P2P Systems and Blockchains
Final Project
Academic Year 2019/2020

Pandemic Mobile Flu:
Virus Diffusion in Mobile Environments

1 Goal of the Project

The goal of this project is to implement a model describing the diffusion of a virus between smartphones which communicate through Bluetooth connections. A virus can infect all Bluetooth-activated phones within a predefined distance, resulting in a spatially localized spreading pattern similar to the one observed in the case of flu.

In the following, a mobile phone will be referred as a *peer*. We consider a scenario where the peers move within a predefined rectangular area. Each peer can directly interact with other peers within a circle of predefined radius, centered on it. We assume that each peer has always its Bluetooth connection active. The propagation of the virus starts from a single peer chosen at random.

The diffusion of the virus can modelled by the *SIR model* which divides a population in *S susceptible*, *I infectious* and *R recovered* (deceased or immune) individuals (`https://en.wikipedia.org/wiki/Compartmental_models_in_epidemiology`). This model must be adapted to the Bluetooth scenario, taking into account that:

- the infection can be propagated to a peer only if its operating system is compatible with the infecting virus. If the operating system is compatible, the virus has a probability p of being propagated.
- each peer either in the susceptible or in the infectious state can dynamically decide to install a patch, so zeroing the possibility to be infected or to further propagate the virus.

The mobility of the peers can be modelled taking inspiration from the model proposed in Section 4 of [1], which was originally presented for the Second Life virtual environments. The model defines a set of hotspots, i.e, high density zones, and by opposition, less densely populated regions. The movement of the avatar is defined by a probabilistic automaton characterized by three states: *H, halting*, when a peer stays still for a given number of steps, *E, exploring*, corresponding to a peer moving inside an hotspot and *T, Travelling*, when the peer moves from one hotspot to another. The transitions between pair of states happen with a probability which is a parameter of the model.

2 Implementation and Experiments

The project requires to implement a simulation of the model presented in the previous section, in a language at the discretion the student. The model is characterized by several parameters: the distribution of the operating systems in the network, the probability of being infected and of being patched, the probabilities which characterise the mobility model and so on. The simulation must be executed with different configurations of the parameters: choose a meaningful set of parameter configurations, trying to relate them with real-world scenarios. Furthermore, repeat the same experiment multiple times, to ensure that the outcomes are not due to statistical anomalies.

For each experiment, build a graph whose nodes correspond to the peers which are infected or removed during the simulation, a labelled edge between two nodes a and b corresponds to the relation *a has infected b* and the corresponding label defines the cycle at which the infection occurred. If the node is patched, after being infected, label the node with the cycle when the patch has been applied.

Plot the results of the experiment. Report, at least, the following measures:

- the total number of infected nodes at each cycle, as a function of the total number of nodes and of the model parameters
- the number of cycles required to infect at least a percentage p of all the nodes
- some structural properties of the graph, like the node degree distribution, the clustering coefficient distribution, the diameter, ...

It is possible to implement the analysis of the graph by exploiting one of the libraries for the analysis of complex networks currently available, see, for instance, *NetworkX* (`https://networkx.github.io/`), or *Networkit* (`https://networkit.github.io/`).

3 Project Submission Rules

The project must be developed individually. The material to be submitted for the evaluation is the following one:

- a report (pdf document) describing the main features of the project. The report should include: a brief summary of the project and of the implementation choices and a set of plots reporting the results obtained by the experiments. The results of the experiments must be adequately commented.
- a pdf document reporting the code implementing the simulation.

The report and the code must be submitted electronically, through the Moodle. The project will be discussed a week after its submission. The discussion of the project consists in the presentation of a short demo, which can be run on the personal laptop and in a general discussion of the choices made in the implementation of the system and of the reported results.

The oral examination (if required) will regard a review of the topics presented in the course. I recall that the oral examination is waived for the the students who have passed the Mid and Final Term.
Do not hesitate to contact us (laura.ricci@unipi.it, andrealisi.12lj@gmail.com) by e-mail, we will fix a meeting in the Meet room of the course.

References

[1] Sergey Legtchenko, Sébastien Monnet, Gaël Thomas *BlueBanana: resilience to avatar mobility in distributed MMOGs*. International Conference on Dependable Systems and Networks (DSN), Chicago, USA 2010.