UNICAMP

INSTITUTO DE COMPUTAÇÃO

# Simulating Smart Campus Applications in Edge and Fog Computing

**Denis Contini, Lucas Castro, Edmundo Madeira, Sandro Rigo, Luiz Fernando Bittencourt**

Fifth IEEE Workshop on Smart Service Systems (SmartSys 2020)
14 September, 2020 | Bologna, Italy

LRC Computer Networks Laboratory

LSC COMPUTER SYSTEMS LABORATORY

# Outline

- ➔ Concepts of Edge and Fog Computing
- ➔ Simulation Tools
- ➔ Testbed, Simulations and Results
- ➔ Conclusions and Future Works

# Edge and Fog Computing

- In **Edge Computing** the processing must occur in the vicinity of the data sources, that is, in the access layers where the devices and clients are connected.

- **Fog Computing** can be defined with “a highly virtualized platform that provides processing, storage, and network services between devices and traditional cloud datacenters, typically, but not exclusively, located at the edge of the network”.

# Edge and Fog Computing

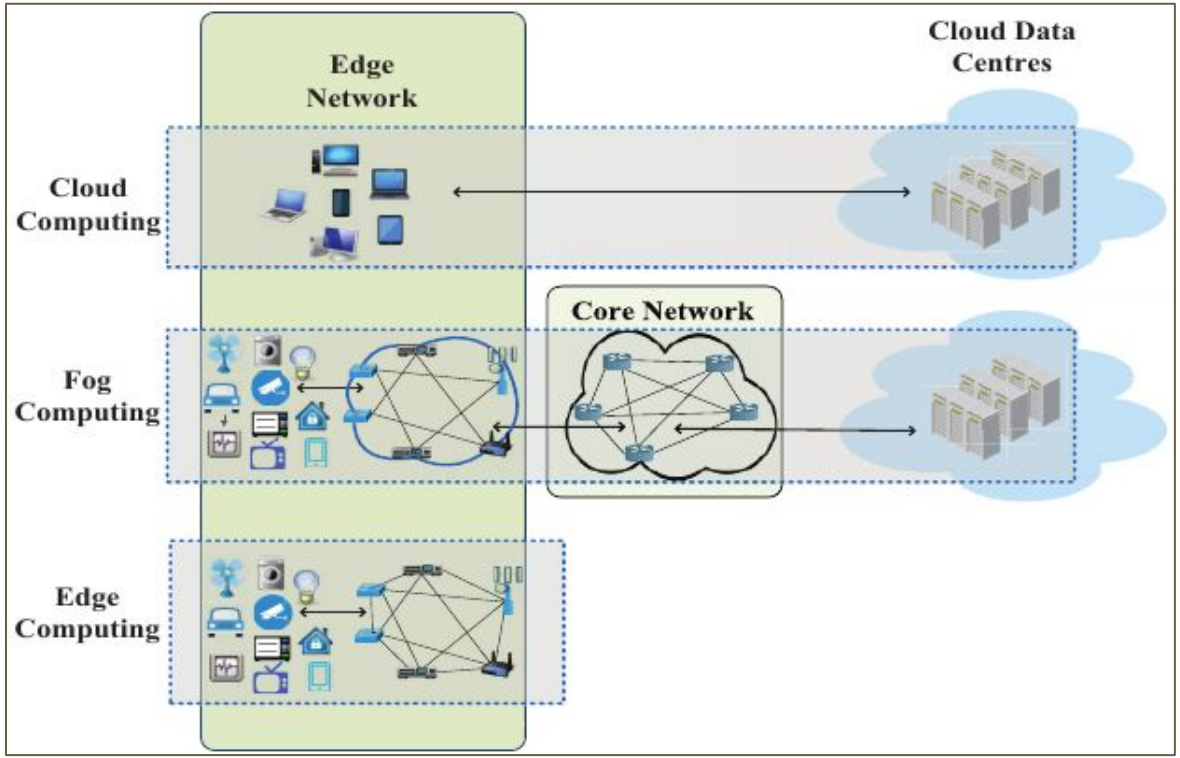



Fig. 1. Computational domain of cloud computing, fog and edge
Adapted from Mahmud et al. (2018). Fog Computing: A taxonomy, survey and future directions. In Internet of Things.

# Simulation Tools

- As with Cloud Computing, researchers and developers also seek to test scenarios and management mechanisms in Fog and Edge computing in order to foresee adverse scenarios.

- Issues and challenges related to deployment costs and scalability make simulations even more interesting due to their lower cost and flexibility, in addition to the time control factor, where long periods may be shortened during simulations.


# Simulation Tools

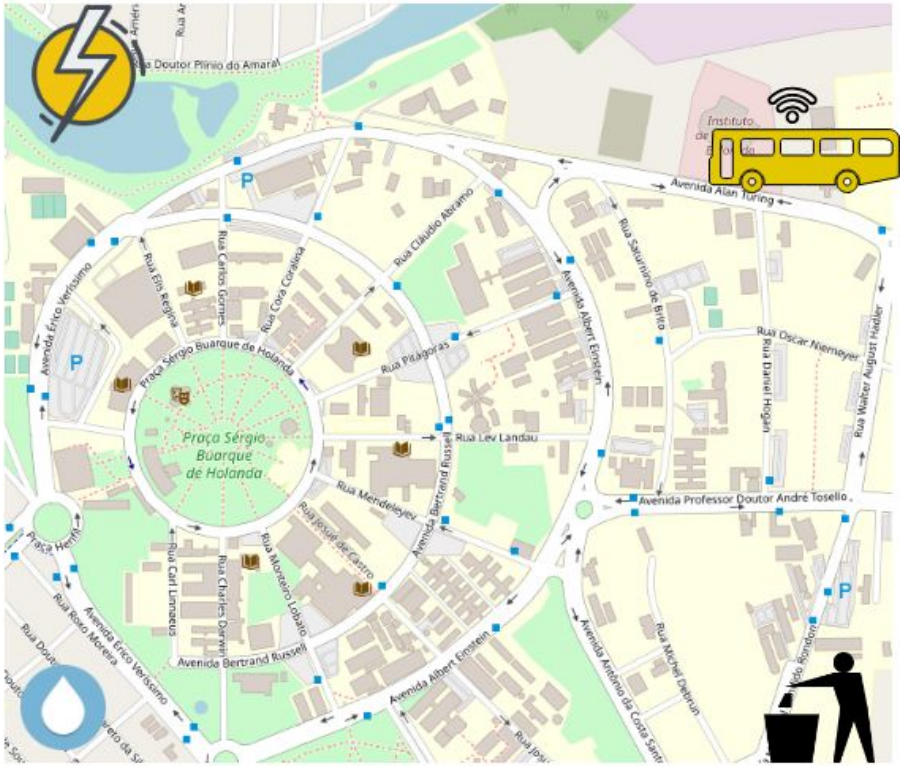
- **iFogSim** (http://www.buyya.com/papers/iFogSim.pdf)
- **EdgeCloudSim** (https://ieeexplore.ieee.org/document/7946405)
- FogNetSim++
- IoTSim
- FogTorchII
- EmuFog
- Fogbed
- YAFS (Yet Another Fog Simulator)

# Testbed and Simulations

- ➔ Smart Campus application designed for the University of Campinas (UNICAMP).

- ➔ 300 smart water meters;
- ➔ 300 smart energy meters;
- ➔ 50 smart battery collection points;
- ➔ 6 location sensors (GPS) installed on public transport;
- ➔ 100 Augmented Reality (AR);
- ➔ Text strings exchanged between clients (sensors) and servers.

**Total ≅ 800 sensor devices**



# Simulations - EdgeCloudSim

➔ Different scenarios and configurations:

I. **Single Tier** - task allocation only at the edge;
II. **Two Tier** - task allocation at the edge and cloud;
III. **Two Tier with Orchestrator** - task allocation at the edge and cloud with orchestrator.

➔ Metrics applied to evaluate the simulations:

- Number of failed tasks
- Hit rate

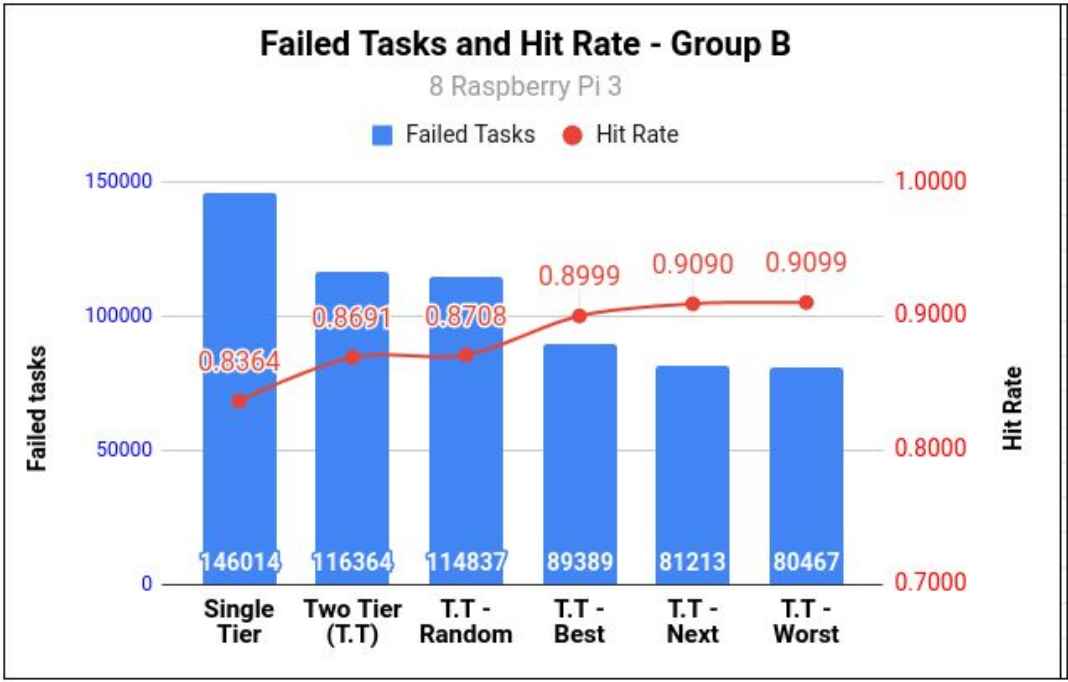
# Simulations - EdgeCloudSim

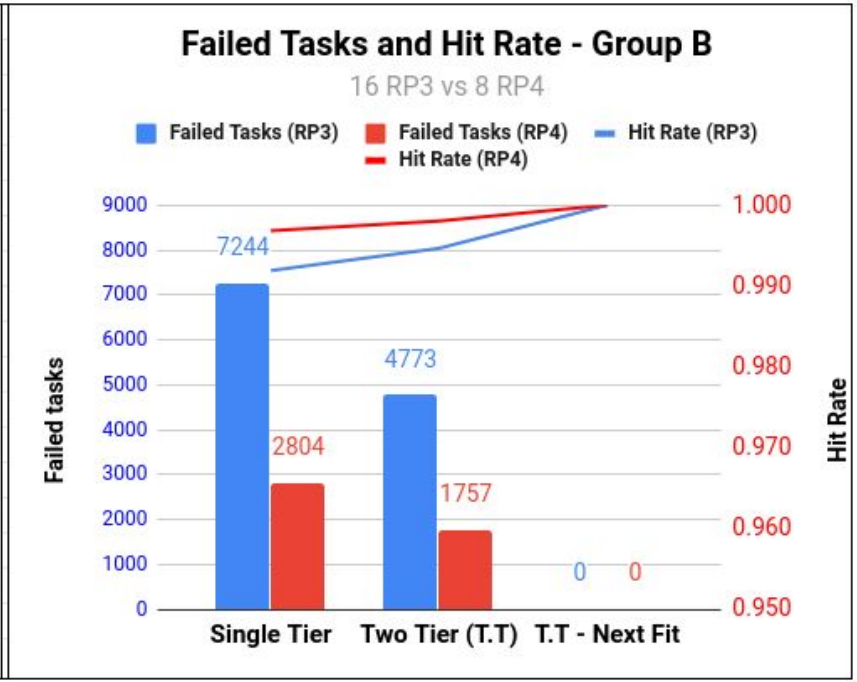
- ➔ 4 groups has been elaborated and tested in EdgeCloudSim (A, B, C, and D);
- ➔ For each scenario group, different orchestration policies were employed:
  - ◆ Next **(N)** Fit
  - ◆ Random **(R)** Fit
  - ◆ Worst **(W)** Fit
  - ◆ Best **(B)** Fit

TABLE II
TABLE II - SCENARIO GROUPS IN EDGECLOUDSIM

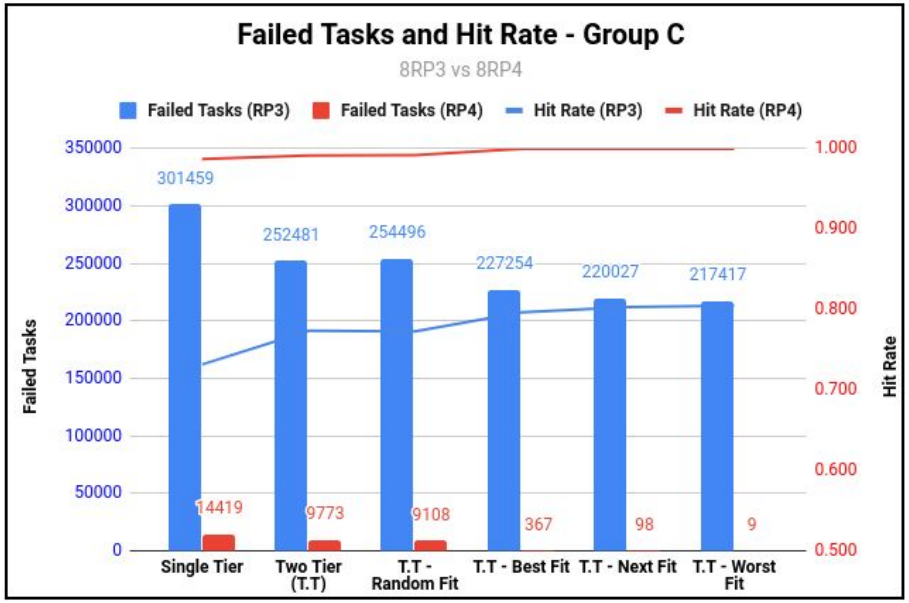
| Group | # Client Devices | #Edge Server Devices | WAN/GSM/ WLAN | Orch. policy |
|---|---|---|---|---|
| A | 800-1600 | 8/16 (RP3-4) and 32 RPx | 50/—/300 | N |
| B | 6400 | 8/16 (RP3-4) and 32 RPx | [20-50] / [2-5] / [54,150,300] | N,R,W,B |
| C | 8000 | 8 RPx | 50/—/300 | N,R,W,B |
| D | 1600-8000 | 8 RPx | 50/—/300 | N |

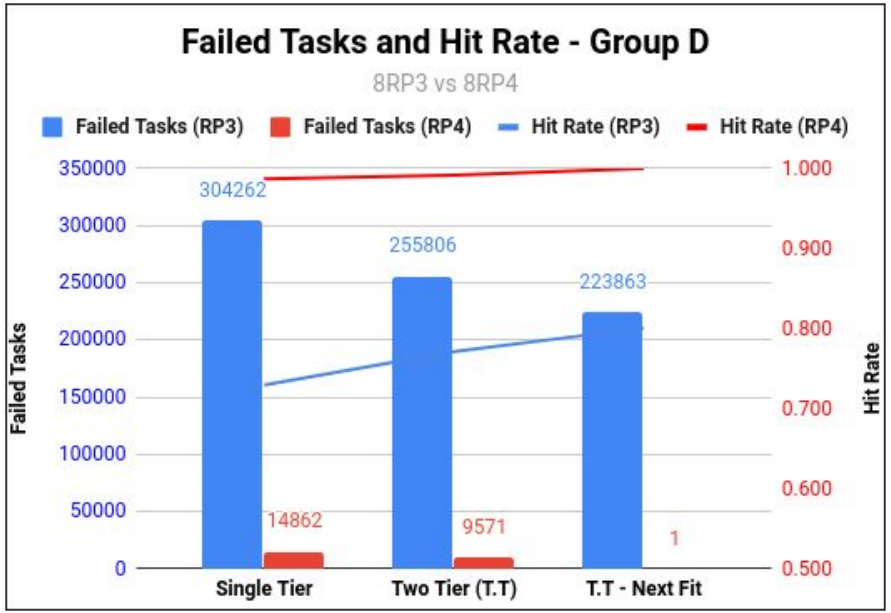
# Simulations - EdgeCloudSim - Group B



# Simulations - EdgeCloudSim - Group C and D



# Simulations - iFogSim

- ➔ Difficulties were encountered when replicating the scenario and topology tested and evaluated in EdgeCloudSim, which is more suitable to simulate applications to be processed in edge and cloud, not offering fog processing capabilities.
- ➔ Topology was created based on the settings of the best simulated scenario in EdgeCloudSim.

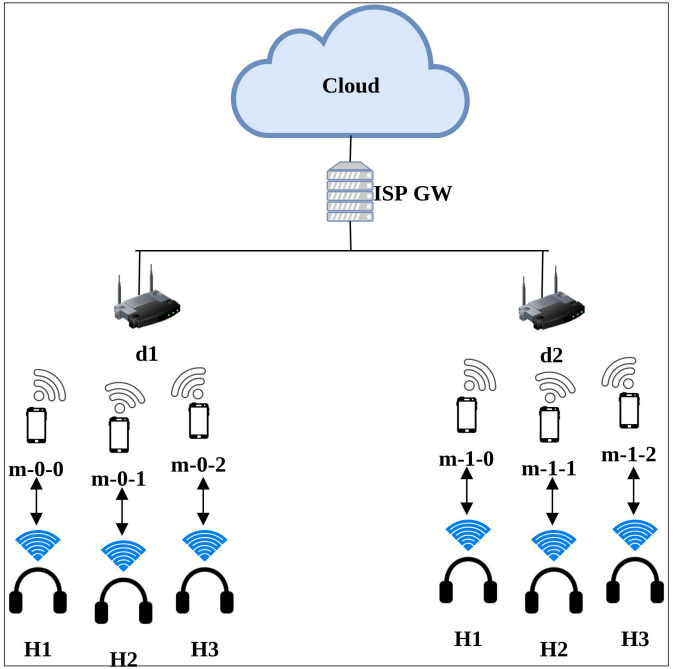
TABLE III
IFOGSIM SIMULATION SETTINGS

| Devices | MIPS | RAM (GB) | Up/Down Link (Mbps) | Level | P. Busy (W) | P. Idle (W) |
|---|---|---|---|---|---|---|
| Cloud | 75,000 | 64 | 100 | 0 | 1,200 | 960 |
| ISP-GW | 7,000 | 4 | 50 | 1 | 100 | 80 |
| AP (d1,d2) | 7,000 | 4 | 100 | 2 | 100 | 80 |
| Mobile | 7,000 | 4 | 300 | 3 | 80 | 50 |

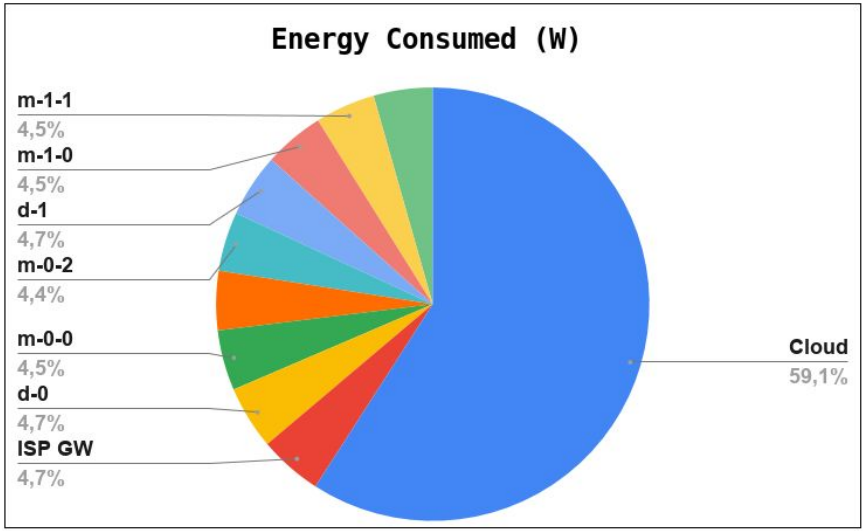
# Simulations - iFogSim

- The topology and metrics used in EdgeCloudSim could not be replicated with the same fidelity in iFogSim due to their specificities.

- 3 sensor devices are associated via WiFi (IEEE 802.11n) to their respective mobile devices, which, in turn, are associated with an Access Point (AP) device, connected with Internet Service Provider (ISP).



# Simulations - iFogSim




- ➔ 5 rounds were performed;
- ➔ The arithmetic mean of the values was computed;
- ➔ The operating time used for simulating the implemented scenario was 30 minutes per round.

# Conclusions

- Edge and Fog Computing present themselves as distinct paradigms and with specific characteristics, where one can be used as an extension of the other, or in conjunction with resources and applications allocated in the Cloud.

- **iFogSim:**
  - Focused on the energy consumption of the application, as well as metrics of bandwidth usage in applications (prioritizing energy consumption or optimizing bandwidth consumption).

# Conclusions

- **EdgeCloudSim:**
  - Shows greater efficiency when the objective is to verify the number of tasks served by the processing devices allocated at the edge, in addition to allowing a more detailed analysis of the various methods of task orchestration helping the researcher to find the more efficient method according to the scenario to be simulated or, allowing the development of a new orchestration policy.

# Conclusions - Future Works

- ➔ Increase the number of devices used to further scale the proposed scenario, increasing it is diversification, not just restricting the Raspberry Pi for Edge and Fog processing.

- ➔ Configure the scenario so that tasks can be sent to the cloud so that bandwidth and latency metrics can be better evaluated.

# Acknowledgment

This work is part of the INCT of the Future Internet for Smart Cities (CNPq 465446/2014-0, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and FAPESP 2014/50937-1, 2015/24485-9 and 2015/24494-8). The authors are grateful for the financial support from the institutions mentioned above.

# Thank You!

Denis Contini
denis.contini@students.ic.unicamp.br

Lucas Castro
lucas.castro@ic.unicamp.br