PhD Thesis Proposal Form
China Scholarship Council (CSC)/ENS Rennes
Call for projects 2020

FIELD: Computer science

Thesis subject title: Building blocks for Fog applications in computing resource-scarce environments

- Laboratory name: IRISA - Myriads
- PhD supervisor (contact person):
  - Name: BERTIER Marin
  - Position: Maître de Conférence
  - E-mail: marin.bertier@irisa.fr
  - Phone number: 02.99.84.25.96
- TEDESHI Cédric
- Position: Maître de Conférence (HDR)
- E-mail: cedric.tedeschi@irisa.fr
- Phone number: 02.99.84.73.05

- Thesis proposal (max 1500 words):

While the Internet was built in a decentralized fashion, we are currently witnessing a strong centralization of computing facilities run by clouds. The intrinsic limitations to this model are increasingly visible chiefly due to privacy, energy issues and reliability. Fog computing proposes to localize computing resources close to users. Fog will be composed of small entities with limited resources but geographically distributed. The aim is then to provide services that are relevant in a particular area (such as gathering and displaying feedbacks on local shops, managing available slots in a parking) but also to provide services with strong constraints in terms of latency and interactions (augmented reality in tourism applications).

Fog provides a distributed infrastructure, which will cover part of a territory according to the application needs. The Fog resources are, in contrast to Clouds, limited in terms of capacity (network, computing capacity, storage...). Consequently, most applications will actually distribute their computation over a hybrid infrastructure composed of both local Fog resources and a core Cloud facility.

In areas such as national parks spreading over large portions of heterogeneous and potentially rough terrain, networking infrastructure is typically sparsely deployed while difficult and costly to install and maintain.

Would they be park managers or hikers, many users would have a common interest in exploiting these scarce resources, for instance to obtain weather conditions, emergency management or simply tourism related applications such as sharing picture and obtaining experience feedbacks. As the networking infrastructure is poor, a collaboration between users and this ad-hoc infrastructure will be necessary to offer these services to everyone in the whole park area. In some part of the park the communication will be ensure by hikers walking from one connected point to another, and in more connected place the application has a direct access to the Internet and more classical services. The application should be able to manage the user mobility, the need of aggregate users' information, allow user to discover his environment (resources available, services) allow user to
interact and share information. As these applications compute users’ information the aspect of privacy, anonymity has to be taken into account.

The majority of current mobile application use clouds. Most of the time, they require a constant connectivity to the Internet. A large research field (over the last 20 years) has been based on ad-hoc wireless communication [11] called Delay Tolerant Network (DTN) where the communication pattern does not allow to establish end-to-end paths on-the-fly. Solutions to this problem are based on the "store and forward" concept, where data are incrementally moved and stored throughout the network in hopes that it will eventually reach its destination. More strictly related to the PhD subject, the Mobile Opportunistic Social Network (MOSN) exploits human behaviours, to allow the end-to-end communication. Routing in MOSNs is a trade-off between the routing performance and the prior knowledge on the network state information [1]. This prior knowledge can be contact history [2], social centrality [3], or clustering [4].

Fog computing adds some infrastructure resources close to the edge to provide local services and avoid communication with the distant cloud, or act as an intermediary node between the edge and the cloud [5, 6].

This subject targets a mixed environment between a classical Fog approach and edge computing like the MOSN algorithm: In a Fog [9, 10], infrastructure resources are in a connected environment where each node has a constant access to the Internet and so to the cloud. In our approach, some Fog nodes cannot have this constant Internet access and have to use the user resources to find a path to the destination. To the best of our knowledge, while some work in both domains addresses similar applications such as vehicle networks ([7] for MOSN, [8] for Fog) the needs of these specific mixed environments have not been addressed optimally.

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Focused on this context, the aim of this PhD is to identify the basic building blocks and define the distribution of computation between local resources and the distant Cloud. To achieve this goal, the way will be to take a first application like sharing picture or emergency management and identify the basic services as routing, services localisation and data aggregation. For each of these services, we have to define models matching the reality of these infrastructures and define distributed algorithms to ensure the needed spreading and aggregation of information. The algorithms developed will be validated through analysis, simulation and/or real experiments at scale.

This project will be conducted within the IRISA Myriads team, which is working on the design of innovative infrastructures and middleware for future fog computing platforms [1].


Required qualifications:
- A master degree in distributed systems and/or Cloud computing.
- Excellent programming skills in Linux environments.
- Excellent communication and writing skills.
- Good command of English.
- Knowledge of the following technologies is not mandatory but will be considered as a plus:
  * Distributed algorithms
  * Cloud resource scheduling
  * Experiments on large computing platforms

Publications of the laboratory in the field (max 5):

- Genc Tato, Marin Bertier, Cédric Tedeschi: Koala: Towards Lazy and Locality-Aware Overlays for Decentralized Clouds. ICFEC 2018: 1-10
- Genc Tato, Marin Bertier, Etienne Rivière, Cédric Tedeschi: ShareLatex on the Edge: Evaluation of the Hybrid Core/Edge Deployment of a Microservices-based Application. MECC@Middleware 2018: 8-15

- Joint PhD (cotutelle): NO
- Co-directed PhD: NO
- Provisional duration and timetable of the PhD student's stay at ENS Rennes:
  Contract duration: 3 years, full time.

Start date: October 2020.

Date: 14/02/2020

Signature of the PhD director

Cédric Tedeschi