EUROPEAN COMMISSION
Research Executive Agency
Marie Curie Actions – Networks for Initial Training

**Project No:** 607584

**Project Acronym:** CleanSky

**Project Full Name:** Network for Cloud Computing Eco-System

# Marie Curie Actions

# Periodic Report

**Period covered: from** 01/09/2014 **to** 31/08/2016

**Period number:** 1st

**Project coordinator name:**
Prof. Xiaoming Fu

**Version:** 2

**Date of preparation:** 29/11/2016

**Date of submission (SESAM):** 13/01/2017

**Project coordinator organisation name:**
GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS

# Periodic Report

## PROJECT PERIODIC REPORT

| | |
|---|---|
| **Grant Agreement number:** | 607584 |
| **Project acronym:** | CleanSky |
| **Project title:** | Network for Cloud Computing Eco-System |
| **Funding Scheme:** | FP7-MC-ITN |
| **Periodic report:** | 1 |
| **Period covered - start date:** | 01/09/2014 |
| **Period covered - end date:** | 31/08/2016 |

**Project co-ordinator:**

| | |
|---|---|
| **Organisation PIC:** | 999845640 |
| **Organisation legal name:** | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS |

**Person in charge of scientific aspects:**

| | |
|---|---|
| **Title:** | Prof. |
| **First name:** | Xiaoming |
| **Name:** | Fu |
| **Tel:** | +49 55139172023 |
| **Fax:** | +49 5513914416 |
| **E-mail:** | fu@cs.uni-goettingen.de |
| **Project website address:** | http://www.cleansky-itn.eu |

## DECLARATION BY THE PROJECT COORDINATOR

I, Prof. Xiaoming Fu, as co-ordinator of the project (607584, CleanSky), hereby confirm that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;

- The project has achieved most of its objectives and technical goals for the period with relatively minor deviations;

- The project Website is up to date.

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project and if applicable with the certificate on financial statement.

- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 5 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

# PUBLISHABLE SUMMARY

Comments:

As a paradigm for information technology (IT), cloud computing is “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.improving., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.” Cloud computing is evolving and supported not only in small data centers but also over large scale, energy-efficient new computing infrastructures. Example scenarios of large-scale cloud computing include scientific computing and telecommunication services, where big data and traffic are generated and need to be processed in a cost-efficient manner.

CleanSky ITN (http://www.cleansky-itn.eu) aims to develop innovative ideas in the emerging areas within the “eco-system” of cloud computing: data center evolution, consolidation and service migration, and beyond, via structural training of young researchers. To achieve this goal, a unique combination of academic institutions and industrial organizations collaborates together and creates a multidisciplinary (computer science, telecommunications, scientific computing and optimization theory), international (four European countries plus USA and China) and intersectoral (public and private; education and industry) environment to embed a pool of young researchers for innovative research in cloud computing.
The specific objectives of CleanSky are to develop innovative methodologies and approaches to satisfy application requirements and ensure efficiency within the emerging cloud computing paradigm, and to optimize the energy and provisioning costs of individual data centers. In particular, CleanSky aims at improving the network infrastructure that supports the cloud eco-system, where in Software-defined Networking (SDN) and Network Function Virtualization (NFV) two new paradigms currently have a big impact on efficiency and resource provisioning, especially in data centers and cloud environments.

Here, in the first half of the project CleanSky fellows have been working and collaborating on a variety of challenges, including the characterization and measurement of cloud network usage, technical methods to improve efficiency and resource provisioning and the theoretical foundations for doing so. For each of these challenges concrete problems have been investigated, including the modeling of user requests and the allocation of these requests to caches (characterization), measuring failures in cloud services (characterization), scaling clouds to computation- or storage-intensive applications (technical methods), service function chaining for mobile and software-defined networks (technical methods), or developing theoretical models for virtual network function placement and energy efficiency of these functions (theoretical foundations). The key contributions to the state-of-the-art and results obtained from studying these problems so far are:

(i.) profiling user requests towards cloud service can reduce the load on these cloud services by implementing a novel cache strategy based on grouping of users developed within CleanSky;

(ii.) based on a measurement study performed by CleanSky on the robustness of cloud services, these cloud services fail more often than previously assumed. Resource provisioning for meeting service level agreements thus needs to be implemented in a more robust fashion;

(iii.) datacenter operators and customers can agree on policies that guarantee the fulfillment of the customers’ data security requirements by implementing a policy management engine designed in CleanSky;

(iv.) datacenter operators can increase their resource utilization by implementing a near-optimal virtual machine placement approach based on a near-optimal placement heuristic that takes into account both operator requirements as well as availability and latency requirements of the customer;

(v.) datacenter operators can increase their resource utilization by virtualizing network functions and chaining them for efficient traffic steering with multiple chaining methods developed for different application cases within CleanSky;

(vi.) the placement of these virtualized network functions can be optimized by the predictive theoretical models designed within CleanSky so that the operational expenditure and energy consumption of the provider can be reduced, while providing the same service quality to the user as in a non-virtualized environment; and

(vii.) operators can further reduce the energy consumption induced by (iii) by applying a robust queue model based on dynamic voltage and frequency scaling to their machines operating their virtual network functions. This model was also developed in CleanSky.

Our results contribute to both more efficient cloud networking from an operator perspective (e.g., placement of network functions or virtual machines) as well as improved user experience when using cloud services (e.g., caching and policy management). Until project completion in 2018, CleanSky will continue to move forward in both directions. For instance, based on result (ii) one additional expected result will be a robust resource provisioning scheme for meeting service level agreements, and based on result (vii) one expected outcome would be a framework that allows cloud operators to consolidate unused resources after applying the scaling model.

Towards project completion, CleanSky also envisions several socio-economic impact opportunities. First, the energy-saving solutions developed by our fellows as indicated above will help to reduce the power consumption in data center computing. While IT infrastructure today is among the highest contributors to CO2 emissions, our research will have a positive impact on these emissions. Second, the works on user profiling and user-based policy definitions will help to improve the user experience of cloud services and yield better usability of these services for end-users, too. This will overall increase the acceptance of cloud-based services. Finally, CleanSky fellows are already and will continue in feeding back knowledge back to students in academic institutions.

As an initial training network, CleanSky also aims at providing excellent training to the twelve fellows that contribute to the research described above. In this regard, CleanSky has been organizing two summer schools in Göttingen (Germany) and Helsinki (Finland) during which the fellows were instructed in both theoretical and practical sessions on the most recent cloud networking technologies (e.g., OpenStack and SDN) by invited world-class lecturers. These summer schools and two workshops on transferable skills were also open to external students. Finally, CleanSky initiated a series of conferences that, in the first two editions in Heidelberg (Germany) and Trondheim (Norway), served as a forum for exchanging the latest research progress among fellows.

Project Contact:

Prof. Dr. Xiaoming Fu; Dr. David Koll
Goldschmidtstr. 7
37077 Göttingen
Germany

fu@cs.uni-goettingen.de; koll@cs.uni-goettingen.de
http://www.cleansky-itn.eu