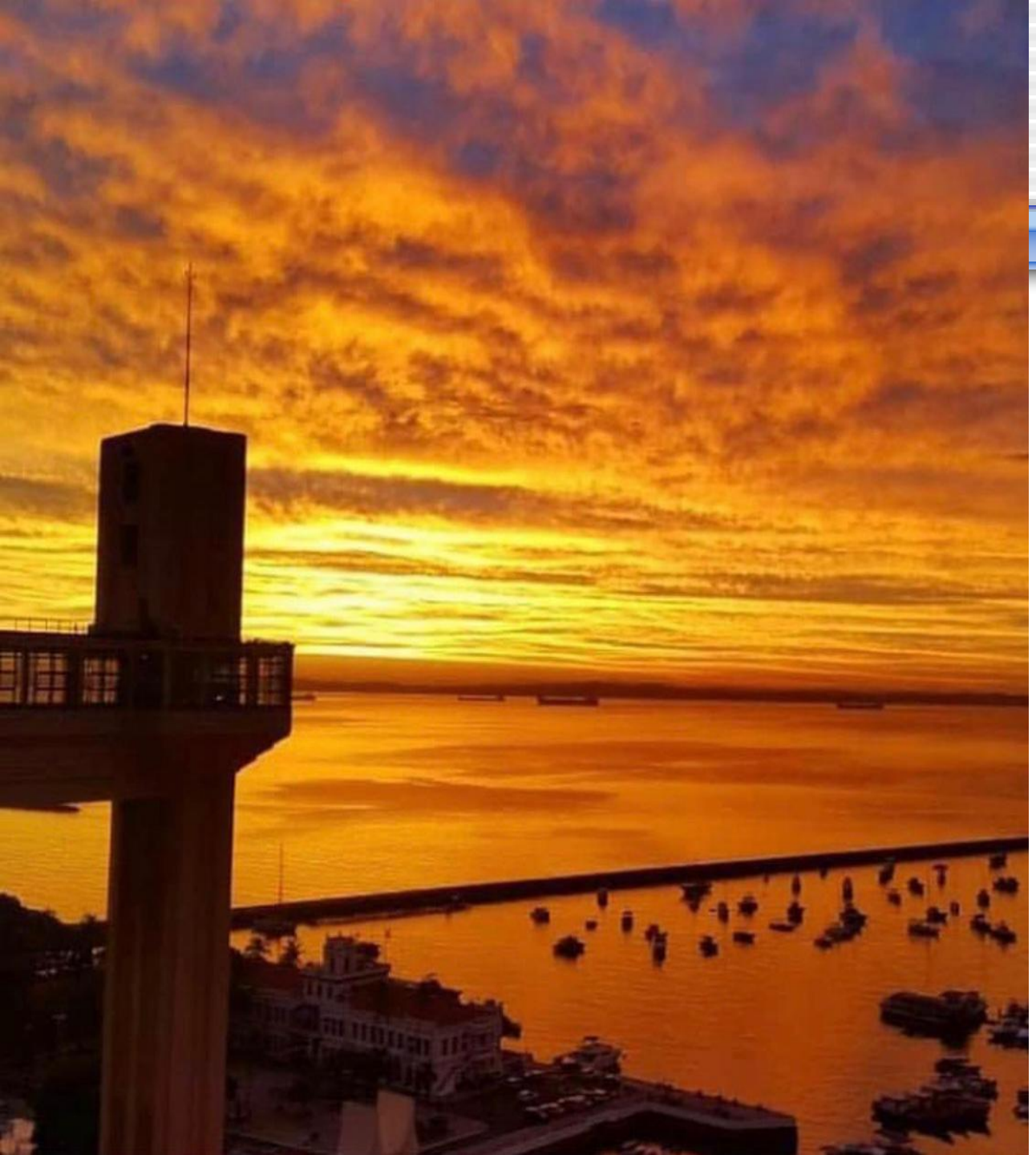
Perspectives on Distributed Computing, Networks and Blockchain

Fabíola Greve
Distributed Computing

Leobino Sampaio
Networks

Computer Science Department
Federal University of Bahia (UFBA)



Salvador de Bahia

- Founded in 1549 as the 1st capital of Brazil
- About 3 million people
- 3rd largest city in the country, largest in Northeast
- Cuisine, music, architecture

www.ufba.br

- 70 years
- One of the most prestigious in Brazil (top 15)
- 3 thousand professors
- 40 th. under-graduate students
- 6 th. graduate

www.dcc.ufba.br
Computer Science Department

Computer Science Department

- 45 professors
- Undergraduate courses in Computer Science, Information Systems
  - 1.250 undergraduate students
- Graduate programs in Computer Science and Mechatronics
  - 400 graduate students
- Fabíola Greve's currently work
  - Gaudi distributed computing group (gaudi.dcc.ufba.br)
  - Part-time administration: Information Tech advisor to the president of the university
  - Semester 1: Distributed Computing course
  - Semester 2: Blockchain course

Blockchain
Tutorials, Talks, Panels

SBRC2018
CAMPOS DO JORDÃO - SP

6 a 10 de Maio

CERTIFICADOS O EVENTO CHAMADAS PROGRAMA CONTATO

MINICURSO 5 (MC-5)

CERTIFICADOS
INSCRIÇÕES
O EVENTO
COMITÊS
ANAIS
TRILHA PRINCIPAL
MINICURSOS
CHAMADA DE MINICURSOS
MINICURSOS ACEITOS

Blockchain e a Revolução do Consenso sob Demanda

Horário: 10/05/2018 (Quinta-feira) – 14:00 às 18:00

Autores: Fabíola Greve (UFBA), Leobino Sampaio (UFBA), Jauberth Abijaüde (UESC), Antônio Coutinho (UEFS), Italo Valcy (UFBA) e Sílvio Queiroz (UFBA)

Apresentadores: Fabíola Greve e Leobino Sampaio

Resumo: Blockchain é uma tecnologia emergente que oferece suporte distribuído confiável para realização de transações com compartilhamento de dados entre participantes que não necessariamente têm confiança entre si e que estão dispersos

Blockchain
Tutorials, Talks, Panels

Fabíola Greve - UFBA

Blockchain
First academic Workshop

SBRC2018
CAMPOS DO JORDÃO - SP

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CERTIFICADOS O EVENTO CHAMADAS PROGRAMA CONTATO

WBLOCKCHAIN – WORKSHOP EM "BLOCKCHAIN: TEORIA, TECNOLOGIAS E APLICAÇÕES"

ORGANIZAÇÃO

Fabíola Greve (UFBA)

Coordenadora do WBlockchain

E-mail: fabiola[at]ufba.br

Eduardo Alchieri (UnB)

Coordenador do WBlockchain

Alysson Bessani (Universidade de Lisboa)

Coordenador do WBlockchain

Research Lines

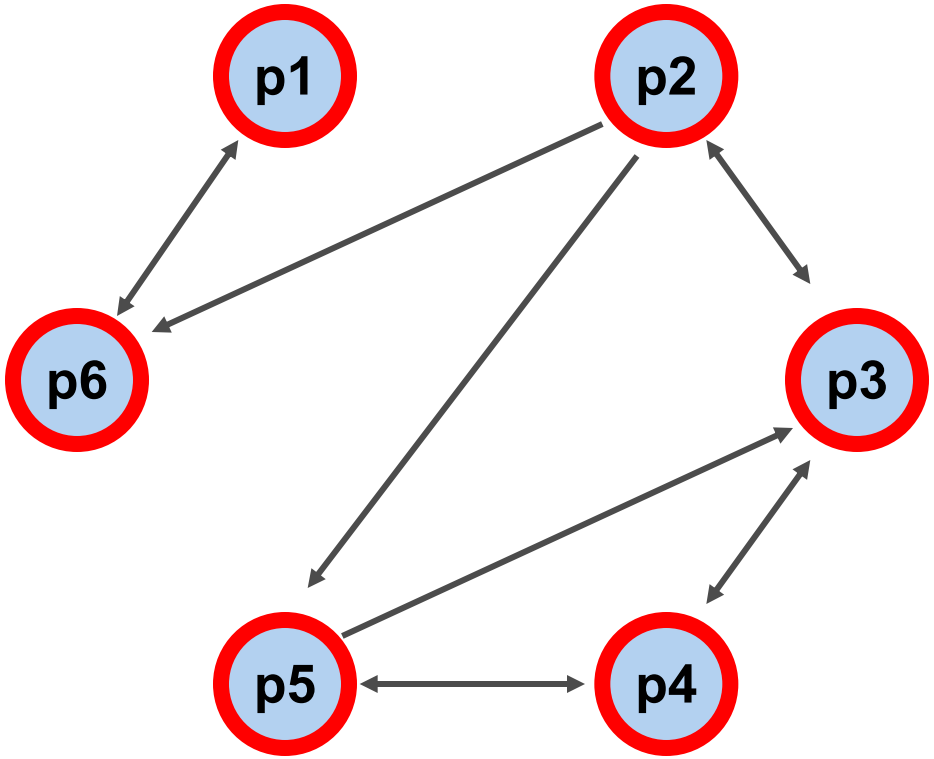
1. Consensus and Fault Tolerant Algorithms
2. Fog Computing
3. IoT Applications
4. Networks

- PhD and Master students, with some other DCC colleagues
- Cooperation with international/national universities, brazilian public institutions and industry

Conditions for the Solvability of Fault-Tolerant Agreement in Unknown Networks

Fabíola Greve (UFBA, Bahia)
Sébastien Tixeuil (LIP6, Paris)
Alysson Bessani (U. Lisboa)
Eduardo Alchieri (UnB, Brasília)

Dynamic Context –Unknown Networks



- Π and n, f are unknown
- Partial Knowledge
  - pi knows $\Pi_i \subseteq \Pi$
  - pi can send a message only to processes in Π_i
- Communication Graph is dynamic
- Knowledge Graph is not complete

Consensus in Unknown Networks

- CUP (Consensus with Unknown Participants)
  - Classical Consensus + No Global Knowledge about Π and n
  - Fail-free environment
- FT-CUP (Fault-Tolerant CUP)
  - Fail-prone environment
- BFT-CUP (Byzantine Fault-Tolerant CUP)

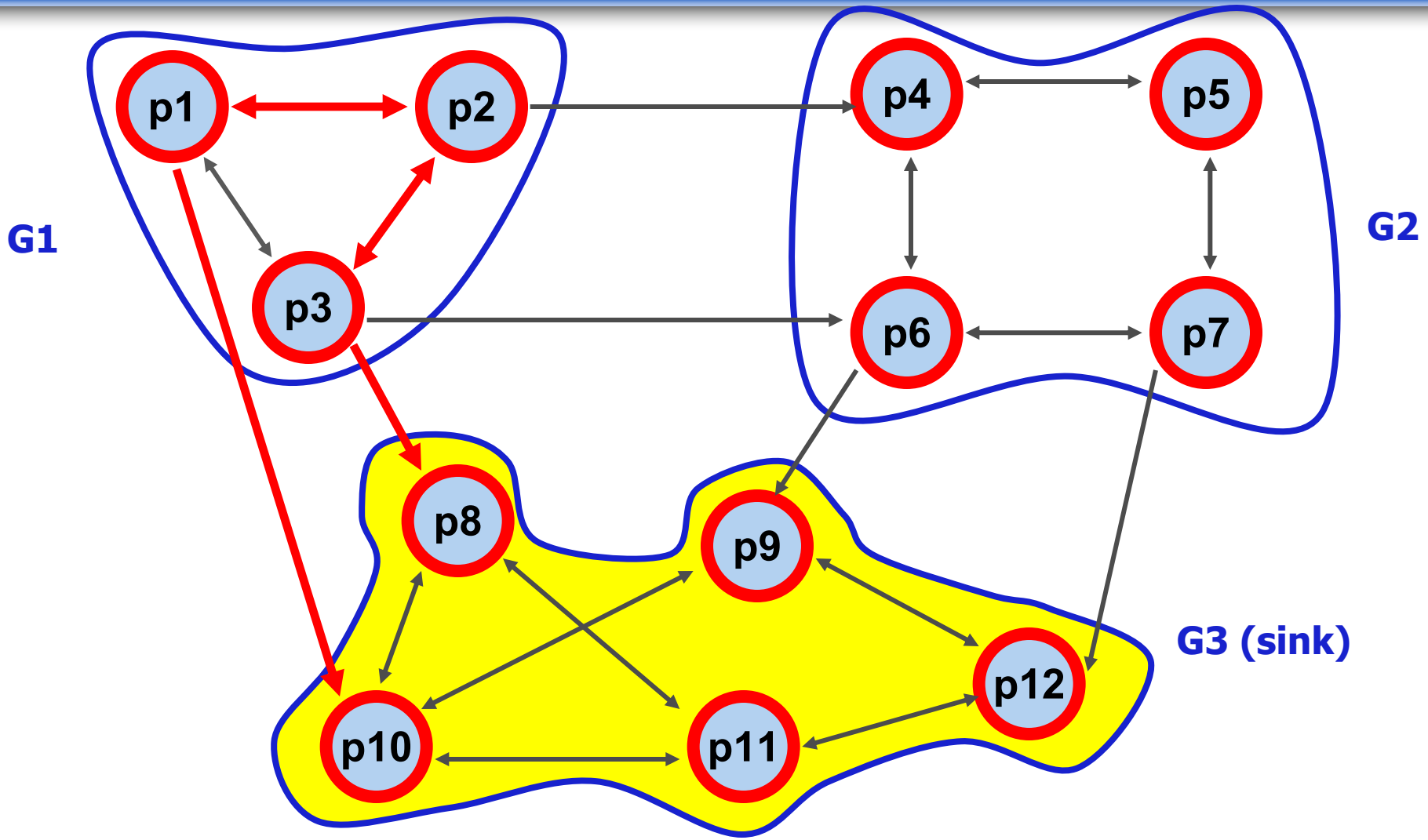
Abstractions to Solve CUP, FT-CUP and BFT-CUP

- Synchrony Conditions
  - Leader Oracles [Lamport, 98]
    - Eventual Leadership Property
  - Unreliable Failure-Detectors [Chandra and Toueg, 96]
    - Hints about failures
- Knowledge Connectivity Conditions
  - Participant Detectors [Cavin, Sasson and Schiper, 04]
    - Hints about participants

Participant Detectors (PD)

- Distributed Oracles
- Partial information about processes in the system
  - Information Accuracy
    - No mistakes about participation
  - Information Inclusion
    - Information is non-decreasing over time
- Enriches the system with a « knowledge connectivity graph » $\mathcal{G}$
- The graph properties establish « participant detectors classes »

k-One Sink Reducibility PD (k-OSR)
$\mathcal{G}$: sink k-connected, ≥ k paths



Conditions to Solve FT-CUP (fault-prone scenario)

[Greve and Tixeuil, DSN 07, PODC:WRAS 10]

Minimal Synchrony → Strongest Connectivity

- k-$OS\mathcal{R}$ (k-one sink reducibility)
- Unreliable Failure Detector: $\diamond S$ or Ω

are necessary and sufficient to FT-CUP, when n is unknown but f is known

- Uniform FT-CUP is possible!
  - Reduction to re-use classical indulgent consensus

FT-CUP Byzantine Failures, Shared-Memory

[Khouri, Greve, Tixeuil, SRDS 2013]

Consensus with Unknown Participants for Shared Memory

[Alchieri, Bessani, Greve, Fraga, TDSC 2016]

Connectivity Requirements for Solving Byzantine Consensus with Unknown Participant (BFT-CUP)

Solving BFT-CUP

- Same participant detector necessary to solve FT-CUP: k-OSR PD
- Same level of synchrony necessary to solve FT-CUP: failure, leader oracles
- But BFT-CUP requires authenticated channels & more connectivity than FT-CUP
  - BFT-CUP ($k \geq 2f+1$), FT-CUP ($k \geq f+1$)

Perspective: BFT-CUP for Blockchains

Alysson Bessani (U. Lisboa) and Eduardo Alchieri (UnB)

- Hyperledger Fabric Project with BFT-SMaRt [DSN 14, DSN 18, DSN 2019 Carter award Thesis]

- Necessary and Sufficient conditions (synchrony and knowledge connectivity) are useful for blockchains?
- How to adapt BFT-CUP algorithms to permissioned blockchains?
- Challenge BFT reconfiguration => Churn/committee management
- Participant detectors are a way to define dynamic BFT committees?

Failure and Leader Detectors for Dynamic Systems

- Most detectors assume
  - Global knowledge about the membership, fully communication connectivity, reliable communication
- Additionally, they are Time-Based
  - Requiring that eventually some bound on the message transmission will permanently hold
- These assumptions are not well appropriate to the new scenario of dynamic systems

The Time-Free Approach to Failure Detection and Leader Election

- Propose a Model and Identify sufficient assumptions able to implement the properties of a new class of FDs suitable for mobile networks with unknown membership.
  - TVG (*Time Varying Graphs*), global membership is unknown (n, f), communication is fair-lossy
- The class of eventually strong FDs with unknown membership (namely, ♦SM)
  - Adapts the properties of the ♦S class to a dynamic system with an unknown membership.

The Time-Free Approach to Failure Detection and Leader Election

- FD Algorithm that implements ♦SM
  - Tolerates mobility, dynamic membership
  - Uses local information about the membership
  - Uses QUERY-RESPONSE pattern to exchange messages between local nodes
    - Based on the reception of sufficient Q-R messages from the neighborhood a node is able to suspect or revoke a suspicion
    - The suspicion information is piggybacked and eventually propagated to the whole network

The Time-Free Approach to Failure Detection and Leader Election

[Pierre Sens (LIP6, Paris), Luciana Arantes (LIP6, Paris)

- An Unreliable Failure Detector for Unknown and Mobile Networks [The Computer Journal 2012, Euro-Par LNCS 2011, Handbook on Mobility 2011, OPODIS 2008]
- What Model and What Conditions to Implement Unreliable Failure Detectors in Dynamic Networks ? [DISC TADDS 2011, DSN HotDep 2011]
- A Time-Free Byzantine Failure Detector for Dynamic Networks [EDCC 2012]
- Eventual Leader Election in Shared-Memory Dynamic Systems [AINA 2018]

Fog Computing

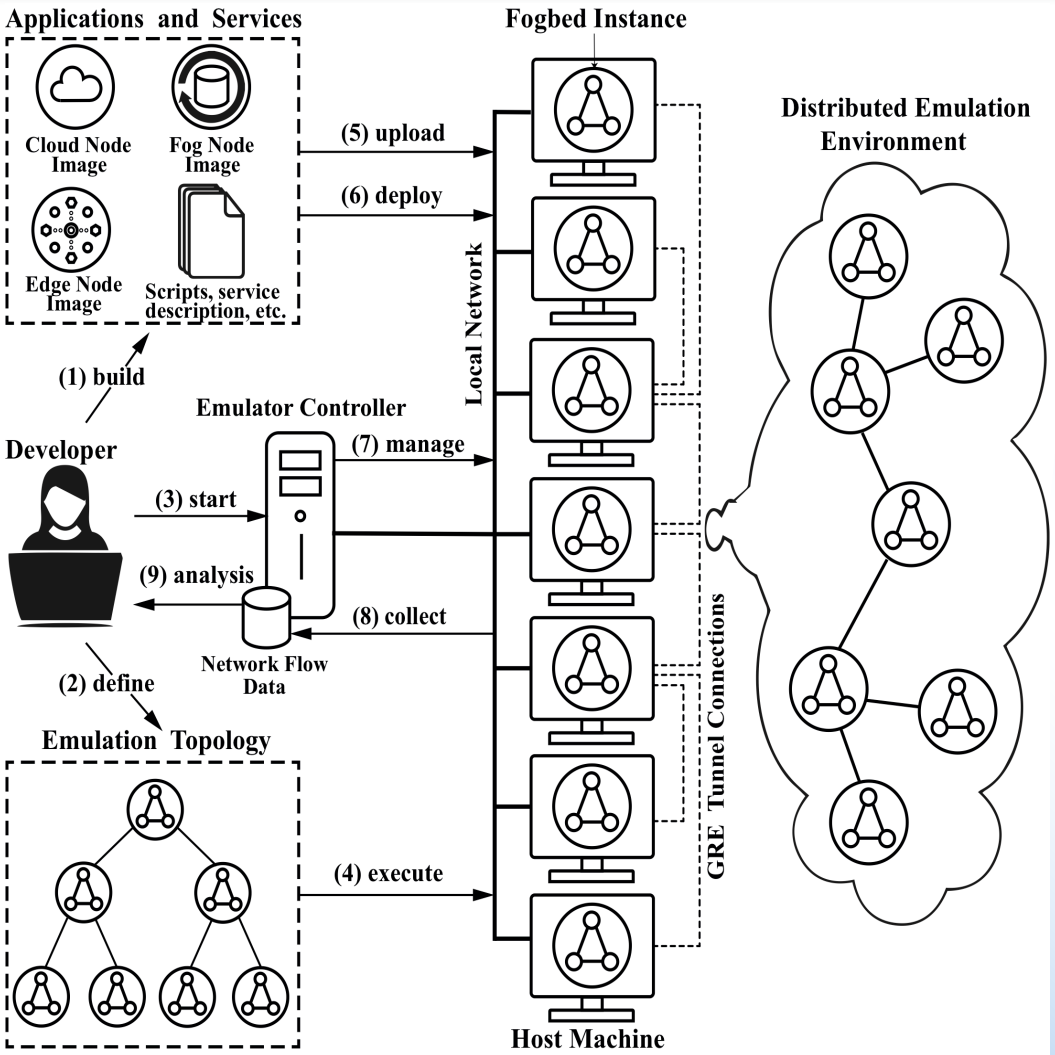
Antônio Coutinho (UFBA, PhD candidate)
Josué Junior(UFBA, Master candidate)
Fabíola Greve (UFBA)
Cássio Prazeres (UFBA)

Fog Testbed Platform Motivation

- No readily available real world fog testbeds that can help researchers to design and verify fog solutions on a truly IoT scale
- To this purpose, net simulators and cloud middleware are adapted to allow the experimental evaluation of fog solutions in limited conditions

Fogbed: Scalable Prototyping Environment for Fog Computing

- A framework and toolset integration for rapid prototyping of fog components in virtualized environments.
- Using a desktop approach, Fogbed enables the deployment of fog nodes as software containers under different network configurations.
- Its design meets the requirements of low cost, flexible setup and compatibility with real world technologies.



Fog Computing
Some Results

- [Antônio Coutinho et al, ICC 2018]
  Fogbed: A Rapid-Prototyping Emulation Environment for Fog Computing
- [Antônio Coutinho et al, ISCC 2018]
  Scalable Fogbed for Fog Computing Emulation
- [Antônio Coutinho et al., Tutorial at SBRC 2016]
  Computação em Névoa: Conceitos, Aplicações e Desafios

Chapter (PDF Available) · May 2016 *with* 3,650 Reads

In book: Minicursos / XXXIV Simpósio Brasileiro de Redes de Computadores e Sistemas Distribuídos, Edition: XXXIV, Chapter: Computação em Névoa: Conceitos, Aplicações e Desafios, Publisher: Sociedade Brasileira de Computação, Editors: Frank Augusto Siqueira, Lau Cheuk Lung, Fabíola Gonçalves Pereira Greve, Allan Edgard Silva Freitas, pp.266-315

Perspectives: Fog Blockchain Architecture

- Most of works integrate blockchain into the Fog as a separate service
- Propose to redesign the Fog architecture with blockchains
  - Offering a Blockchain SLA support in the Fog architecture

IoT Aplications

Jauberth Abijaude (UFBA, PhD candidate)
Alef Chaves (UFBA, Master candidate)
Hellan Viana (UFBA, Master candidate)
Fabíola Greve (UFBA)

IoT Applications
Some Results

- [Jaubert et al, ISCC 2018]

  I2oTegrator – Multiservice middleware with IoT, Ontology and Blockchain support
- [Jaubert et al, SBSI 2018]

  IoT Água – Intelligent system for water consumption management and planning

IoT Applications
Some Results

- [Jaubert et al, SBSI 2017]

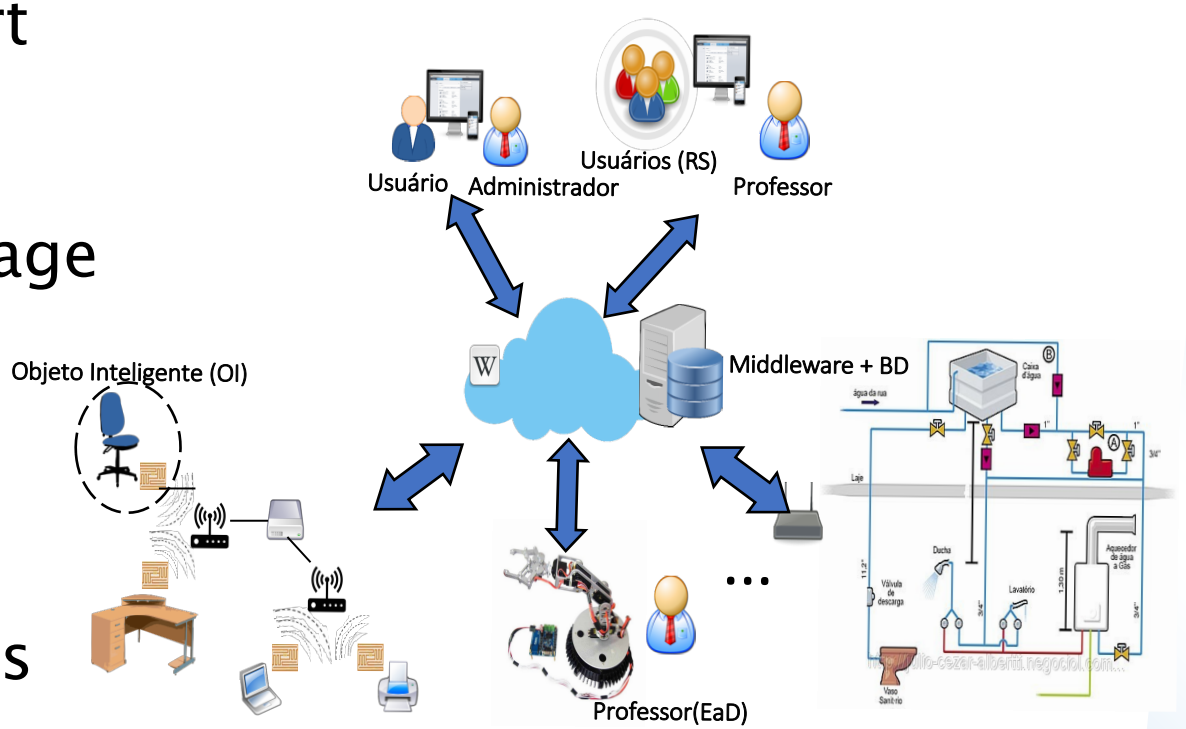
  I^2oT Inventory – Autonomous asset inventory system

- [Jaubert et al, in Progress]

  IoTCocoa – IoT and blockchain support for gourmet cocoa production

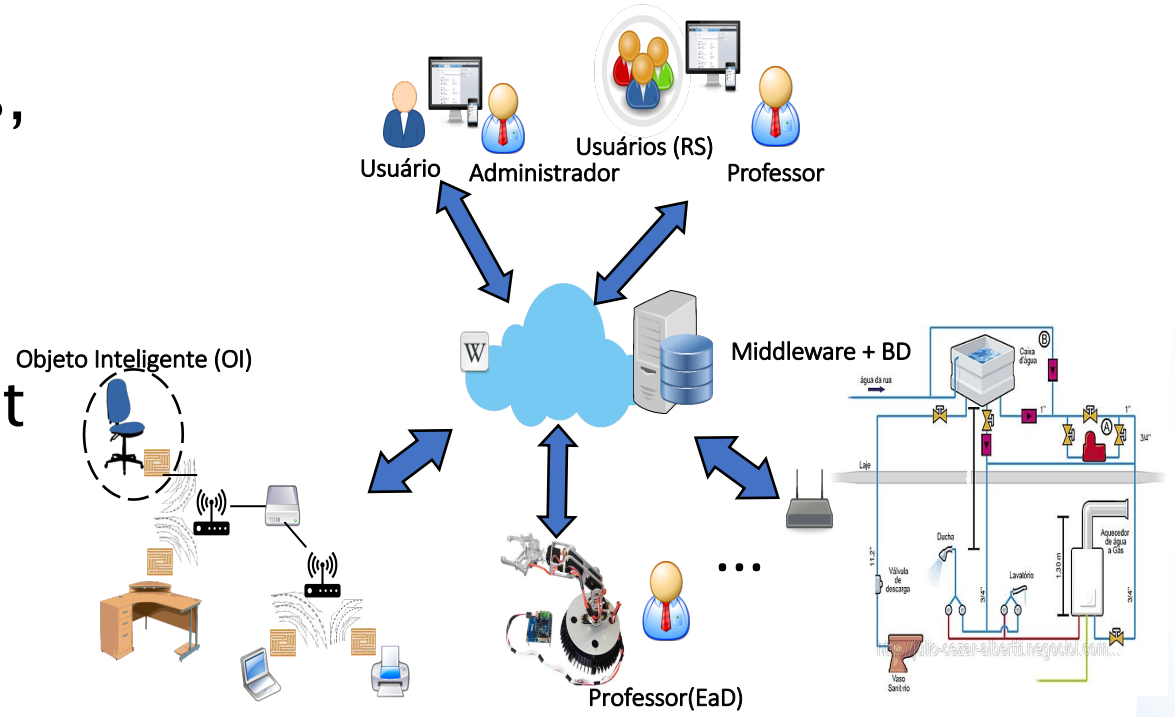
I²oTegrator – Multiservice middleware with IoT, Ontology

- A service-oriented middleware, with support for ontology, REST architectural style and communication by message exchange
- Solve the problem of uniform management of objects, including their tracking and autonomous monitoring



I²oTegrator + Blockchain

- Innovative features: take decisions, recognize situations, trigger alarms, send and receive information by exchanging messages with applications or client software
- **In construction** – Smart contacts creation, compilation and implementation, on-demand, integrated into a web system

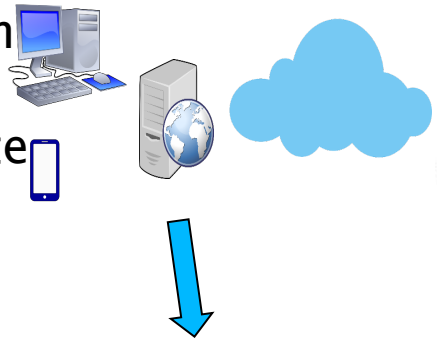


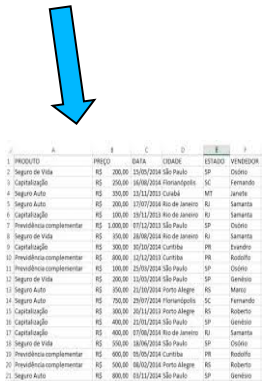
IoTÁgua – Intelligent system for water consumption management and planning

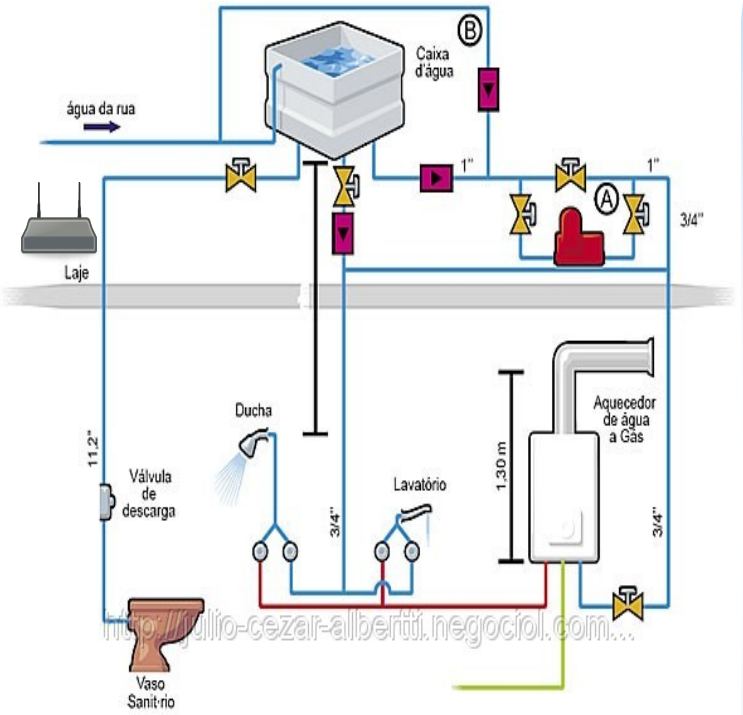
Intelligent water consumption monitoring system, associated to the construction of a database for analytical studies of stored values.

The interconnected Internet system which controls the water supply process in residential and corporate environments, monitors the individual consumption of water outlets, detects leakages, send alerts and creates consumption graphs

Thanks to a middleware able to manage sensors and trigger actions: checking the tank level, measuring the water flow, and handling solenoid valves

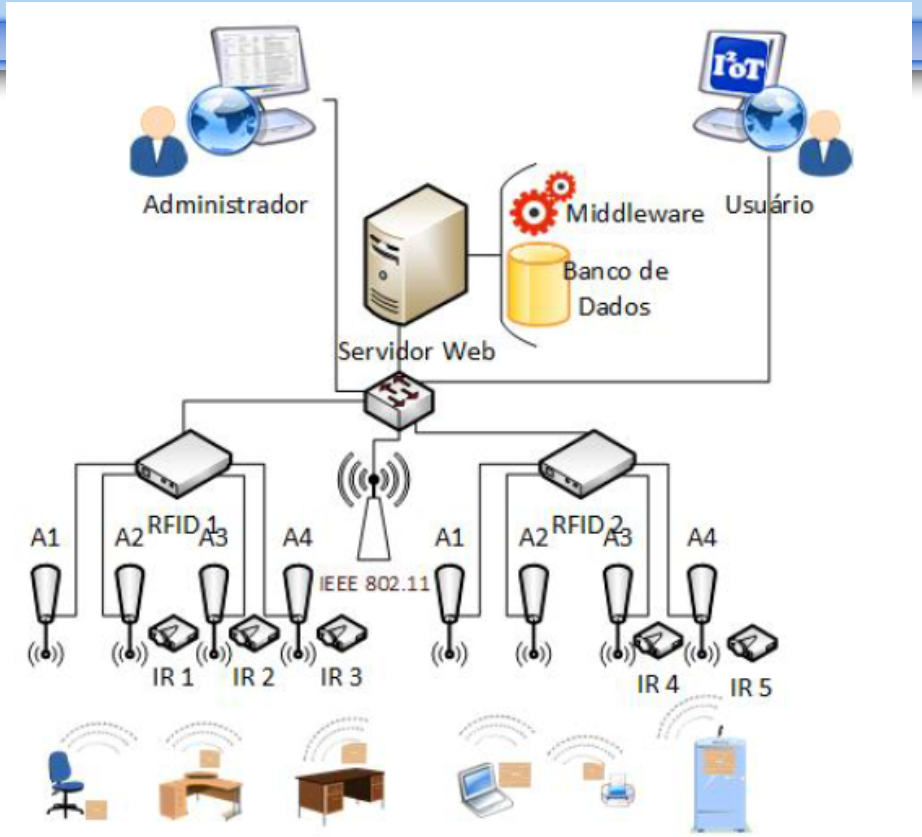






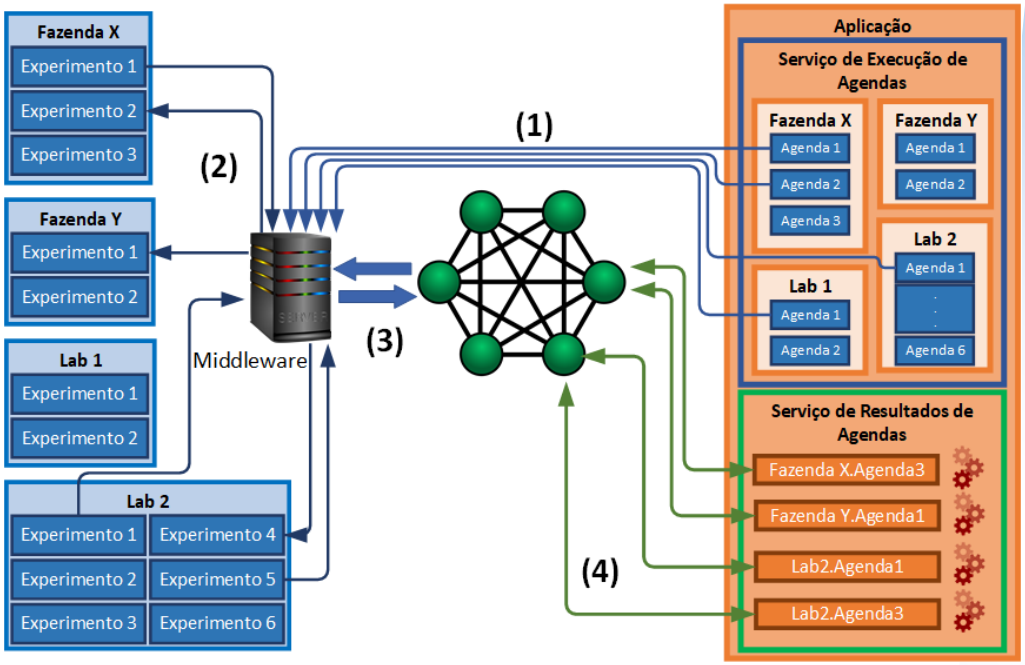
I²oT – Inventory IoT

- Middleware that allows the communication among smart objects (RFID) and the Web system, which operates as a social network.
- A platform able to perform the intelligent management and monitoring of the movement of goods within a institution in an automatic way, reducing the human labor time and keeping the information always updated.



IoTCocoa – support for gourmet cocoa production

- The worldwide search for gourmet cacao has rekindled interest in production, whose fermentation and drying processes are the key.
- Develop a Web system for the control and monitoring of these events, based on IoT, blockchain and smart contracts to catalog valuable information of the process for improvement and future research.
- Proof of concept and performance evaluation done.



Thanks!

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Salvador de Bahia

- In 1985 the Historic Centre of Salvador was made a World Heritage Site by UNESCO
- A center of Afro-Brazilian (*negro*) culture, due to slaves descendants