correlation of system metrics, implemented by an efficient correlation algorithm without need for training or complex infrastructure set up. LADT is based on the hypothesis that, in an anomaly-free...

Read More

CACTOS BLOG | Presenting a comprehend solution, monitoring our OpenStack Physical Testbed

Published on April 5, 2016 by Thanos Tsitsipas

This blog entry presents a robust solution for monitoring a data centre infrastructure exemplified at the OpenStack testbed UULM provides for the partners in the CACTOS consortium, described in "Part 3: Staying Up-To-Date with Software and Requirements". The implementation is part of CactoScale, described initially in "Meet CactoScale". An...

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CACTOS at CeBIT 2016

Published on March 22, 2016 by Christian Stier

The CACTOS project is excited to have been present at this year's CeBIT. CeBIT is the largest international computer show held annually in Hannover, Germany. CACTOS was represented at the common booth of the CACTOS member FZI Research Center for Information Technology and the Karlsruhe Institute of Technology (KIT) FZI was pleased to...

Read More

Using Games and Gamification to Reduce Energy Use

3. ONLINE REPOSITORY MAINTENANCE

FZI will continue hosting the CACTOS project Subversion repository as basic service for enabling the dissemination for each, and between each, of the project partners. The repository will also continue to host all code developed within CACTOS for access by the public (post project term).

IV. MEDIA GENERATION

1. PUBLICATIONS

Part of the CACTOS Dissemination strategy, the consortium aimed to have 15 articles published in relevant journals/conference proceedings by the end of the project in M36. This target has already been surpassed, with 29 (29 incl. posters) articles accepted or published by M24. A full list of publications follows.

Title	Partner	Туре	Event	Publication Date	Status	Link
Modeling laaS Usage Patterns for the Analysis of Cloud Optimization Policies	FZI, UULM	Confere nce Paper	7th Symposium on Software Performance 2016	15/10/2016	Accepted	http://www.perfor mance- symposium.org/201 6/program/
Experiences of Models@run-time with EMF and CDO	UULM in collaboratio n with PaaSage, CloudSocke t, and Acardia	Confere nce Paper	9th ACM SIGPLAN International Conference on Software Language Engineering (SLE)	12/10/2016	Accepted	http://www.sleconf. org/2016/Accepted Papers.html
PEAS: A Performance Evaluation framework for Auto-Scaling strategies in cloud applications.	UMU	Journal paper	ACM transations on Modeling and Performance Evaluation of Computing Systems (TOMPECS),	09/2016	Accepted	http://dl.acm.org/ci tation.cfm?id=2930 659
Towards Usage-based Dynamic Overbooking in IaaS Clouds	UULM	Confere nce Paper	The 13th International Conference on Economics of Grids, Cloud, Systems and Services (GECON 2016)(20.09.2016- 22.09.2016, Athens, Greece)	21/09/2016	Accepted	http://2016.gecon- conference.org/pro gram
Context-Aware Cloud Topology Optimization for OpenStack	UULM	Confere nce Paper	The 5th European Conference on Service- Oriented and Cloud Computing (ESOCC 2016)(05.09.2016- 07.09.2016, Vienna, Austria)	05/09/2016	Accepted	http://esocc2016.eu /eu-project-track- program/
Challenges and Opportunities in Edge Computing	QUB	Confere nce Paper	IEEE International Conference on Smart Cloud, New York, USA, 18-20 November 2016.	05/09/2016	Accepted	http://csis.pace.edu /CSCloud/sc2016/in dex.html
Die-Hard: Reliable Scheduling to Survive Correlated Failures in Cloud Data Centers,	UMU	Proceed ings and present ation	CCGrid 2016	16- 19/05/2016	Accepted	http://ieeexplore.ie ee.org/document/7 515669/

Towards Understanding	UMU	Proceed	CCGrid 2016	16-	Accepted	
HPC Users and Systems:		ings and		19/05/2016		http://ieeexplore.ie
A NERSC Case Study.		present		-,,		ee.org/document/7
		ation				515730/
Decentralized cloud		lournal	Euturo Conoration	02/2016	Accontod	5157567
datacontor	01010	publicat	Computer Systems	03/2010	Accepted	
		publicat	computer systems			
reconsolidation through		ion				nttp://dl.acm.org/cl
emergent and topology-						tation.cfm?id=2869
aware behaviour.						424
Lightweight and Scalable	QUB	Paper	Communications in	03/02/2016	Accepted	http://link.springer.
Anomaly Detection for			Computer and			com/book/10.1007
Cloud Datacentres			Information Science,			%2F978-3-319-
			Cloud Computing and			29582-4
			Services Science, 135-			
			152 Springer			
			International Bublishing			
			Switzeriand, vol. 538,			
			February 2016.			
Considering Transient	FZI in	Paper	International ACM	05/04/2016	Published	http://ieeexplore.ie
Effects of Self-	collaboratio	and	SIGSOFT Conference on			ee.org/stamp/stam
Adaptations in Model-	n with KIT	present	the Quality of Software			p.jsp?tp=&arnumbe
Driven Performance		ation	Architectures, Venice,			r=7515438&isnumb
Analyses			Italy			er=7515382
Ensuring model	FZI	Paper	Modeling and	01/04/2016	Published	
continuity when		and	Simulation of	- , - ,		
simulating self-adaptive		nresent	Complexity in			
software systems		ation	Intelligent Adaptive			
soltware systems		ation	and Autonomous			http://dl.acm.org/ci
			and Autonomous			hetion effected 2002
			Systems 2016 (IVISCIAAS			tation.ctm?id=2962
			2016)			666
Improving laaS Cloud	FZI	Paper	Symposium on	04/11/2015	Published	http://pi.informatik.
Analyses by Black-Box		and	Software Performance			uni-
Resource Demand		present	2015			siegen.de/gi/stt/35_
Modeling		ation				3/03_Technische_B
						eitraege/SSP 2015
						paper 6.pdf
Model-Based Energy	FZI in	Paper	European Conference	07/09/2015	Published	
Efficiency Analysis of	collaboratio	and	on Software			http://sdaweh.ind.k
Software Architectures	n with KTI	nrocont	Architecture (ECSA '15)			it edu/publications/
Software Architectures		present	Architecture (LCSA 15),			ndfa/ation2015a.ndf
-				24/22/2245		puis/stierz015a.pui
Iowards Automated	DCU, FZI,	Confere	Light EAI International	24/08/2015	Accepted	http://simutools.org
Data Driven Cloud	and QUB	nce	Conference on			/2015/show/progra
Computing Simulation		Paper	Simulation Tools and			m-final
Model Creation			Techniques			
			(SIMUTOOLS 2015),			
			Athens, Greece, 24 – 26			
			August 2015			
BUNGEE: An Elasticity	FZI in	Paper	Software Engineering	18/05/2015	In Press	http://se2.informati
Benchmark for Self-	collaboratio		for Adaptive and Self-	_0,00,2020		k uni-
Adaptive Jack Cloud	collabol atio		Managing Systems			wuorzburg do/po/u
nuaptive laas clouu			(CEANS 2015)			waerzburg.ue/pa/u
Environments	oniversity		(SEAIVIS 2015),			pioaus/papers/pape
	or		Fiorence, italy, 18 – 19			r-782.pat
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Analysis and characterization of a video-on-demand service workload	UMU	Paper	ACM Multimedia Systems (MMSys), 18 – 20 March 2015, Portland, Oregon, USA	01/03/2015	Published	http://www.mmsys. org/index.php/mms ys-2015
The CACTOS Vision of Context-Aware Cloud Topology Optimization and Simulation	All (FZI and UMU lead)	Paper	The 6th IEEE International Conference on Cloud Computing Technology and Science (CloudCom 2014), 15 – 18 December 2014, Singapore	01/12/2014	Accepted	http://www.cactosfp 7.eu/wp- content/uploads/20 14/10/The-CACTOS- Vision-of-Context- Aware-Cloud- Topology- Optimization-and- Simulation-CACTOS- .pdf
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Optimised Cloud Data Centre Operation Supported by Simulation	UULM, DCU and FZI	Paper and Present ation	eChallenges conference, 29 – 30 OCtonber, 2014, Belfast, Ireland.	01/10/2014	Accepted	

2. DISSEMINATION MATERIAL



Fig 2 – CACTOS branded promotional items

3. POSTERS AND PRESENTATIONS

In order to successfully disseminate CACTOS, the CACTOS poster is used to provide highlight information, and prompt further investigation or discussion. The poster covers both the project, and the tools the project will produce.

Further, for occasions when members of the CACTOS consortium have an opportunity to present CACTOS to an audience, a template presentation has been available in the Subversion repository (as well as on the project website), since early in the project. The focus of this presentation was originally on CACTOS as a project, given the early stage of the project, in order to explain our intentions. However, the presentation will now focus more on the outcomes of the project, in line with the shift in our dissemination intentions, using clear messaging to promote the CACTOS solution to the core target markets identified in D2.5.2.



www.cactosfp7.eu

Context-Aware Cloud Topology Optimisation and Simulation



Figure 1: The CACTOS Poster



Figure 2 The latest CACTOS Poster presented in ISC 2016

4. FACTSHEET

The purpose of the CACTOS factsheet is to provide based project information for people interested in the project generally.

Whilst we have adopted a more product-focused approach to dissemination during the second year of the project, and so created a new flyer (see below), it is important that the factsheet remains up to date and still conveys the most recent information regarding the project. Therefore, the factsheet has been updated throughout the project as it has matured.

The factsheet does remain an important dissemination tool for project awareness, however, we expect to see a shift use of the factsheet to use of the product-focused flyer (below) so that the CACTOS tools are able to make the biggest possible impact amongst our target users.

September 2015



CACTOS

Context-Aware Cloud Topology Optimisation and Simulation

CACTOS delivers three major tools as part of two different toolkits: the Runtime Toolkit for managing a live data centre and the Prediction Toolkit for what-if-analyses. **CactoScale:** A set of tools and methods to acquire and analyse application behaviour and infrastructure performance data. **CactoOpt:** Mathematical models and their realisation to determine the best fitting resources within a provider context. **CactoSim:** A prediction and simulation environment for diverse application workloads

Context

AT A GLANCE

Project title: CACTOS Context-Aware Cloud Topology Optimisation and Simulation

Projects coordinator: Prof. Stefan Wesner stefan.wesner@uni-ulm.de Ulm University, DE

Partners:

The Queen's University of Belfast, UK Flexiant Limited, UK Umeå Universitet, SE FZI Forschungszentrum Informatik am Karlsruher Institut für Technologie, DE Dublin City University, IR PlayGen, UK

Duration: 36 months, Oct 2013 – September 2016

Total cost: 4,761,232 €

Website: http://www.cactosfp7.eu

User demand and new technologies are driving a dramatic increase in cloud infrastructure scale. heterogeneity and complexity. Demand for better energy efficiency has led to a variety of different technological options to build servers from different CPU architectures optimised for energy efficiency or performance as well as specialised options for highly parallel tasks such as manycore systems or General Purposed Graphical Processing Units, GPGPUs. Additionally the service complexity has evolved from models very similar to traditional server hosting to more interactive services (e.g. remote rendering or gaming) as well as moving towards more complex services on top of hardware and basic platform services. Similarly data centres have made significant investments in energy efficient buildings, server racks and facility management technology and understand themselves as Smart Consumers in evolving SmartGrid environments.

To cope with the challenge to optimise the mapping of services to a variety of different resources, both hardware and software related (e.g. licenses), requires topology-aware mappings. This mapping needs to consider placement of the services across geographically distributed centres and demands new intelligent and cross-domain integration of actual and historical data.

Figure 3: Page 1 of updated CACTOS Factsheet

Approach

CACTOS addresses the challenges of this increased complexity and heterogeneity from several angles.

- An intensive modelling activity will deliver models for workloads, infrastructure landscapes as well as facility management information and energy supply information.
- Collection and analysis of historical usage data and derivation of intelligent management strategies integrating research results from the cloud and data centre management field as well as from Mathematics and operations research build the basis for the optimisation and topology aware placement
- Dynamic workload placement, scheduling and migration by continuous optimization across multiple partially orthogonal or correlated criteria
- A simulation framework for conducting costs and risk analysis in order to validate the developed intelligent context-aware cloud topology optimisation strategies for robustness on a large scale beyond the limits of prototypical installations and deployments
- Validation by deployment in three distinct scenarios for business analytics, enterprise applications and technical computing use cases.

In summary, the CACTOS project addresses the particular challenges faced by infrastructure and service providers of substantially increased diversity of computing systems and platforms from leading edge specialised hardware to "low end" commodity off-the-shelf equipment. With its results, the project is addressing different timeframes. In the short term the work on modelling infrastructure and workload will deliver the basis for changing operation policies already during the lifetime of the project. In the mid term the integration of the models and their validation using simulations will open the opportunity to enable a simulation and knowledge based management system automatically adapting to and optimise for different pre-planned scenarios. The CACTOS project will aim in its long-term vision to pave the way towards the highly exploratory field of self-automated and self-optimized adaptation for the highly dynamic and complex workloads faced by cloud operators.



Figure 1: Overview on the CACTOS Toolkits.

Impact

CACTOS addresses the specific problems data centre operators face due to the exploding heterogeneity of the underlying hardware, increasing demand for energy efficiency while supporting more demanding and diverse applications on top of cloud infrastructure and platforms.

The major targeted impact of CACTOS is to enable data centre operators to deliver cloudbased applications on top of current and future heterogeneous hardware as energy efficient as possible.

CACTOS aims to deliver the infrastructure that fits best to the application of a customer in terms of observed quality with minimised operational costs and consequently increased competitiveness.

CACTOS will bring these benefits directly to innovative cloud providers and data centre operators delivering more efficient services on modern and more energy-efficient hardware. CACTOS will speed up the availability of research results by integrating research concepts immediately into prototypical versions of a commercially available cloud middleware. The ability to adopt new hardware offers faster either leads to a reduced energy and CO2 footprint or allows delivering results for the same problem in shorter time frames.

Figure 4: Page 2 of updated CACTOS Factsheet

5. FLYER

We have also produced a CACTOS flyer, which has been used to publicize the project at various events. The flyer is more marketing oriented and can be handed to people interested in managing their cloud platforms with CACTOS, in order to engage potential users of the CACTOS outcomes, rather than those specifically interested in the project behind the tools. The flyer has, and will continue to be, used to maximize our impact at trade fairs and meetings, as well as giving potential users from the target market a 'take home' that will enable and encourage them to follow up their interest in the CACTOS tools at a later date.

Given the purpose of the flyer is more of a marketing intention; the main attention of the user is drawn to the outcomes of the project, rather than information about the project itself. In this way, it is much more product orientated and shows our move in the second year from project-focused, to

tool-focused dissemination. For more information, users are directed to the CACTOS website, which when the redesign is live will also adopt this product-focused approach.

Once folded, the Flyer features a front cover with the project logo. This is opened to reveal the information concerning each tools, as well as the insert explaining why users should be interested in CACTOS. The insert can be folded out of the way to reveal information concerning the CACTOS vision. Finally, the back cover of the folder flyer shows the project partners, and EU funding information.



Figure 5: Flyer front cover (right), back cover (middle) and insert (left)



Figure 6: Flyer inside information when opened. The CACTOS Tools (left and middle) and immediately visible, whilst the vision is covered by the insert which explains why users should be interested in CACTOS

6. BLOGS

Hosted on the project website, the CACTOS blog has been a major dissemination platform for CACTOS, as it provides regular updates on the project and the CACTOS tools on our core dissemination 'hub' of the website.

Further, the content created for the blog is used to supplement our social media dissemination channels, which in turn drive additional traffic to the blog and website.

Using Games and Gamification to Reduce Energy Use

Published on February 17, 2016 by Kate Pigden

Games and gamification can be used to motivate and support citizens' behaviour in energy use, but this is not without it's potential downfalls. Since most games rely on some method of internal or external reward, associating rewards with activity is not to be taken lightly. One false move and...

Read More

CACTOS wins Symposium of Software Performance 2015 Best Poster Award Published on February 4, 2016 by Christian Stier

Christian Stier, Dr.-Ing. Henning Groenda, Prof. Ralf Reussner from the FZI Research Center for Information Technology and Jun.-Prof. Anne Koziolek from the Karlsruhe Institute of Technology received the Best Poster Award at the Symposium on Software Performance 2015 (SSP 2015). The poster illustrates an architecture-level approach for evaluating energy...

Read More

CACTOS Workshop & Networking Session @ ICT2015

Published on October 29, 2015 by ainnes

CACTOS was pleased to attend the ICT 2015 event in Lisbon last week, along with partners from Flexiant, the University of Ulm and Dublin City University; we were there to talk to the attendees about CACTOS and share our flyers and thoughts with them. In addition we were joined...

Read More

Figure 7: A snapshot of our CACTOS blog posts

In year 3 the blog became a crucial tool in raising awareness of the CACTOS tools and flagging events we were a part of as the project was at a mature stage. The content complemented the CACTOS github which now hosted tools, technical information and support documents for those using tools. focus of the blogs content developed to cover all elements of the technical work that was being undertaken by project partners. This helped to both inform our audience, but also to demonstrate the leading nature of the project, and so position the project as experts in the field so that the target users are aware that the tools which are produced are of high quality and benefit from expert development.

EXTERNAL BLOGS

In addition to CACTOS project blog posts, the project received valuable coverage on many external blogs which have an ongoing impact for dissemination to relevant audiences. For example, the blog post on UULM's blog in February 2016 had an estimated 2460 views,

In order to ensure that all elements of the project's technical work is covered, we utilised a blog schedule which mapped out when each partner would be due to submit a discussion of their work.

7. TOOLS, VIDEOS & GUIDES

As part of the shift in our dissemination strategy to be more product-orientated and increasingly focus on the tools that the project will produce, the consortium has created tool specific promotional videos and user guides. These are to be incorporated into the redesigned website, as well as ensuring that potential users are aware and able to make use of the CACTOS tools.

Promotional videos have been produced, with CactoScale, CactoOpt, and CactoSim each having a video featuring a demonstration and explanation of the tools, so that potential users can preview and get a better understanding of the tools

These include a demonstration of the tools in action, so that users are able to better visual the usage of the tools and awareness of their functionality.



Figure 8: A still from the 'Meet CactoScale' video

As well as promotional videos, the consortium has also produced user guide documents for CactoScale, CactoOpt, and CactoSim.

These user guides are designed in order to ensure that potential users of the tools are able to make full use of the software. This will mean that they are more likely to take advantage of the tools, as well as recommend them to others. These guides will therefore contribute to maximising not only the impact of the CACTOS tools, but also the wider it's dissemination.

Both the videos and user guides will be updated as each tools develops to ensure that they are relevant.

Video title	Producing	Number	Link
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		views	
CactoSim Demo - Design-	FZI	144	https://www.youtube.com/watch?v=vPI5RkpCElc
Time Predictions for			
Cloud Data Centres			
CACTOS Cloud Expo	FLEX	55	https://www.youtube.com/watch?v=pBoAKapVpFI
Workshop Discussion			
Meet CactoSim	DCU	43	https://www.youtube.com/watch?v=Ah6uW1kfjkA
Meet CactoOpt	UMU	29	https://www.youtube.com/watch?v=0sqlksUOiPM
Meet CactoScale	QUB	58	https://www.youtube.com/watch?v=afK1KDSIVYg
ICT2015 CACTOS Workshop	FLEX	160	https://www.youtube.com/watch?v=_Q5Yx0mOyqU
and Networking			

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8. OTHER

Branded pens, mugs and keyrings were produced to promote CACTOS, in line with our 'project and product' approach to raising awareness of the CACTOS innovations. These were disseminated at industry events and conferences.



V. DISSEMINATION ACTIVITIES

This section outlines the activities the consortium has taken part in to further enhance the dissemination and potential uptake of the CACTOS solution through collaboration between partners, and with external actors.



Figure 10 Christopher Hauser (UULM) explains the CACTOS architecture in ISC 2016

1. UULM

- Provided one blog entry as planned (March 2016)
- Promoted CACTOS in lectures:
 - Stefan Wesner, "Data Centre Networks Architecture and Protocols", Lecture for Master Students, University of Ulm, Summer Term 2016
 - Stefan Wesner/Lutz Schubert: "Cross-organisational distributed systems and clouds", Lecture for Bachelor and Master students, University of Ulm, Summer Term 2016.
 - Stefan Wesner, Jörg Domaschka: "Computer Networks", Lecture for Bachelor and Master students, University of Ulm, Winter Term 2015.
 - Jörg Domaschka, "Research Trends in IoT", Seminar for Master Students, University of Ulm, SummerTerm 2016
- Bachelor and Master theses:
 - Efficient transport and anomaly analysis in large networks, Benjamin Droemer, October 2015 (BT completed)
 - o Classification of Virtual Switch Approaches in Clouds, Arslan Khan, March 2016 (MT completed)
 - A Proactive Alert Engine for Cloud-enabled Applications using Machine Learning Algorithms, Syed Tauqeer Hasan, June 2016 (MT completed)

- Network Bandwidth Sharing for VMs, Timo Müller (BT on-going)
- o Dynamic VM Network Scheduling, Santhosh Ramaputam (MT on-going)
- Live Migration mit den Hypervisor VMWare ESXi und Microsoft Hyper-V, Udo-Günther Bootsch (BT)
- Publish academic results:
 - Papers and Presentation
 - ESOCC 2016
 - GECON 2016
- Poster designed and animation to be presented at the CACTOS booth at the ISC 2016.
- Representation and dissemination of CACTOS at ICT 2015 in Lisbon
- Several meetings with industry partners
 - German cloud provider; interested in trying out CACTOS results and tools in their data centre (3 meetings in 2016), agreement on further collaboration, cf. (D2.5.3 Exploitation Activities Report)
 - IT operator of large German manufacturer; interested in CACTOS results on application modelling techniques, cloud data centre operation, and optimisation algorithms (4 meetings in 2016); agreement on common research project, cf. (D2.5.3 Exploitation Activities Report).
 - Ulm-based SME specialised on data centre operation; interested in automatic data centre operation (4 meetings in 2016). agreement on common research agenda around automatic deployment and data centre optimisation.
- Several meetings with research and uptake partners with promoting of results
 - bwCloud project consortium: Baden-Württemberg wide consortium of university data centres; interested in automatic data centre operation and dynamic scheduling (7 meetings since Sep 2015); agreed on use of CACTOS tools in bwCloud production phase starting in January 2017; cf. cf. (D2.5.3 Exploitation Activities Report).

UULM data centre operators: interested in insights gained with Molpro modelling (3 meetings since Sep 2015).

2. QUB

• QUB ran a stream at the Multidisciplinary International Scheduling Conference held in Prague August 2015 (http://www.schedulingconference.org/). As co-Chair of this conference series, this was an excellent opportunity to alert and expose the project to researchers in the scheduling community. Further to co-Chairing the event, a paper was presented, with collaboration from Umea.

- Blog entries and guidelines were provided for the project website. Further entries will be provided in the future and the guides will be further updated and refined.
- A presentation was done at CLOSER 2015 conference for a regular paper. The paper was nominated for the best student paper award.
- Published academic results (paper and presentation) at CloudCom 2014
- Published academic results (paper and presentation) at CLOSER 2015
- Published academic results (paper and presentation) at Simutools 2015
- Published academic results (paper and presentation) at MISTA 2015
- Promoted project to scientific and industrial community through Newsletter and LinkedIn groups.

3. FLEX

- Led WP2, coordinating telcos, workload and deliverables
- Presenting CACTOS at FIA Athens March 2014
- Presenting CACTOS at Cloud Expo London March 2015
- Presenting CACTOS at SummerSoC Crete July 2015
- Presenting CACTOS at ScotSecure April 2015
- Presenting CACTOS at ScotCloud June 2015
- Presenting CACTOS at ICT Lisbon October 2015
- Internal presentation of CACTOS to angel investors June 2016
- Internal presentation of CACTOS to Flexiscale June 2016
- Presenting CACTOS at at SummerSoC Crete July 2016
- Presenting CACTOS at Venturefest Glasgow September 2016
- Internal presentation of CACTOS to Exalnformatics September2016
- Presenting CACTOS at ICT Proposers' Day Bratislava September 2016
- Managed social media channels to promote project.
- Managed, maintained and updated live CACTOS website
- Completed initial draft of redesigned website
- Managed the online blog, editing, publishing and promoting all blogs
- Contributed 3 blogs written by Flexiant
- Web and social media analytics

- Leading on STORMCLOUDS collaboration
- Updated Factsheet
- Designed Flyer
- Edited and branded partner-produced tool-specific videos

4. UMU

- UMU organized the 3rd, 4th, 5th, 6th, 7th, 8th and 9th Cloud Control Workshops where we presented in each of them results from CACTOS. The workshops where widely attended with invited guests from the industry including Google, VMware, Simula Research, Ericsson Research, Microsoft research, Battery ventures, IBM Research, Alcatel-Lucent, and Intel Research. Besides the industry guests, in total, more than 400 attendees were present in all the workshops, many of them from academic institutions in Europe, the US, and Asia. More Information on what was presented in each workshop can be found here (http://cloudresearch.org/workshops/workshops/)
- Paper presented in MMSys 2015 on the analysis of Video-on-Demand workloads
- Poster presented in EuroSys 2015 on the design of the Workload Analysis and Classification Tool
- Paper presented in CCGrid 2015 on vertical elasticity within CactoOpt
- Paper presented in CLOSER 2015 on optimization in heterogeneous environments
- Paper presented in ICCAC 2015 on the tradeoffs between different management decisions when optimizing Cloud systems
- Two papers in CCGrid 2016
- Three journal papers in top journals
- One Tutorial in IEEE ISPASS 2016, one of the premier conferences on performance modeling and evaluation. The tutorial was attended by more than 30 researchers from around the world.
- Two posters in top cloud and system conferences (SoCC2016nd EuroSys2015)
- Keynote speech by Erik Elmroth at CloudTech 2015
- Blogs
- Results integrated in the Cloud computing course taught in 2014, 2015 and planned for 2016 for M.Sc. students.

5. FZI

FZI will continue hosting the CACTOS project Subversion repository as basic service for enabling the dissemination for each and between all partners. The repository will also continue to host all code developed

within CACTOS for access by the public. FZI will contribute to and assist the consortium in creating CACTOS white papers and online documentation. We will continue to use our close collaboration with the chair on Software Design and Quality at the KIT to raise awareness in the academic world and introduce students to the state of the art in lectures. Spreading our ideas among students allows us to get into contact and makes it likely that they'll use our approach later on in industry. As academic partner, we have published and plan to publish our academic research results, preferably joined with other partners, at appropriate venues in journals, conferences, workshops, and provide tool demonstrations. Targeted venues are COMPARCH, SEAA, ICSE, ESEC/FSE, WICSA/ECSA, ASE, MODELS, ICPE, FESCA, WCOP, FACS, and for IDE and technical results EclipseCon. We will leverage our established cooperation with researches and industry to promote CACTOS and Open Source solutions. FZI has promoted and will continue to promote CACTOS results to partners from industry and academia that collaborate with FZI on topics from the domain of Cloud Computing, energy efficiency and Continuous Quality Engineering.

- Updated project flyer
- Updated project factsheet
- Provisioning of content for the website including news, blog entries and social media content (ongoing)
- Providing and maintaining a Subversion repository (ongoing)
- Collaborate with chair SDQ at KIT (ongoing), promote jobs and theses to students
 - o Master theses
 - Profiling and optimization of energy consumption of mobile applications at design time (completed). Received an award by the Karlsruhe Association of Software Engineers: <u>http://www.vksi.de/sneak-preview-big-data-ein-jahr-nach-dem-hype-mit-preisverleihung/</u>.
 - Design and analysis of run-time criteria for the partitioning of applications between servers and mobile devices (completed)
 - Practical courses
 - Analysis and visualisation of predicted power consumption threshold violations (completed)
 - Development of an optimization plan-based reconfiguration interface for SimuLizar (completed)
 - Coupling of SimuLizar with the optimisation framework PerOpteryx in order to support the optimisation of self-adaptive software systems at design time (completed)
 - Instrumentation and extension of SPEC SERT benchmarking tools for the automatic extraction of server power models (completed)
 - Extraction of hierarchical power models for CACTOS (completed)
 - Implementation and integration of distance metric evaluations for EDP2 (completed)
 - o Student jobs
 - Implementation of energy analyses for self-adaptive software systems (completed)
 - Implementation of reconfiguration time measurement infrastructure in simulations (completed)
 - Extension of Palladio to support the simulation of black-box behaviour models (completed)

- Extension of SimuLizar to support further metric collection and processing (completed)
- Improvement of transient effect interpreter implementation in SimuLizar (completed)
- Implementation of EDP2 result storage metadata in CDO (completed)
- Publish academic results
 - Paper and Presentation
 - SoSP 2014
 - CloudCom 2014
 - Seams 2015
 - Simutools 2015
 - ECSA 2015
 - SSP 2015
 - MSCIAAS 2016
 - QoSA 2016
 - Poster at SSP 2015
- Update of architecture and overview diagrams
- Research exchange with Fraunhofer IESE (ongoing)
- Research exchange with chair for Software Engineering at Universität Würzburg (ongoing)
- Creation of CactoSim poster
- Produced and published CactoSim Screencast Tutorial video.
- Tool demonstration of CactoSim with DCU at SoSP 2014.
- Provided feedback on product-oriented website relaunch.
- Provided feedback on CACTOS code dissemination and documentation structure for final GitHub code release
- Automated creation of deployable artefacts for taking the toolkits for a test drive.
- Contributing simulation extensions and results from CACTOS to the Palladio community (ongoing)
- Creation of a heedlessly executable CACTOS Prediction Toolkit for use and integration in command line workflows
- Promoted CACTOS at CeBIT 2016 (<u>http://www.cactosfp7.eu/2016/03/22/cactos-at-cebit-2016/</u>)
- Promoted CACTOS in biannual FZI report

Promoted and summarized CACTOS results in book on the Palladio approach (<u>https://mitpress.mit.edu/modeling</u>)

6. DCU

- Contribution to project flyer
- Contribution to project factsheet
- Providing news to the CACTOS FP7 website
- Providing blog entries to the CACTOS FP7 website
- Providing social media content to the CACTOS website
- Dissemination through www.sim.ie research group channel
- On-going PhD thesis (Sergej Svorobej)
- Integration of CACTOS results towards course development
- Dissemination at ICT 2015 (Lisbon)
- Lead presenter at NC4 2014, NC4 2015, NC4 2016
- Contribution to CactoSim poster
- Meeting with IT Solutions Ltd. (Ireland) in relation to simulation capability and potential future collaboration (ultimately leading to successful national funding)
- Meetings with industry promoting CACTOS work (Intel, BT, SATEC, Linknovate, Tieto) ultimately culminating in successful H2020 funding from the ICT-06 call for the RECAP project, with UULM and UMU
- Preliminary meetings with DCU spin out company (Modelling and Simulation Technologies Ltd.) regarding potentially exploiting results from CACTOS work
- Meeting with Universidad Politécnica de Madrid (UPM) ETSISI (Spain) in relation to potential future collaboration as a result of CACTOS outputs
- Contribution to website relaunch.
- Ongoing contributing of simulation-related results from CACTOS to the Palladio community

7. PLAYGEN

No update since D2.3.2.

VI. EVENT IMPACT ASSESSMENT

1. UULM

Event	DateTarget AudienceCountries addressedSize of Audience			Size of Audience		
ICT 2015		20- 22/10/2015	Research & Industry Europe 6000		6000	
Partner	UULM		Attendee(s)	Jörg Domaschka, Lutz Schubert, Christopher Hauser, Athanasios Tsitsipas, Daniel Seybold, Frank Griesinger		
Reason for participation	Disser Europ Invite	Dissemination of CACTOS results and on-going research work within the European Research community and Industry. Invited speaker about the challenges on software engineering.				
Feedback received	Discus	sions on collabora	ation points with t	the CACT	OS project.	

Event	Date Target Audienc			e	Countries addressed	Size of Audience	
ISC High Performa 2016	ance 19- 22/06/2016		HPC audience. Users, Buyers and Influencers		International	3000	
Partner	UULM		Attendee(s)	Stefan V Athanas Stefan E Kushna	Stefan Wesner, Christopher Hauser, Athanasios Tsitsipas, Marion Moser Stefan Bonfert, Volodymyr Kushnarenko		
Reason for participation	Spread CACT(Spread the results on operating HPC applications and their workloads on a CACTOS enabled Cloud Infrastructure.					
Feedback received	Aware operat (unde	ness of CACTOS a ing an OpenStack r discussions unof	bilities was raised testbed, intereste ficially)	. Datacen d using C	tre operators fr ACTOS on their	om Europe, premises.	

Event D		Date	Target Audienc	Target Audience		Size of Audience
<i>ESOCC 2016</i>		05- 07/09/2016	Academic Community		International	90
Partner	UULM		Attendee(s)	Christopher Hauser, Daniel Baur		
Reason for participation	Preser	it how CACTOS car	n be enabled in an	0penSta	ick testbed	

Feedback	Audience showed interest in the project and further discussions on CACTOS
received	were going.

Event Da		Date	Target Audience		Countries addressed	Size of Audience		
GECON 2016		20- 22/09/2016	Academic Community		International	40		
Partner	UULM		Attendee(s)	lee(s) Athanasios Tsitsipas				
Reason for participation	Preser Clouds	Present how to move towards a usage-based dynamic overbooking in IaaS Clouds.						
Feedback received	The pa discus	aper and the prese sions on dynamic	ntation received p overbooking in th	oositively e cloud v	[,] feedback. Furth vere made.	ier		

Event	Date		Target Audience		Countries addressed	Size of Audience	
F2F meeting with IT 25.02.2016 operator of large 14.03.2016 German manufacturer 30.05.2016 22.07.2016 22.07.2016		Industry		Germany/Int ernational	5		
Partner	UULM		Attendee(s)	Jörg Do Christo	rg Domaschka, (Stefan Wesner, Iristopher Hauser)		
Reason for participation	Preser	Present CACTOS results and ideas for collaborations and CACTOS uptake.					
Feedback received	Partic signed	pants expressed h in September 201	luge interest. Agre l6.	ed on fut	ture collaboratio	on. Contract	

Event		Date	Target Audience		Countries addressed	Size of Audience	
F2F meeting with German cloud prov	th rovider 22.07.2016, Industry		ndustry Ger ern		ndustry		4
Partner	UULM		Attendee(s)	Jörg Do	Domaschka, (Stefan Wesner)		
Reason for participation	Preser	Present CACTOS results and ideas for collaborations and CACTOS uptake.					
Feedback received	Partici CACTO upon i Submi	Participants expressed huge interest. Agreed on future collaboration. Opened CACTOS testbed for interested party. Memorandum of understanding agreed upon in July 2016. Preparation of common research proposal underway. Submission planned for December 2016.					

	Event	Date	Target Audience	Countries addressed	Size of Audience
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F2F meeting with Ulm- based SME 10.08.2016 29.08.2016 13.09.2016 Industry			Germany/Int ernational	2			
Partner	UULM		Attendee(s)Jörg Domaschka, (Stefan Wesner, Daniel Baur)				
Reason for participation	Preser	Present CACTOS results and ideas for collaborations and CACTOS uptake.					
Feedback received	Partic Prepa Decem	Participants expressed huge interest. Agreed on future collaboration. Preparation of common research proposal underway. Submission planned for December 2016.					

2. FLEX

Event	DateTarget AudienceCountries addressedSize of Audience						
Internal meeting with angel investors June 2016 Tech Investors			US, UK	5			
Partner	FLEX	FLEX Attendee(s) Craig Sheridan, Al Innes					
Reason for participation	Present CACTOS as commercial entity, assess MVP of CactoScale, CactoOpt						
Feedback received	Receiv feedba the pr	Received feedback regarding potential avenues for commercial interest; main feedback involved TRL maturity and need to attract customers actually using the product before angel investment would be viable route					

Event	DateTarget AudienceCountries addressedSize Aud			Size of Audience			
Presentation to Flexiscale		June 2016	CFO, CTO, CEO		EU, UK, US, MEA	3	
Partner	FLEX	FLEX Attendee(s) Craig Sheridan, Al Innes					
Reason for participation	As a fo intere	As a follow up to our earlier meeting with investors, Flexiscale expressed interest in commercial packaging of VMI technology with their sales dept.					
Feedback received	Develo promo	opment of plan for otion/consultancy	commercial expo service – outlined	sure of C. l in D2.5.3	ACTOS solution 3	via cross-	

Event	Date	Target Audience	Countries addressed	Size of Audience
SummerSoC 2016	July 2016	Research Scientists, Phds, SMEs	EU, US	50

Partner	FLEX	Attendee(s) Craig Sheridan, Al Innes					
Reason for participation	Present CACTOS to scientific research community in order to gauge level of interest, present results, explore potential for follow up research/commercial avenues/community building						
Feedback received	General interest in success of project, several demonstrations of material available on website resulting in engagement online with media generation						

Event		DateTarget AudienceCountries addressedSize of Audience					
Presentation to ExaInformatics		September 2016	CFO, CTO UK 2			2	
Partner	FLEX	FLEX Attendee(s) Craig Sheridan, Al Innes					
Reason for participation	As a fo ExaInf solutio	As a follow up to our collaboration with PaaSage we established a link with ExaInformatics, and SME interested in commercially exploiting the CACTOS solution for their OS services					
Feedback received	Develo consul	opment of plan for tancy an feasibilit	commercial expo y assessment of U	sure of C ULMs OS	ACTOS, initially tools – outlined	through l in D2.5.3	

3. UMU

Event		DateTarget AudienceCountries addressedSize of Audience				
ICCAC 2015		21-24.09.2015	Academic and Industry Communities		Worldwide	~60
Partner	UmU	UmU Attendee(s) Jakub Krzywda				
Reason for participation	Preser	nt A Sensor-Actuat	or Model for Data	Center C	ptimization pap	ber
Feedback received	Paper	received positivel	у			

4. FZI

Event	Date	Target Audience	Countries addressed	Size of Audience
ECSA 2015	0711.09.2015	Scientifc Audience	Worldwide	>120 people

Partner	FZI	Attendee(s)	Christian Stier			
Reason for participation	Present work on energy efficiency analysis					
Feedback received	Audience was highly inte design decisions	erested in the imp	lications of energy efficiency on			

Event		DateTarget AudienceCountries addressedSize of Audience					
SSP 2015		0406.11.2015	Scientifc Audience, Industry		EU	>60 people	
Partner	FZI	FZI Attendee(s) Christian Stier					
Reason for participation	Preser	Present work on energy efficiency analysis, Black Box application simulation					
Feedback received	Audier design	Audience was highly interested in the implications of energy efficiency on lesign decisions					

Event		DateTarget AudienceCountries addressedSize of Audience					
MSCIAAS at Spring 2016	Sim	0306.04.2016	Scientifc Audience		Worldwide	>120 people	
Partner	FZI	FZI Attendee(s) Christian Stier					
Reason for participation	Preser	Present work on simulation coupling and model continuity					
Feedback received	Audier runtin	udience showed great interest in challenges of coupling simulation and untime optimizations.					

5. DCU

Event		Date	Target Audience		Countries addressed	Size of Audience
The Fifth National Conference on Clou Computing and Commerce (NC4)	ud	12/04/2016	Cloud computing industrial and academic community		Ireland + Global	>100 in attendance
Partner	DCU		Attendee(s)	Sergej Svorobej (DCU)		
Reason for participation	Preser SAP, Ii	Present CactoSim and the wider CACTOS concept to industrial audience (Oracl SAP, Intel, Maxeler, IBM etc. in attendance)				ience (Oracle,

Feedback	Positive feedback received relating to CactoSim from both academic and
received	industrial participants,

Event Date		Target Audience		Countries addressed	Size of Audience		
Meeting with IT Solutions Ltd.	<i>vith IT</i> <i>Ltd.</i> I2/10/2015 IT Solutions (CEO and company employees)		Ireland	5			
Partner	DCU		Attendee(s)				
Reason for participation	Feasib preser	Feasibility investigation for academic/industrial collaboration, further presentation of DCU group simulation capability including CACTOS related				ther Frelated	
Feedback received	Projec of >€2	Project proposal put in place, ultimately leading to successful national funding of $\geq 200,000$ for DCU				nal funding	

Event Date		Target Audience		Countries addressed	Size of Audience		
<i>ICT Lisbon 2015</i> 20-22 2015		20-22 October 2015	Academic and industrial, potential H2020 research partners. General CACTOS dissemination		European	>1000	
Partner	DCU		Attendee(s)	Paul Lis (DCU)	ton (DCU), James Byrne		
Reason for participation	Dissen Also p	ninate CACTOS inf artners for Develo	ormation (flyers e pment of H2020 F	etc.) Proposal	for ICT-06-2016)	
Feedback received	Successfully recruited partners at an early stage, ultimately leading to a high scoring proposal (RECAP) largely on the back of CACTOS output, project successfully funded				g to a high roject		

Event		Date	Target Audience		Target Audience		Target Audience		Countries addressed	Size of Audience
Proposal Development (RECAP) related meetings for H2020 ICT- various 06-2016, follow up meetings from ICT 2015		various	Industrial (Intel Ireland, BT, SATEC, Linknovate, Tieto) and Academic (IMDEA, and 3 CACTOS partner participants) – successful proposal leading to wider target audience		European	9 Partners, leading to large audience size over duration of project				
Partner	DCU/I	JMU/UULM	Attendee(s)	DCU etc.						
Reason for participation	Develo	opment of H2020 I	Proposal for ICT-0	6-2016						
Feedback received	High s succes	ligh scoring proposal (RECAP) largely on the back of CACTOS output, project uccessfully funded								

VII. COLLABORATION ACTIVITIES

1. HORIZONTAL COLLABORATION ON PROJECT LEVEL

During the collaboration event based on discussions with representatives of the project the following collaboration opportunities could be identified and will be further investigated.

Project	Joint interest	Action
Panacea	While the approach to optimisation and resource and topology adaption is different in CACTOS (Model based) and Panacea (machine learning) an exchange on requirements and ideas would be beneficial.	The interaction with Panacea led to the conclusion that an integration of both projects on technical level would be too complex. However, Panacea heavily influenced the RECAP proposal as a follow up project to CACTOS.
MONDO	Application models is part of CACTOS as well as MONDO.	The MONDO project has its focus on providing scalable models to human users and focusses on support of large models. The models in CACTOS are in contrast processed by tools with a high frequency. In addition, the model repository is a core component of CACTOS that has to be stable. This led the consortium to the conclusion that CACTOS should be based on mature technology such as CDO. The scalability investigated by MONDO, however, becomes important when CACTOS runs in really large data centres with hundreds of thousands of nodes.
CloudScale	Elasticity and optimization of applications from an application point of view. This could contribute an orthogonal view on optimization with respect to the data centre view of CACTOS.	 1) Extending dynamic system analysis for energy efficiency metric. 2) Extended measurement- based reconfiguration rules. 3) Tested and applied dynamic workload changes based on LIMBO curves. 4) Joint improvement of Palladio/SimuLizar simulation platform

STORMCLOUDS	Focus on dissemination and common interest knowledge and contents sharing activities.	We have successfully collaborated with the STORMCLOUDS consortium in publicising our work across we 2.0 channels.
MODAClouds	Uses the same prediction mechanism and tool (Palladio). However, no specific action can be derived as of now.	Ongoing updates to core prediction mechanism provided open source from CACTOS -> Palladio -> MODAClouds and vice versa, until the end of MODAClouds in November 2015. With respect to application deployment, CACTOS builds on CAMEL which in turn is a successor of MODAcloud's CloudML language.
PaaSage	The creation of a common modelling infrastructure that serves to manage and control cloud systems is a common interest between CACTOS and PaaSage. Optimising resource provisioning is also a key concern of both CACTOS and PaaSage.	Use of provisioning interfaces developed in PaaSage to provide scientific computing services in a CACTOS-managed cloud. In M30-M36, a strong collaboration on integrating the application provisioning tool in CACTOS, took place. Was used as a prototype in Y2.5 Review and a stable form is planned for the final Y3 Review.
bwCloud (German project funded by federal state)	The federation of multiple different geographical data centers, operating under the open source cloud middleware OpenStack. Extend CACTOS for such hybrid infrastructures.	Multiple face-to-face meetings in 2016 and a reached consensus of installing CACTOS toolkit for the bwCloud project, in the second quarter of 2017.
CloudLightning	Aspects of simulaionoutput from CACTOS being used in CloudLightning where simulation is also being used to evaluate decision making algorithm.	CACTOS simulation researcher from DCU moved to CloudLightning project in May 2016 and onto UCC currently using knowledge and aspects of CactoSim towards enhancing existing and ongoing work in CloudLightning.
Mikelangelo	Monitoring frameworks and extraction of specific metrics from the hypervisor level. Interest on disk I/O optimisation. For CACTOS, applies to the scientific usecase application(Molpro).	Joint discussions with UULM and XLabs(coordinator of Mikelangelo project) during the participation in ISC conference(part of dissemination activities for CACTOS). Plan to evaluate the disk I/O optimized hypervisor developed in Mikelangelo project, in December 2016.

2. HORIZONTAL COLLABORATION AT PARTNER LEVEL

These activities include those which feature collaboration with organisations outside of the CACTOS consortium., for the purpose of identifying synergies, eliciting further valuable additional requirements, community building, and knowledge exchange.

Collaboration has included:

- On-going research exchange with scientists of Fraunhofer IESE in Kaiserslautern by FZI.
- On-going research exchange with scientists of Universität Würzburg by FZI.
- On-going research exchange with scientists of TU Chemnitz by FZI.
- On-going collaboration with graduate students in the Graduate School Energy Status Data at KIT
- Post and Paper submissions by FZI and DCU to Symposium on Software Performance 2014 in order to get into contact with researchers and practitioners.
- Involvement with Palladio Open Source community at SoSP and SSP.
- Paper submission to eChallenges Conference by UULM, FZI, DCU, UMU in order to get into contact with practitioners.
- Presentation at CloudCom 2014
- Presentation at ECSA 2015.
- Presentation of CACTOS results at SEAMS 2015 by Uni Würzburg.
- Presentation of DCU at SIMUTOOLS 2015.
- Presentation of CactoSim to industrial and academic partners by DCU at NC42016, NC42015, NC42014
- Presentation of CACTOS results at QoSA 2016 by FZI
- Presentation of CACTOS results at MSCIAAS 2016, located at SpringSim 2016 multi-conference.
- Joint project meeting with PaaSage in June 2015, participation of UULM, FZI and FLEX from CACTOS. Presentation of project results and plans, identification of commonalities and collaboration opportunities.
- FZI collaboration with the chair on Software Design and Quality at the KIT raised awareness of CACTOS in the academic world and introduce students to the state of the art in lectures.
- Collaboration with bwCloud project and operators of bwCloud infrastructure by UULM.
- Research exchange with XLabs, coordinator of H2020 Mikelangelo project, since participation in ISC conference by UULM.
- UULM collaboration with IT department of a large German manufacturer, for cloud deployment and management of a datacenter.
- UULM collaboration with a large German cloud provider, for cloud optimisation and management of a datacenter.

• On-going research exchange with companies (Ulm-based SME, DC operator, IT providers) for automation of data center operation.

VIII. CONCLUSION

This document represents the final version of the CACTOS dissemination activity report.

As the project has matured, the dissemination strategy has developed to become more focused on the promotion of the CACTOS tools rather than on the project itself. This new approach is married to the sustainability of the project beyond the grant lifetime and can be seen elaborated on in D2.5.3.

In order to pursue this goal, the dissemination materials and channels that CACTOS utilizes have been continually maintained and developed. Further, events and workshops have given the consortium the opportunity to promote CACTOS and showcase its outcomes.

Throughout the final year of the project, the focus has been on building momentum and ensuring that the outcomes of the project reach the widest possible audience. This has supported the sustainability of the project beyond its completion and can be seen in the various collaborations with outside parties and the interest shown by commercial interests (details in D2.5.3).

At the end stage of CACTOS, we have met our dissemination goals and seen the impact that these have had on behalf of the project. The dissemination activity has achieved the goals of making the academic and industrial communities aware of CACTOS, initiating interest from developers and users, initiating collaborative work and productive discussions, and giving the project a high level of exposure at EU community events.

A. SOCIAL MEDIA CHANNELS

a) LINKEDIN

http://www.linkedin.com/groups/CACTOS-FP7

This group has been utilized as a news outlet, or newsletter format, being used to distribute to promote the blogs hosted on the project website, and to drive traffic directly to the website.

The LinkedIn group contains individuals who have been identified specifically as being interested in the work of CACTOS, and so this approach is much more targeted than the mass-media approach of Twitter.

There are currently 37 members of the CACTOS FP7 LinkedIn Group, a 12% increase from the previous year.

Unfortunately, on 30th June 2015, LinkedIn removed the LinkedIn Group Statistics feature, and so we are not able to undertake a detailed assessment of the key demographics/interests of our group member

cactos	CACTOS F	P7						37 members	Member	\$	*
	Discussions	Promotions	Jobs	About	Search	Manage					
Enter a discussion	ussion with your g	group					Ch We Net To visit	anges for mes ve updated the ru work members in read more about h t our Help Center.	saging group les for messagin your Groups to p low we've impro	g the Out prevent ab ved Group	of use. us,
Al Innes R Get to know t will be making Working across the 0	esearch Communic he people be cACTOS w	ations Manager chind the pr vork in our e University of U	at Flexiant Oject a latest b	and find blog.	Manager Out whe	Sort by: Recent 's Choice ~ ere they s handling	Yo Sta par	ur group contr It by commenting ticipants get 4x the	ibution level in a discussion. a number of prof Finding an Audi	Group ile views. ence	
	Meet th cactosfp7 Organisa	he Project – U 7.eu - Ulm Univers tion and Managen	Iniversity sity is repre	/ of UIm esented in C rmation syst	ACTOS by th tems .	e Institute for		About Feedb	oack Privacy	& Terms	i
Comment (0) • Like	(2) • Follow gej Svorobej like thi	s				August 11, 2014					

Figure 11: The CACTOS LinkedIn Group

b) *FACEBOOK*

https://www.facebook.com/cactosfp7

Similarly, to LinkedIn, the CACTOS FP7 Facebook page has been used to publicise new blog posts, and to draw vistors to the main CACTOS website. In this type of update, the 'Call to Action' is to read the blog on the main site, and so interested parties will click through. The more social nature of Facebook compared to LinkedIn means that the reach of such posts is potentially greater, given that as users 'like' or share the post, it will appear in the timelines of their friends. This snowball effect is particualrly useful.



Figure 12: A CACTOS Facebook post which seeks to draw new visitors to the CACTOS website and blog

Further, the CACTOS Facebook page has been successfully used to encourage internal dissemination among project partners and to engage in sharing insights and relevant content among the consortium



We are hard at work at our plenary meeting at the University of Ulm in Germany this week. You can find out about all our latest news by taking a look at the Cactos blog.

www.cactosfp7.eu/blog



Figure 13: A Facebook post regarding the July plenary meeting in Ulm

Facebook is also utilised to promote our involvement in events, both before and after. This approach allows us to use social channels to increase awareness of our involvement in event and thus publicise the event, our involvement and therefore increase our audience. Secondly, adopting this method allows us to use the content generated from involvement in the event after it has finished, such as photos, videos, slides, and reflections on the event, to publicise the project further, and draw more visitors to the site.



c) GOOGLE+

http://Bit.ly/CACTOSgplus

The CACTOS Google+ page has had 15,044 views since it was created in November 2012, up from 12,931 in M12 as reported in D2.3.1. Followers have also increased 59% since M12, from 17 to 27. This is a positive sign as in D2.3.1 we identified engagement on this platform as an issue, and so increasing significantly increasing our follower numbers here is a demonstration of the increased engagement we have been able to leverage.

The CACTOS Google+ page had 45,211 views in reporting period 3, up from 15,044 at M24, an increase of over 200%. Engagement was not a priority on Google+ as is was primarily a strategic tool to improve SEO through Google listings, but we retained our 26 followers and have published all blogs and updates on the page, creating a permanent, public presence for CACTOS on a beneficial forum that links directly to the project website.



Figure 14: CACTOS Google+ Page September 2016

d) Twitter

https://twitter.com/cactosfp7

FLEX administer the CACTOS twitter account, with partners contributing by sharing content via their company/organization Twitter accounts and providing relevant content to be scheduled.

The major purpose of the CACTOS twitter account is to provide a micro-blog which engages interested partners, provides public updates on project progress, and ultimately drive traffic to the website that serves as the major online hub for CACTOS dissemination.

In addition project partners are able to 'live-tweet' during events and at relevant points in the project, helping to engage new audiences for CACTOS.



Twitter Sept 2015-16

Figure 15:Twitter followers increase in m25-36

The @CACTOSfp7 twitter account has gained 50 new followers taking the total to 142.

e) Overview M30-M36

SEPTEMBER 2016



AUGUST 2016

Aug 2016 · 31 days

TWEET HIGHLIGHTS	AUG 2016 SUMMARY	
Top Tweet earned 60 impressions	Tweet impressions	Profile visits
ResearchFest winner urges others to share their research ow.ly/CNzH502cuCS	Nentions	42 New followers
View Tweet activity View all Tweet activity	1	3



View profile

View followers dashboard

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JULY 2016

TWEET HIGHLIGHTS JULICION STUDY Top Tweet earned 154 impressions CACTOS Biog Setting up a Secure COO Server CACTOS Ownly/Cog/G3023023rak Top mention earned 16 engagements Toe descent of Juli 11 Tweet 11 Tweet 11 Tweet 11 Tweet 11 Tweet 11 The word Could Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu @CactosFP7 The new Cloud Application Modelling and Execution Language (CAMEL) website came-dsl.org CC @PasSage @Couldococketeu	Jul 2016 · 31 days				
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Top Follower relowed by 653 people File X and X	t3 1 ♥ 1 View Tweet activity View all Tweet activity	The new Cloud Application Modelling and Execution Language (CAMEL) website camel-dsl.org CC @PaaSage @cloudsocketeu @CactosFP7	A6	2	
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View profile UNE 2016 Jun 2016 - 30 days WEET HIGHLIGHTS Top Follower followed by 593 people Top mention earned 13 engagements Dillita Inca W1Witter - Jun 22 Dillita Inca W1Witter - Jun 22 Diank you guys of @Cactos FP7 Hope to se you in Perul Last day of the Exhibition show at #ISC16 #HPC #cactosfacts jc.twitter.com/yktCbozIaD Dillita Inca W1Witter - Jun 22 Diank you guys of @Cactos FP7 Hope to se you in Perul Last day of the Exhibition show at #ISC16 #HPC #cactosfacts jc.twitter.com/yktCbozIaD Diank you guys of @Cactos FP7 Hope to se you in Perul Last day of the Exhibition show at #ISC16 #HPC #cactosfacts jc.twitter.com/yktCbozIaD Diank you guys of @Cactos FP7 Hope to se you in Perul Last day of the Exhibition show at #ISC16 #HPC #cactosfacts jc.twitter.com/yktCbozIaD	Helix Nebula @HelixNebulaSC FOLLOWS YOU Bridging Cloud Computing Innovation & Open Science				
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Guardería enrique mu	UNE 2016 Jun 2016 - 30 days TWEET HIGHLIGHTS TOP Follower followed by 593 people	Top mention earned 13 engagements	JUN 2016 SUMMARY Tweet Impressions 370	Profile visits 54	
guardería enrique mu pic.twitter.com/yktCbozlaD @guarderiaenriqu FOLLOWS YOU CENTRO DE ATENCIÓN A LA INFANCIA AUTORIZADO POR LA CONSEJERÍA DE EDUCACIÓN . ESTAMOS EN LA ALBERCA Y PATIÑO FOLLOWS YOU		Julita Inca @Yulwitter - Jun 22 Thank you guys of @CactosFP7 Hope to see you in Peru! Last day of the Exhibition show at #ISC16 #HPC #cactosfacts	Mentions 4	New followers	
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View profile View followers dashboard	CENTRO DE ATENCIÓN A LA INFANCIA AUTORIZADO POR LA CONSEJERÍA DE EDUCACIÓN . ESTAMOS EN LA ALBERCA Y PATIÑO View profile View followers dashboard				

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MAY 2016 SUMMARY

Tweet impressions

New followers

641

-

Tweets

38

Profile visits

MAY 2016

May 2016 · 31 days

TWEET HIGHLIGHTS

Top Tweet earned 71 impressions

On the blog today, we look at LADT -CactoScale's Lightweight Tool for Anomoloy Detection **#cactos** cactosfp7.eu/2016/05/26/lad...

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