## **!CHAOS Annual Report 2015 (final report)**

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ICHAC IN Solution In 2015 the !CHAOS project, partially supported by the CNS5, concluded the activities foreseen by the *"premiale"* proposal<sup>1</sup>. Two main deliverables were scheduled for 2015: firstly the release of an Alpha version in June, as conclusion of the design study of all the tasks planned in the project and the development and integration of the core functionality; secondly the release, by the end of the year, of a Beta version where all the functionalities expected were developed, integrated, tested and qualified.

*"!CHAOS: a cloud of controls"* has been an open source project aimed to develop a national infrastructure prototype to deploy high performing services devoted to devices and polyfunctional sensors distributed on LAN and WAN. Moreover, the activities developed have demonstrated the !CHAOS functionalities through three main use cases: Distributed Control Systems (DCS), Data Acquisition (DAQ) for High Energy Physics (HEP) and low cost applications for building automation (environmental monitoring and control). To achieve these objectives, the project consisted of 4 work-packages (WP2-5) and a coordination, communication and documentation activity (WP1). In the following we provide the task milestones and deliverables reached by any WP<sup>2</sup>.

WP2 (LNF) was focused on the implementation, test and qualification of the main framework whit attention to stabilize and qualify all the related subparts. Particular effort has been dedicated to the communication channels DirectIO – devoted to high throughput data transfer - and RPC – designed for services

<sup>&</sup>lt;sup>1</sup> <u>https://web2.infn.it/chaos/images/pdfs/PropostaPremialeChaos.pdf</u>

<sup>&</sup>lt;sup>2</sup> see annual report 2014 for the general description of the work-packages

http://www.lnf.infn.it/rapatt/2014/CHAOS%20Annual%20Report%202014.pdf

messaging. Metadata service and also a program for controlling and monitoring the server and control units have been rewritten. The metadata service implementation uses MongoDB. APIs published through the RPC metadata service are described at the following link: <u>https://opensource-confluence.infn.it/confluence/display/chd/High+Level+API</u>.

The data service has been rewritten in order to replace the direct communication among the control unit and user interfaces with the centralized caching system. It also enables a single data stream to manage the storage of data in the cache and lively in the history storage. The CU-UI Toolkit has been modified to create a single UnitServer and an abstract method has been implemented to allow the recovery of a save point.



Figure 1 !CHAOS Data Service (CDS)

WP3 (LNF) For the Flagship Project we controlled and monitored the Beam Test Facility (BTF). The scope of the test was to exploit the !CHAOS framework in a real operating condition, test the IT infrastructure and the Graphical User Interface (GUI), verify the stability and capability of the information service – Meta Data Service (MDS) and storing – the !CHAOS Data Service (CDS). Through the second run in BTF we also added DAQ functionalities to the DCS. The final implementation of !CHAOS in BTF was able to control it for two weeks without any downtime. For the ESCO use case, the WP3 realized the low and high-level drivers, Control Units, the REST interfaces to implement GUI inside WEB and the UTA through an in house electric panel developed by WP4. The WP3 realized also a WEB control page to manual controlling the UTA and integrating !CHAOS into LabVIEW from National Instruments (NI). For this use case, we have written VIs (labVIEW modules) able to access !CHAOS resources and to easily build a control GUIs.

During the summer, it has been hosted a Summer Student who adapted the open source MATLAB toolbox middle layer for particle accelerators, developed and used in many accelerators plants, to the DAFNE collider, interfacing with the

## **!CHAOS framework.**

WP4 (LNF/LNS/ROMA2/INFN-PE) The Hardware Reference Platform (HRP) implementation for the ESCO use case has been completed, this includes: collecting the ESCO requirements, defining and testing the HRP, implementing the sensors interconnection and topological structure for both wired and wireless solutions, developing the first revision of the reference platform for its assessment, test release and qualification. This has realized a generic "!CHAOS box" formed by an ADC/DAC controller, relays and zigbee for a wireless connection to sensors to be used in different applications.

The !CHAOS framework has been applied on the modified HRP system for BTF and LNS accelerators' sources.

WP5 (LNF/CNAF/INFN-PA) The team implemented a generic IaaS solution based on OpenStack to host each of the !CHAOS services. The final goal of this activity has been to produce a Software as a Service (SaaS) implementation of !CHAOS and to provide users the possibility to automatically deploy a complete !CHAOS instance on a private Cloud environment. The Figure 2 represents a simplified schema of the !CHAOS deployment on OpenStack. The common backend services are on top of the OpenStack components and can be automatically provided within the Cloud environment, as Platform as a Service (PaaS) components. The !CHAOS frontend services (CDS and MDS) exploit the virtual instances of PaaS components and can be run as unique or multiple instances. A VPN service has been deployed within the OpenStack Cloud to enable the frontend services to communicate in a bidirectional way with the remote !CHAOS clients, such as the Control Unit (CU) and the User Interface (UI).



Figure 2 Schema of !CHAOS deployment on OpenStack

Moreover, the INFN Frascati group also worked on the continuous integration (entrusted to JIRA and Stash) and the automatic build of the !CHAOS work, delegated to Jenkins. We are also collaborating to the development of a multisite Cloud infrastructure for deploying and distributing !CHAOS at regional level.

The INFN Frascati group (WP1) has been also in charge of the coordination, communication and dissemination of the project: to maintain the national web site <u>http://chaos.infn.it;</u> document the whole project <u>https://opensource-</u>

<u>confluence.infn.it/</u>; organize regular meetings<sup>3</sup> for monitoring and coordinating the technical development. Last but not least, during the last year the WP1 staff worked to a new proposal submitted to MISE called *"Industria 4.0"* in collaboration with the IMA enterprise<sup>4</sup>, Scuola di Ingegneria ed Architettura e Scuola di Disegno Industriale dell' Università di Bologna, ELEIDIA Università di Trento, JKU Johannes Kepler University, Linz (AU) and CNR NANO/NEST Scuola Normale Superiore di Pisa. This new project, called MaXima, has been approved and founded by MISE. Within this project, the !CHAOS group will be in charge of transferring the !CHAOS technology and cloud based applications in order to realize a prototype of a computing system for prognostics, fault prediction, data analysis, system monitoring and optimization.

## Presentation

- [1] G. Mazzitelli Controls, Monitoring and DAQ, HEP Software Foundation Workshop - 20-22 January 2015, SLAC - USA
- [2] F. Spagnoli A Cloud of Controls (IFAE), IFAE Conference 8-10 April 2015, Rome Italy
- [3] E. Gioscio, !CHAOS, WIRE15 Workshop Impresa, Ricerca Economia, Scuderie Aldobrandini, 21 May, Frascati, Italy
- [4] M. Tota, !CHAOS: a Cloud of Controls (CCR), CCR Workshop 25-30 May 2015, Frascati Italy
- [5] R. Orrù, !CHAOS: un prototipo nazionale di infrastruttura open source per il controllo di sistemi distribuiti, 101° Congresso Nazionale della Società Italiana di Fisica - 21-25 September 2015, Rome – Italy
- [6] F. Spagnoli, Cloud of Controls (itAIS),12° Conference of the Italian Chapter of AIS 9-10 October 2015, Rome Italy

## **Publications**

- [1] !CHAOS STATUS AND EVOLUTION, C. Bisegni, S. Caschera, C. Di Giulio, G. Di Pirro, L. G. Foggetta, R. Gargana, E. Gioscio, D. Maselli, G. Mazzitelli, A. Michelotti, R. Orrù, S. Pioli, F. Spagnoli, A. Stecchi, M. Tota, May 2015, Proceedings of IPAC2015, Richmond, VA, USA
- [2] !CHAOS: a cloud of controls, S. Angius, C. Bisegni, P. Buzzi, I: Catani, S.R. Cavallaro, B Checcucci, P. Ciuffetti, B.F. Diana, C. Di Giulio, G. Di Pirro, F. Enrico, E. Fattibene, L. G. Foggetta, F. Galletti, R. Gargana, E. Gioscio, P. Lubrano, D. Maselli, G. Mazzitelli, A. Michelotti, M. Michelotto, R. Orrù, M. Panella, M. Piccini, M. Pistoni, S. Pulvirenti, G. Salina, F. Spagnoli, D. Spigone, A. Stecchi, T. Tonto, M. A. Tota, April 2015 Proceedings of IFAE2015, Rome, Italy
- [3] !CHAOS: a prototype of a Cloud Computing infrastructure to control High Energy Physics systems in Italy, C. Bisegni, S. Caschera, L. Catani, C. Di Giulio, G. Di Pirro, E. Fattibene, L. G. Foggetta, R. Gargana, E. Gioscio, D. Maselli, G. Mazzitelli, A. Michelotti, M. Michelotto, R. Orrù, M. Panella, M. Pistoni, F. Spagnoli, M. Piccini, A. Stecchi, T. Tonto, M. Tota, October 2015, Proceedings of itAIS2015, Rome, Italy

<sup>&</sup>lt;sup>3</sup> <u>https://agenda.infn.it/categoryDisplay.py?categId=673</u>

<sup>&</sup>lt;sup>4</sup> <u>http://www.ima.it/</u>