Data driven future ICT for cybersecurity and social goods

PhD Student: Barbara Attanasio
Supervisor: Prof. Ing. Aurelio La Corte
**XXXIV Cycle**

RESEARCH PROJECT

My PhD research project focuses on the designing of innovative **context-aware ICT services** based on **collective cooperation and competition** conducted thanks to the analysis of complex structures, processes and dynamics.

- Addressing the **offloading problem** exploiting a model of **interplay and cooperation among Cloud and Fog entities** in IoT environment. The aim is to find out which is the role of exploring the evolution of cooperation in a service-based multiplex network in Cloud/Fog scenario to shed light on the way to manage resource sharing, which encompasses incorporating collective dynamics.

- Evaluating a game-theoretical approach in the formation of **cooperative mining pools** among constrained resource devices for the resolution or the mining process in **mobile Blockchain**.

- Quantifying the impact of homophily, network heterogeneity and social dilemmas on the **mobile crowdsensing**. Quantifying a novel measures of **QoI** and **user reputation score** based on the evolution of **human cooperation** in a **MEC** scenario.

OBJECTIVES

The prefixed objectives of the research are:

- analysing and leading strategies of the "Future ICT" in application domain such as security, public health, sustainability of energetic consumption.

- discovering the real complexity of systems and anticipating the evolution of collective dynamics and their consequences on the focused infrastructure.

- evaluating the effect and the evolution of services.

- highlighting how some strategies lead the system dynamically towards the "**common good**", that mean what brings benefits to the whole system in the most effective way possible, such us a correct use of shared resources.
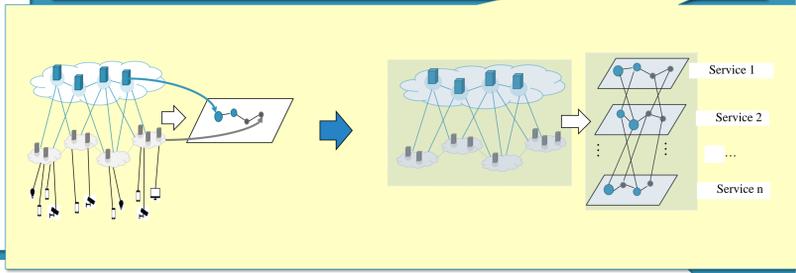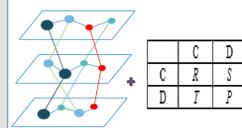
STAGES OF THE RESEARCH
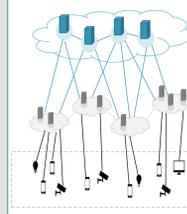
Research problem: Offloading, constrained resources end devices need to delegate their task to cloud and fog nodes.
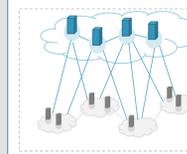
It is useful evaluating the role of **cooperation** in Fog and Cloud resource sharing

**Methodology**: the modelling approach is based on Multiplex networks and EGT

Expected Outcomes: What are factors that influence cooperative dynamics? How to characterize Cloud / Fog nodes? What's the role of interactions among them on different layers?

- Node's profile
- Metrics
- Complex networks
- ...

METHODOLOGY

MULTIPLEX NETWORKS

are particular kind of multilayer networks where the only type of interlayer connection is between a node and its counterparts in other layers. They provide a description for systems in which entities have a different set of interactions in each layer.
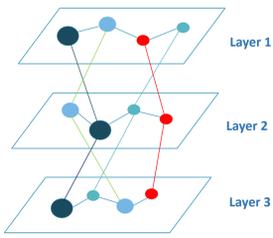
EVOLUTIONARY GAME THEORY

constitutes the mathematical framework to study the evolution of strategic interactions whitin a complex system highlighting how and why some behaviours emerge and are able to persist in a system.

In a game there are:
- A set of N players
- A set of possible strategies
- A payoff matrix which defines results obtained by the players as a consequence of their choice.

Together are powerful tools to reveal how the influence among nodes depends on the connections existing between them.

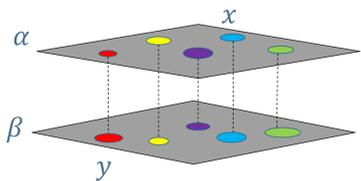Factors that act on the emergence and sustainability of cooperation:
- **Iterated interactions**
- **Network structures**
- **Homophily**
- **Critical Mass**
- **Communicability**
- **Parameters of the game**

SIMULATIVE APPROACH

Replicator dynamics-> **Fermi's rule**:

$$W(S_x \rightarrow S_y) = \eta_x \frac{1}{1 + \exp[\frac{P_x - P_y}{\delta_{xy}K}]}$$
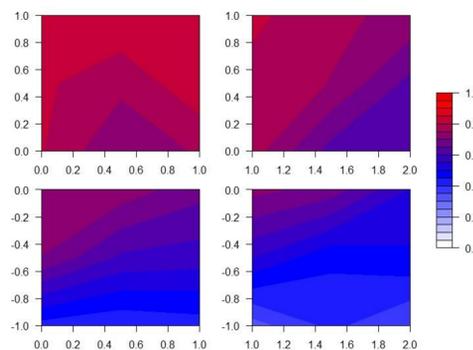
Fig. 1: Contour plots. The figure shows the density of cooperators in the T-S plane, which is divided into four quadrants representing the various social dilemmas: HG (upper-left), SD (upper-right), SH (lower-left), and PD (lower-right). The colour corresponds to the density, ranging from 'white' (lowest) to 'red' (highest).
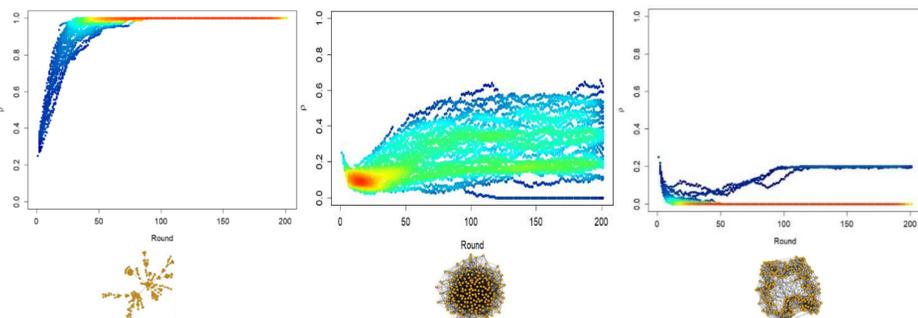
Fig. 2. Fraction of cooperative nodes against the rounds or time steps. The figure shows the evolutionary dynamics of the PDG played between the interacting nodes in a multiplex network with M = 2 and N = 200 nodes. The colour corresponds to the density: "red" indicates the highest density while "blue" means the lowest density. As can be observed, in the Scale-Free network (a) we note a faster emergence of cooperation than in Erdös-Rényi (b) or Small-World Network (c).

FUTURE WORKS

- To investigate various systems and methods of **data integration, machine learning** and **deep learning**.

- To analyze those application scenarios that could benefit from the cooperation between Cloud and Fog nodes, for instance **healthcare, smartcities,** etc... in which real-time processing and event response are critical.

- To develop new models, to perform tests and to collect data.

CONTRIBUTIONS

- B. Attanasio, A. Di Stefano, A. La Corte, M. Scatà: "*A modeling approach based on Multiplexity and EGT for resource sharing in Fog/Cloud Computing*", International School on Data Science and IoT, 09/2019, Catania.
- A. Di Stefano, M. Scatà, B. Attanasio, A. La Corte, S. K. Das, P. Liò: "*A Homophily-based Multi-layer Game-theoretic Methodology in Mobile Crowdsensing*", IEEE Transactions on Network Science and Engineering. (Submitted)
- B. Attanasio, S. Grimaldi: "*A novel approach for the development of innovative services for social inclusion and education*", International Conference on Social Inclusion, Education and Digital Society, 10/2019, Malta.