50 anos da Internet: Origem, Presente e Futuro(?)

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2019

Perguntas

- Você usa a Internet?
- Você sabe o que é a Internet?
- Você sabe que a Internet é considerada uma das realizações da Engenharia de maior impacto do seçulo 20?
  - por que será?
- Quando surgiu a Internet?
- Quais os motivos que levaram à criação da Internet?

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Internet faz 50 anos

- Em 29 de Outubro de 1969 o primeiro pacote de informação foi enviado da UCLA
- Workshop na UCLA em 29 de Outubro de 2019!

A Palestra

- Fazer um breve histórico
- Qual a importância da ciência no desenvolvimento da Internet?
- Falar sobre o presente
  - Aplicações
  - Falar um pouquinho sobre a pesquisa atual no grupo que coordeno na COPPE.
- Considerações sobre o futuro.
- Façam perguntas

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In the Beginning

In the Beginning

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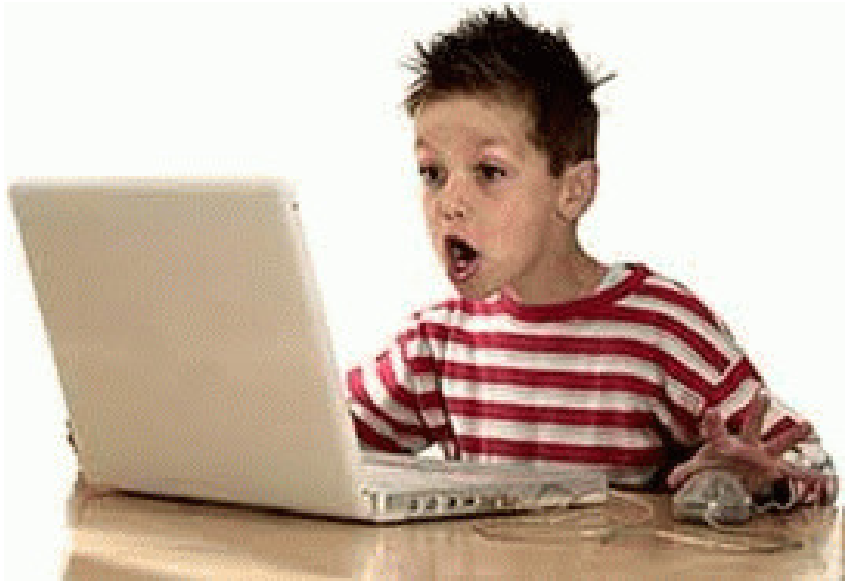

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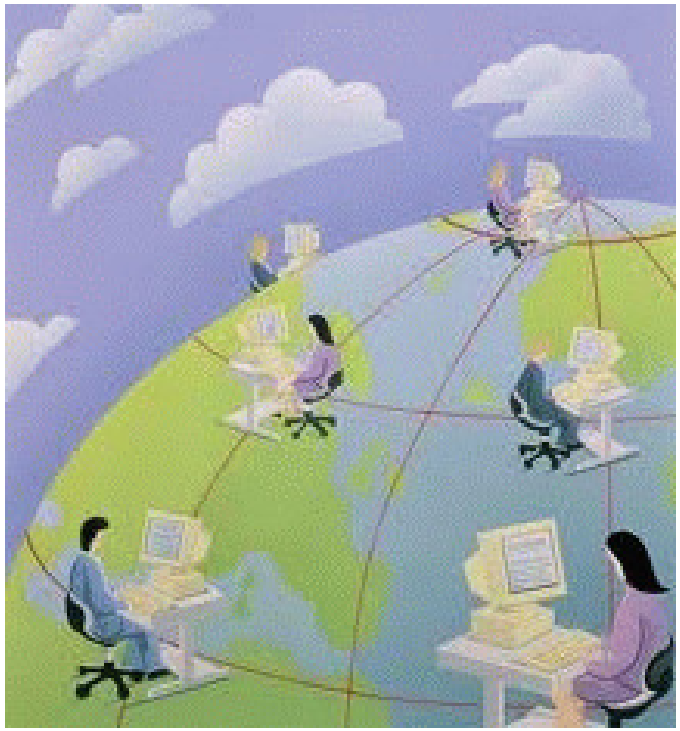
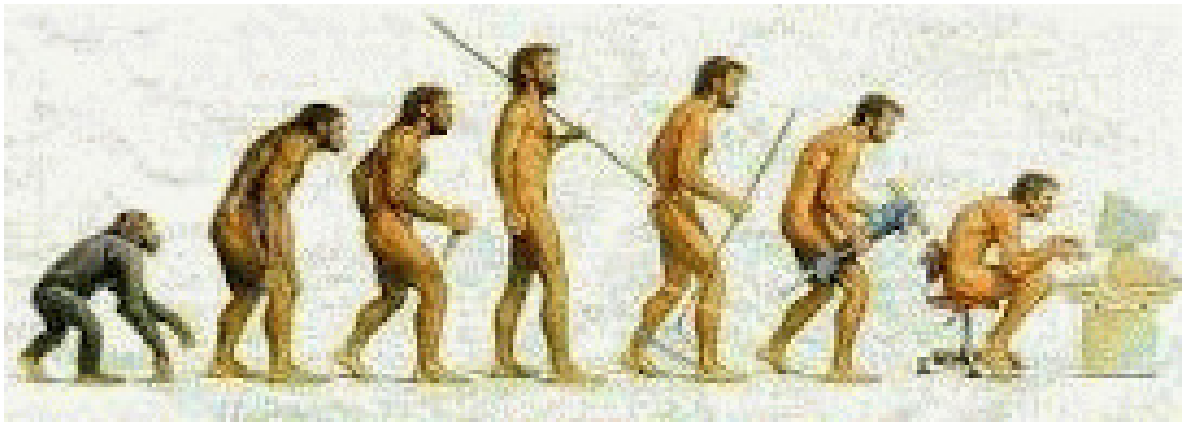


O que é a Internet?
Evolução



Histórico
Início

- Necessidade de COMPARTILHAR RECURSOS
- Acesso remoto a recursos
  - o que é um RECURSO?
- Custo de hardware baixando
- “Inteligência” para compartilhar recursos

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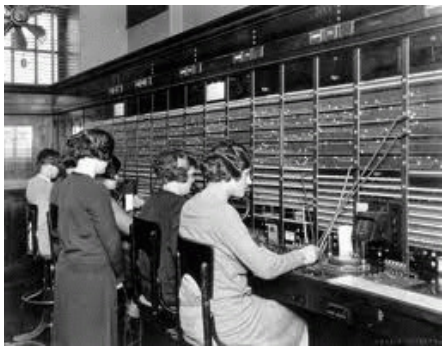
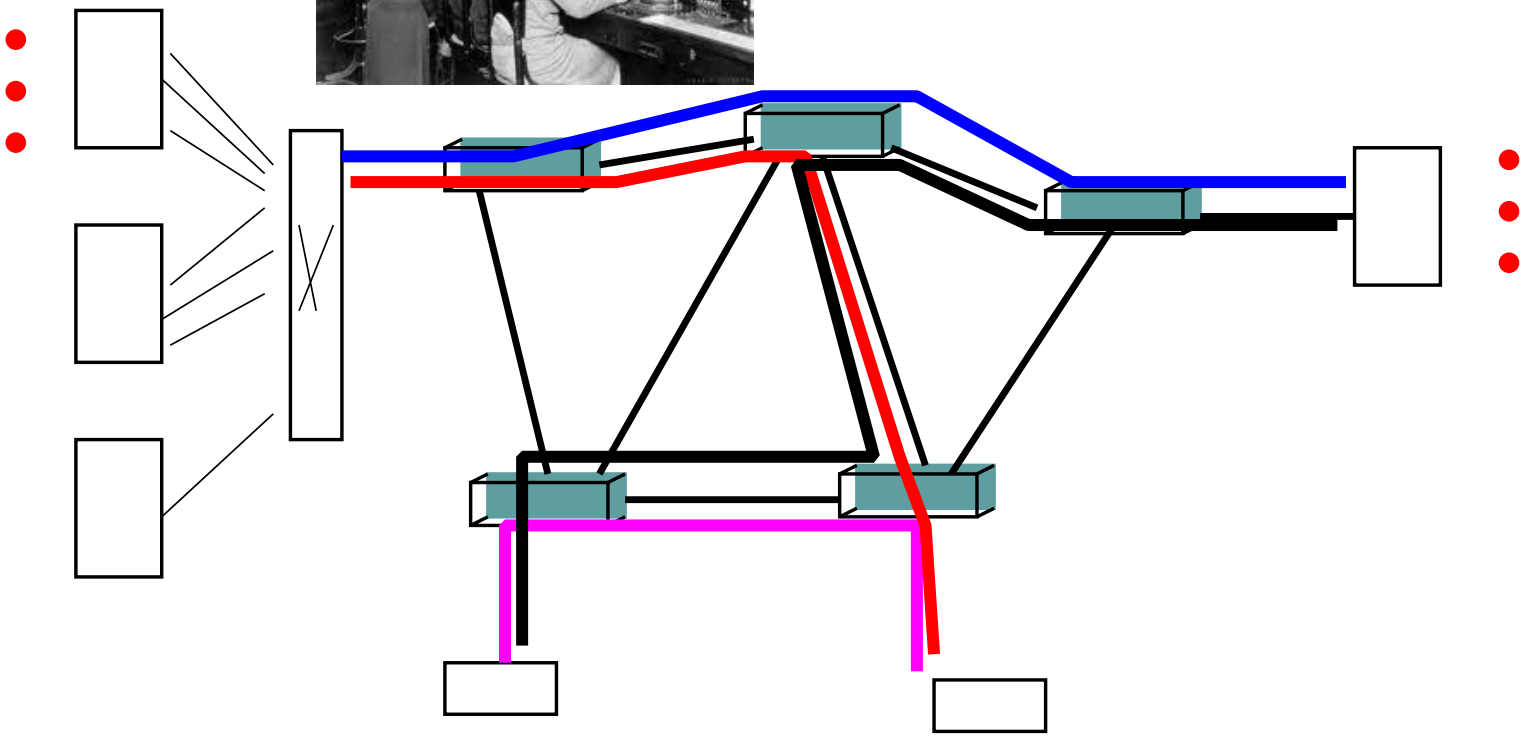
Histórico
O que existia?

- Rede Telefônica

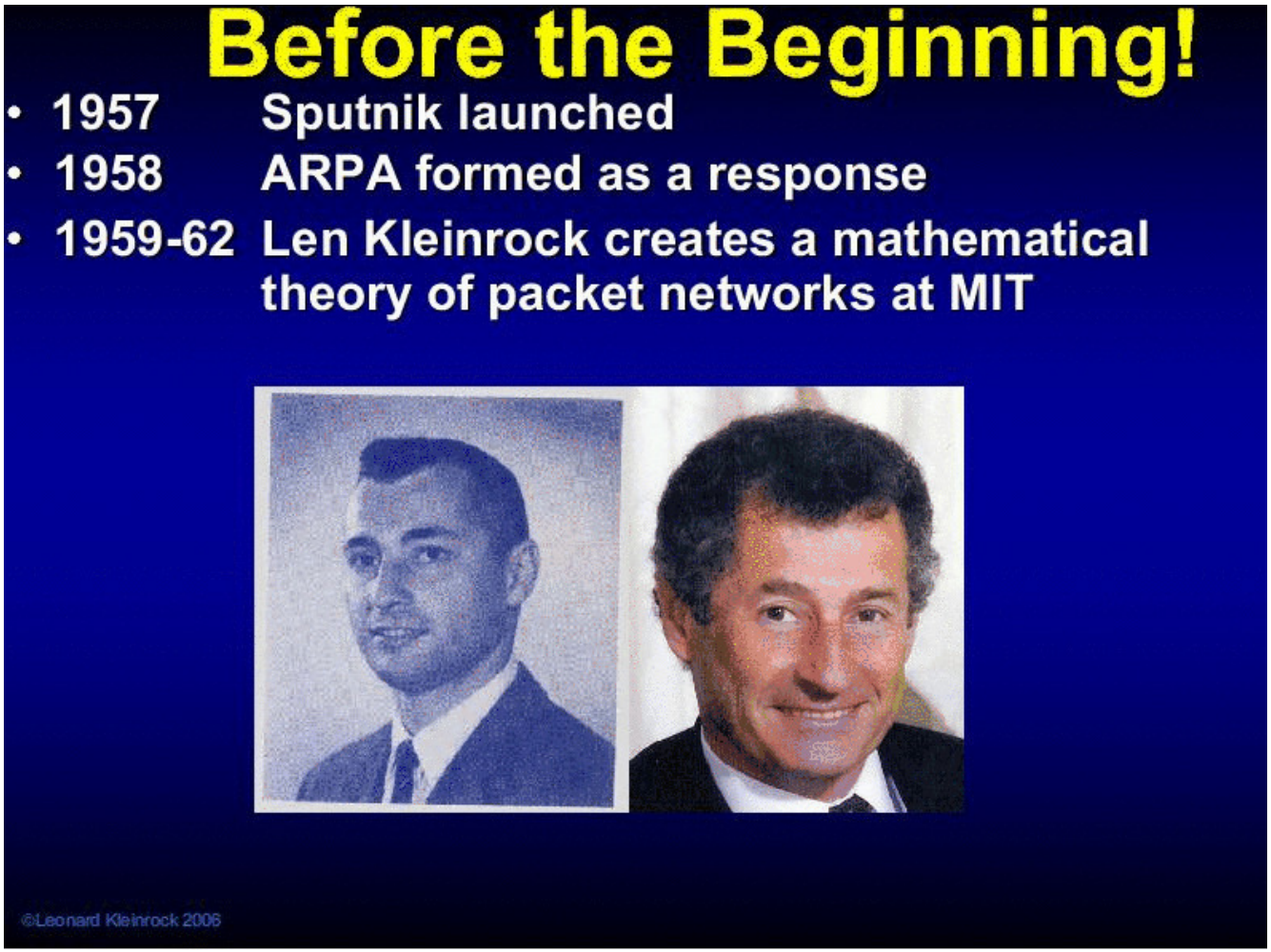




Histórico

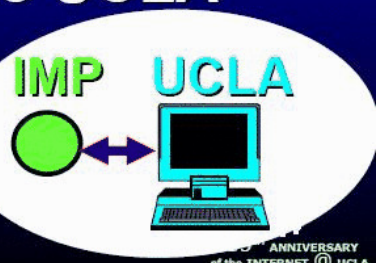
- Leonard Kleinrock descreve os princípios da tecnologia de comutação por pacotes
- University of California, Los Angeles (UCLA) ganha a proposta para implementar a primeira rede de comutação por pacotes junto com a BBN.

Histórico
UCLA



Histórico
UCLA

- 1968 UCLA selected to be the first node and serve as Network Msmnt Center
- 1969 (Jan-Aug) BBN & UCLA are Busy!
- 1969 UCLA puts out Press Release
- 1969 8/29 BBN sends first switch to UCLA
- 1969 9/2 First data moves from UCLA Host to UCLA switch



ANNIVERSARY of the INTERNET @ UCLA

Histórico
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- Qual foi a primeira mensagem enviada na Internet?
- LO
- Por que?

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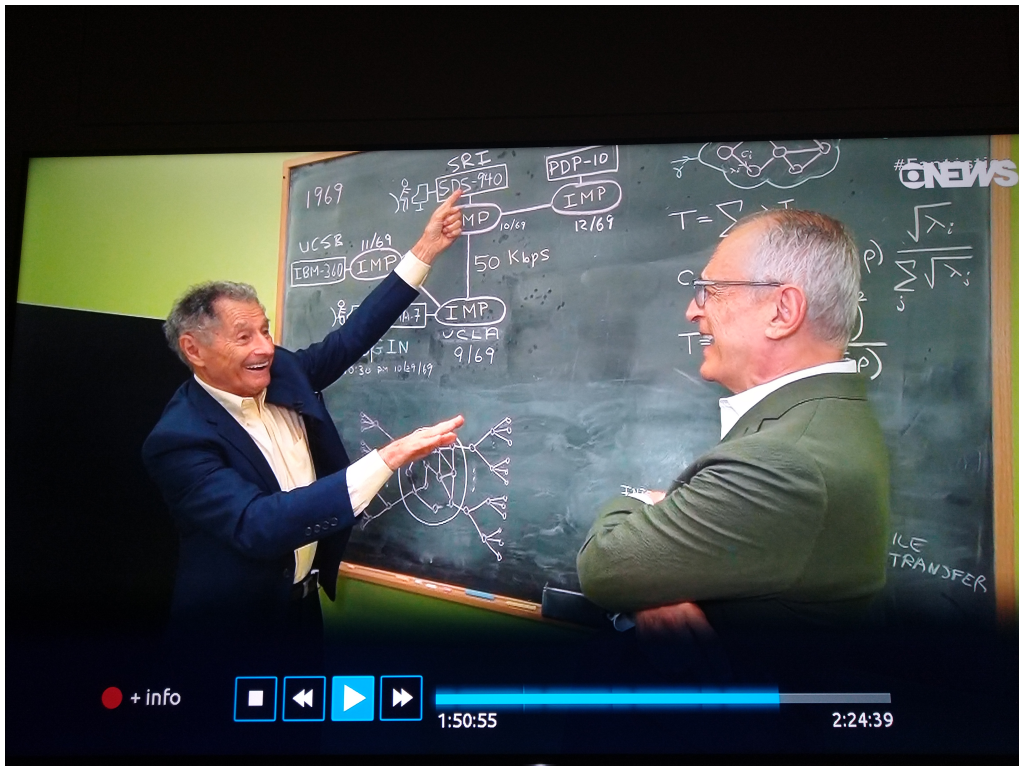

A Ciência por trás da Internet

- Compartilhamento eficiente de recursos
- Comutação por pacotes
  - o que é Comutação por pacotes?
- Informação é dividida em pequenos pacotes?
- Pacotes enviados independentemente
- Por que é eficiente?
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Resource Sharing

- What are the problems?
- Are the solutions proposed efficient?
- One abstraction: a queue
- The Internet used basic queueing theory since its inception

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Resource Sharing
Queues

- Queues are everywhere
- Why queues naturally arise?
- Contention for resources
  - communication line
  - disks
  - CPU
  - ⋮

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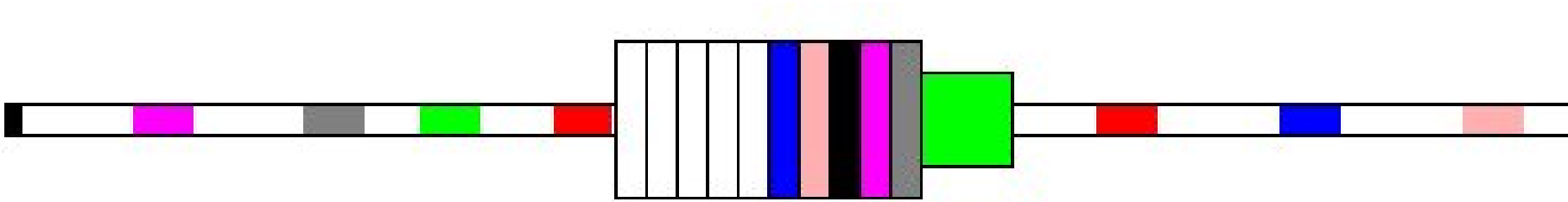
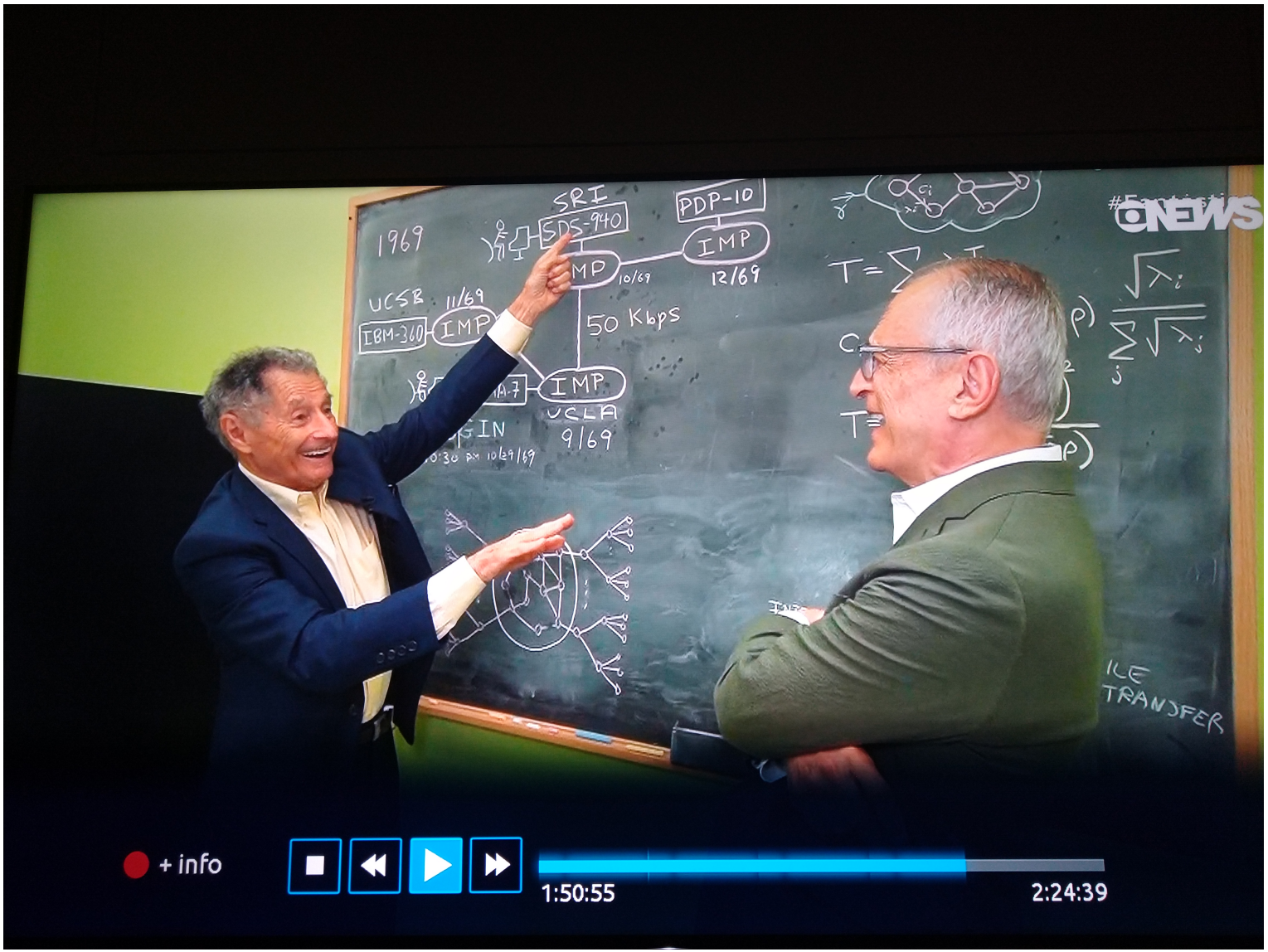
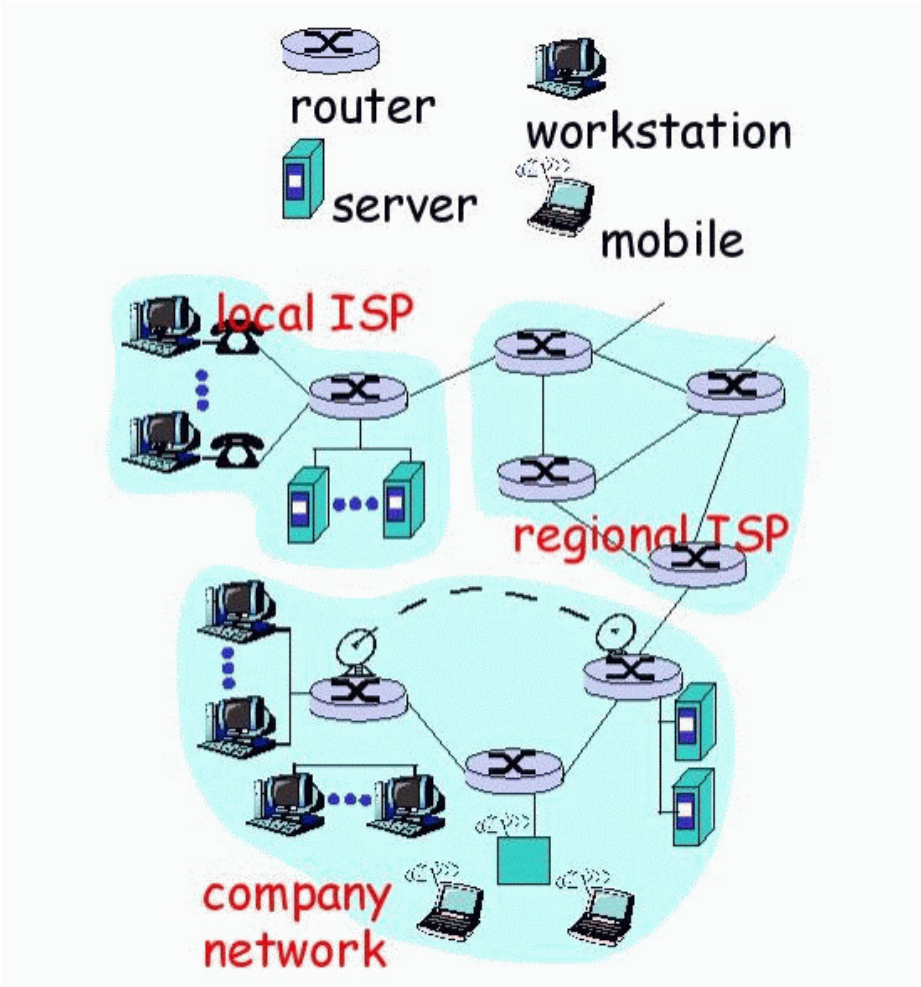


Na UCLA


1969
SRI
SDS-940
PDP-10
IMP
10/69
12/69
UCSB
11/69
IBM-360
IMP
50 Kbps
IMP
UCLA
9/69
+ info
1:50:55
2:24:39

A Ciência por trás da Internet

redes



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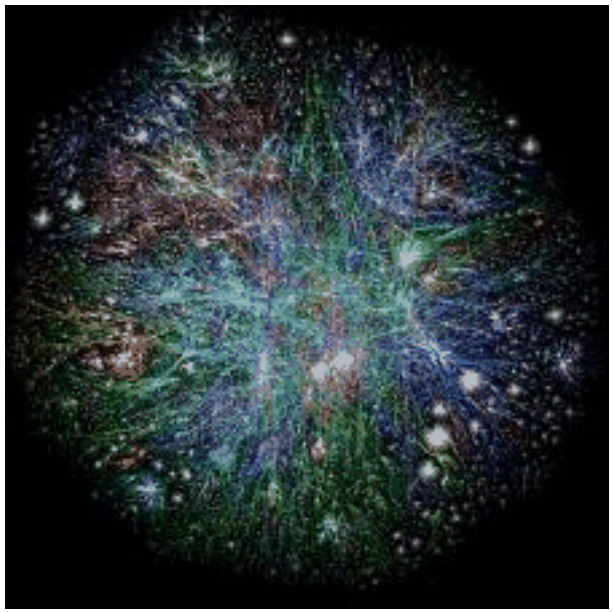

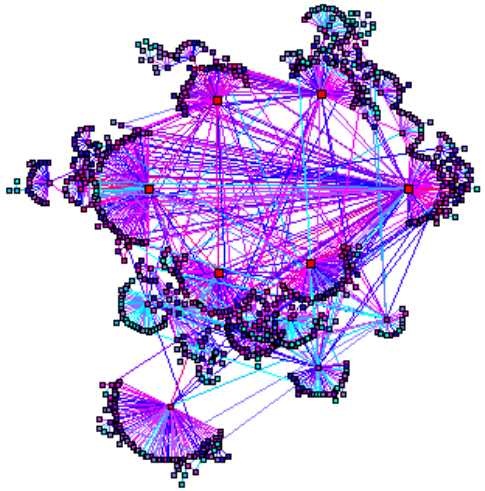

- A Internet e a Web: muitos problemas reais interessantes

Wireless: distributed queue

- How to share the wireless channel among users?
  - User can send data at any time.
  - Users do not know when other users want the channel. Therefore, we cannot form a simple queue of requests.
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- A simple proposal?

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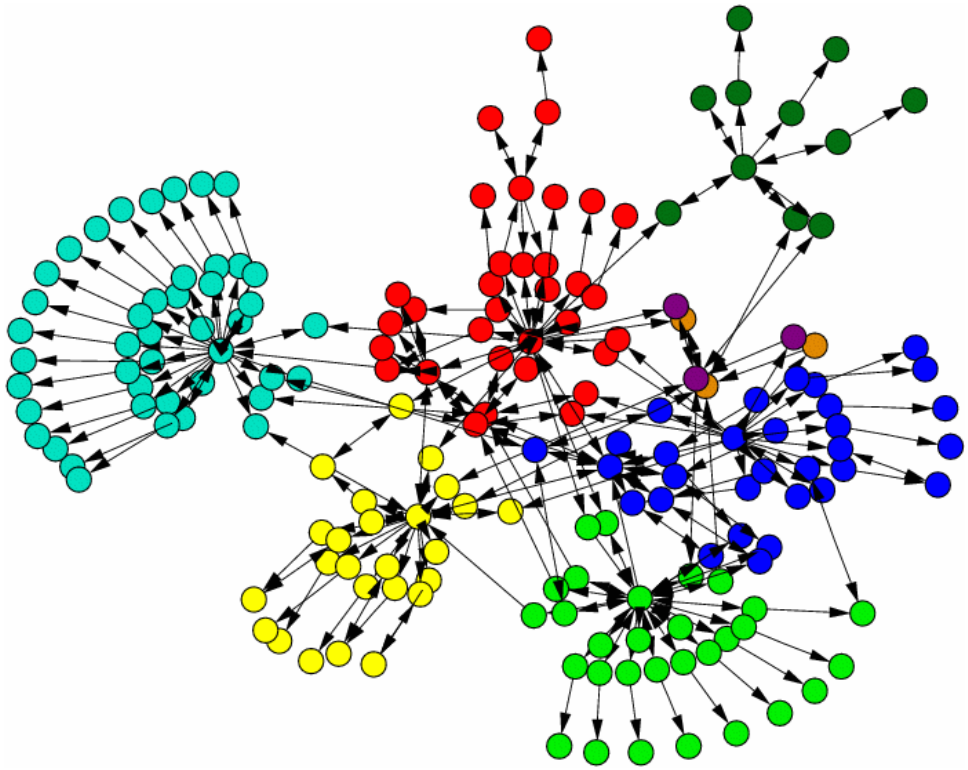
- Data: connections between webpages
- Question: which webpage to suggest to a web user?



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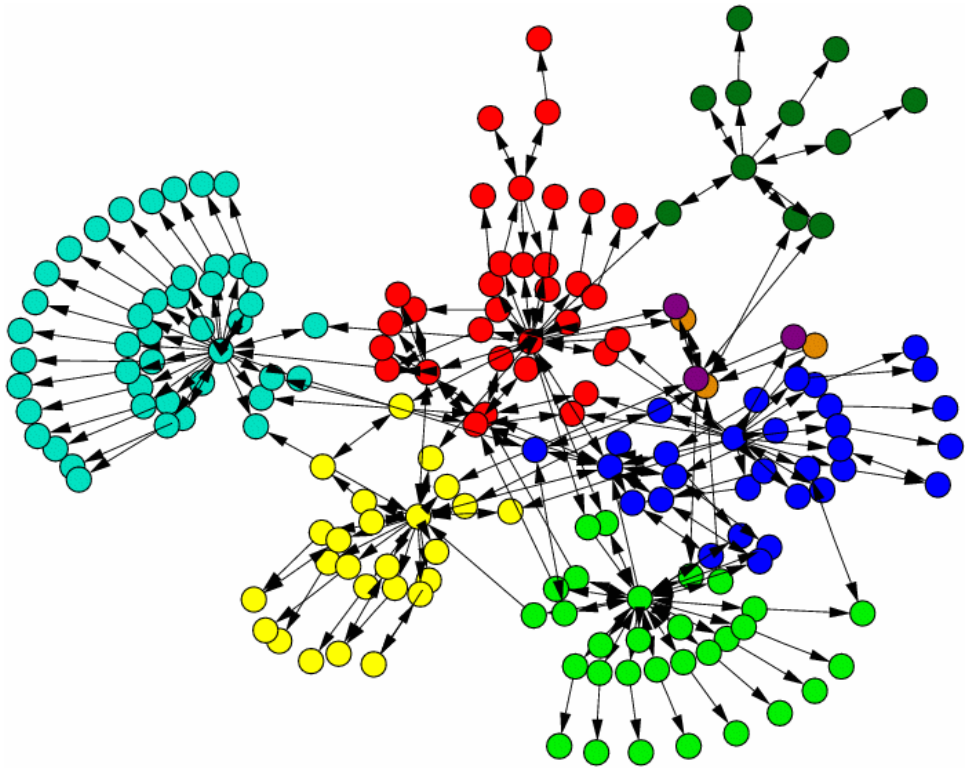
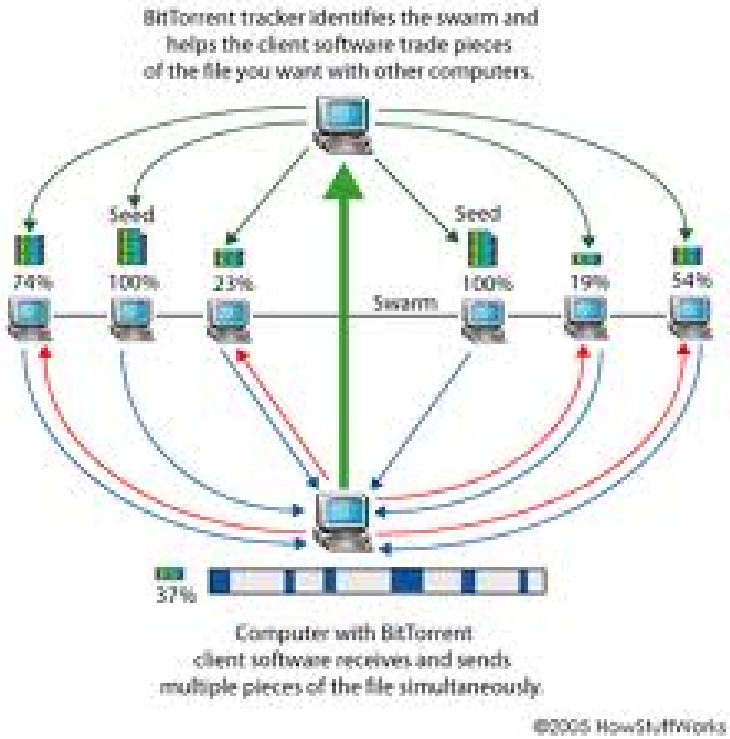


P2P



- Scalability issues
- Design more robust systems

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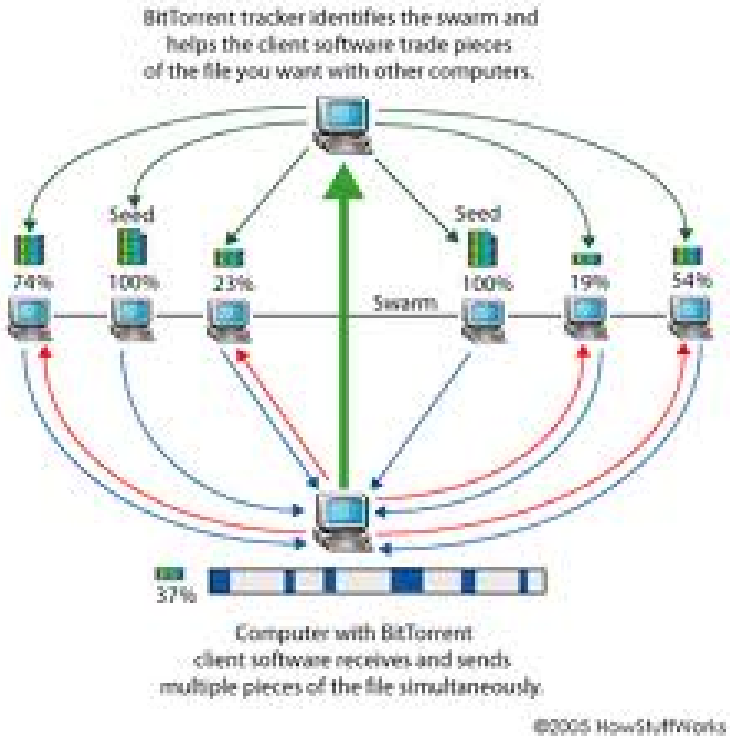

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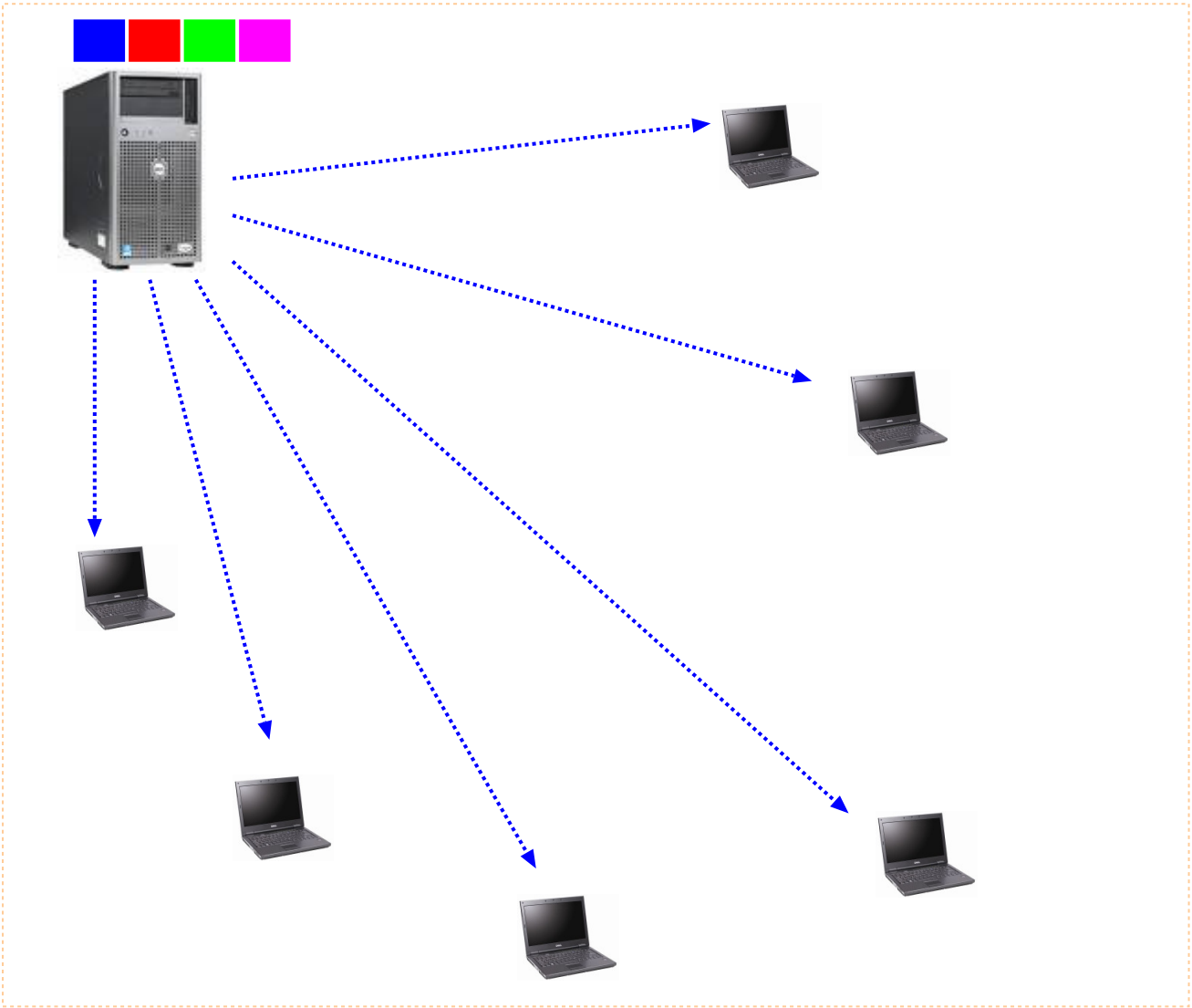

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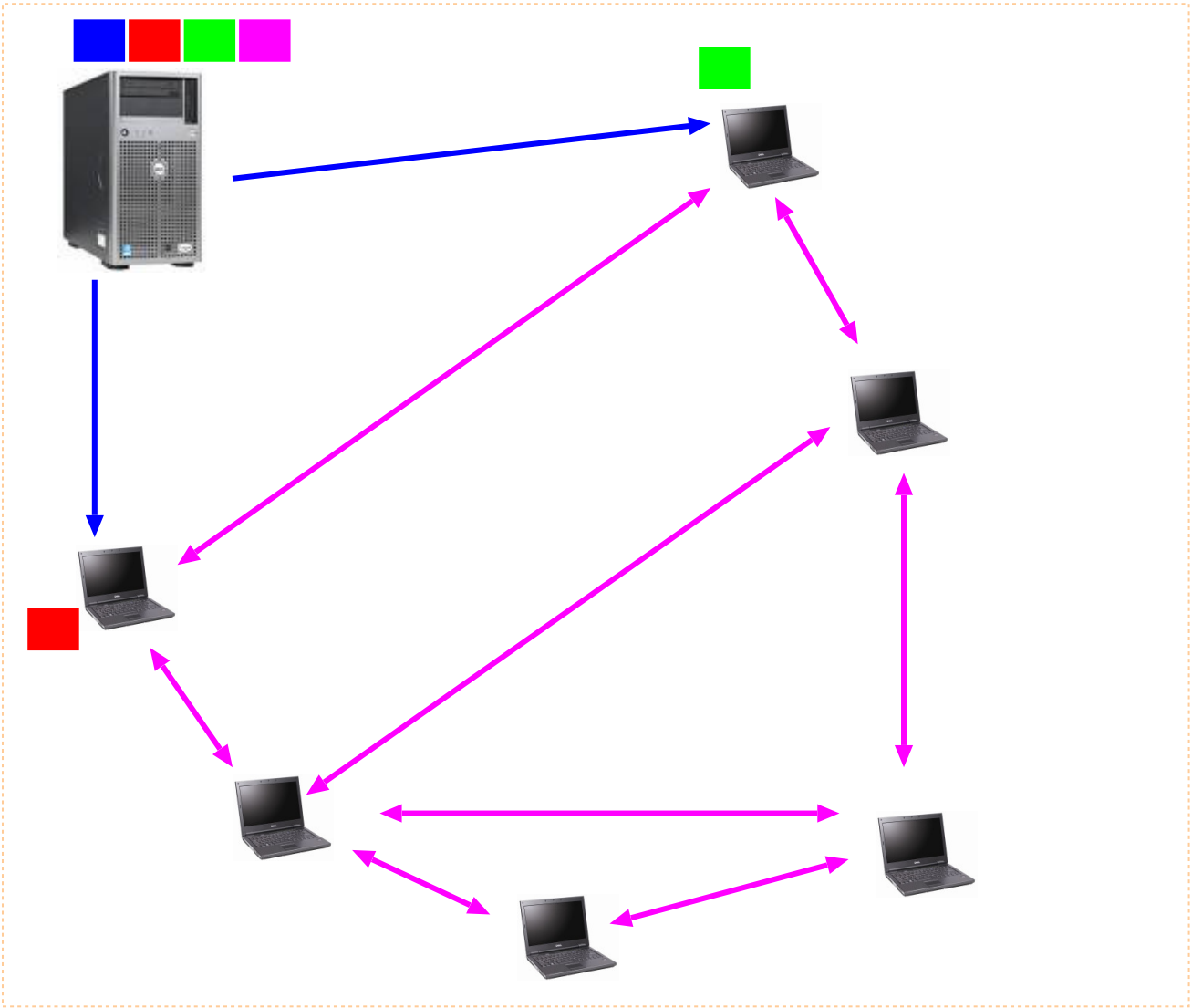

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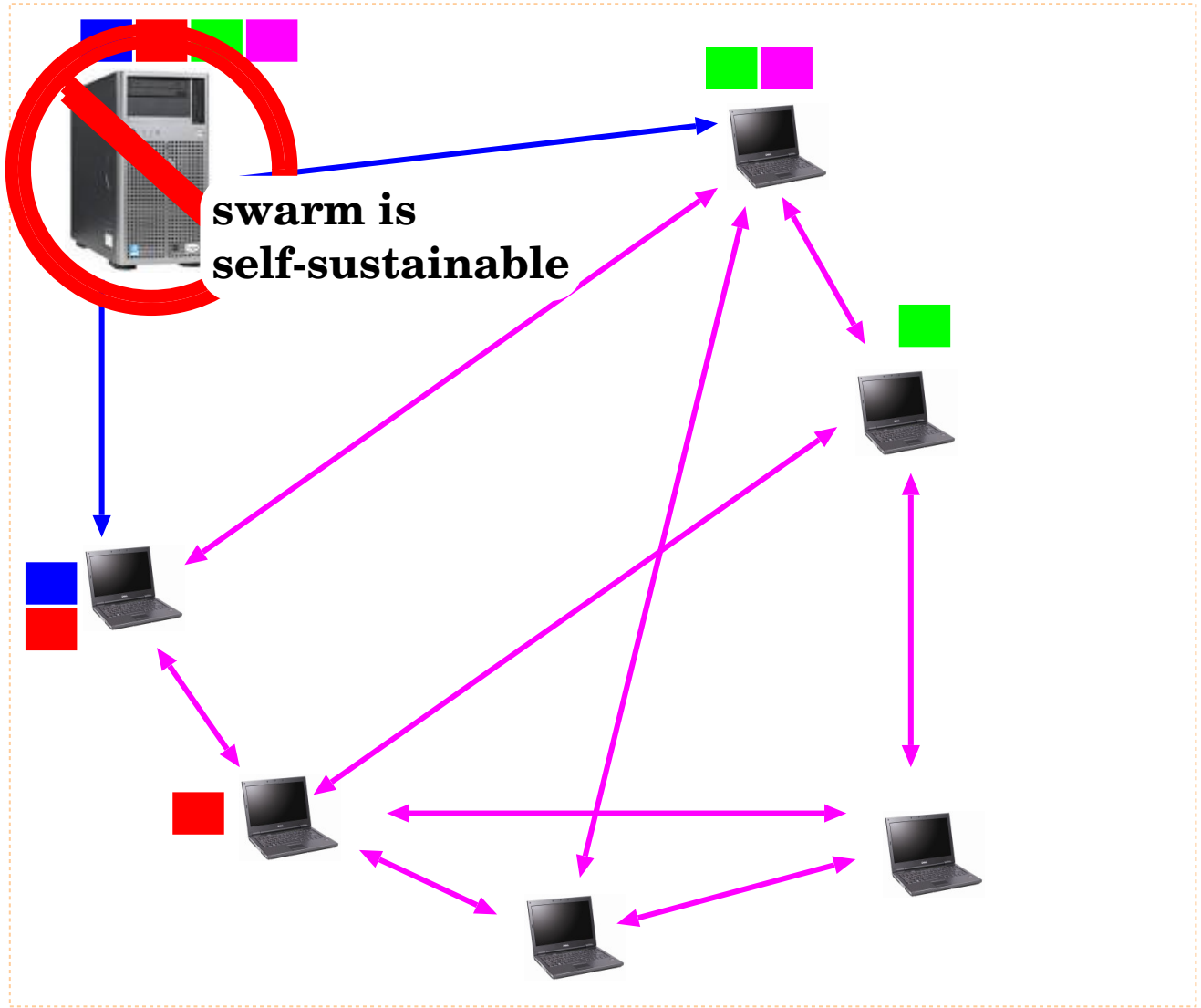

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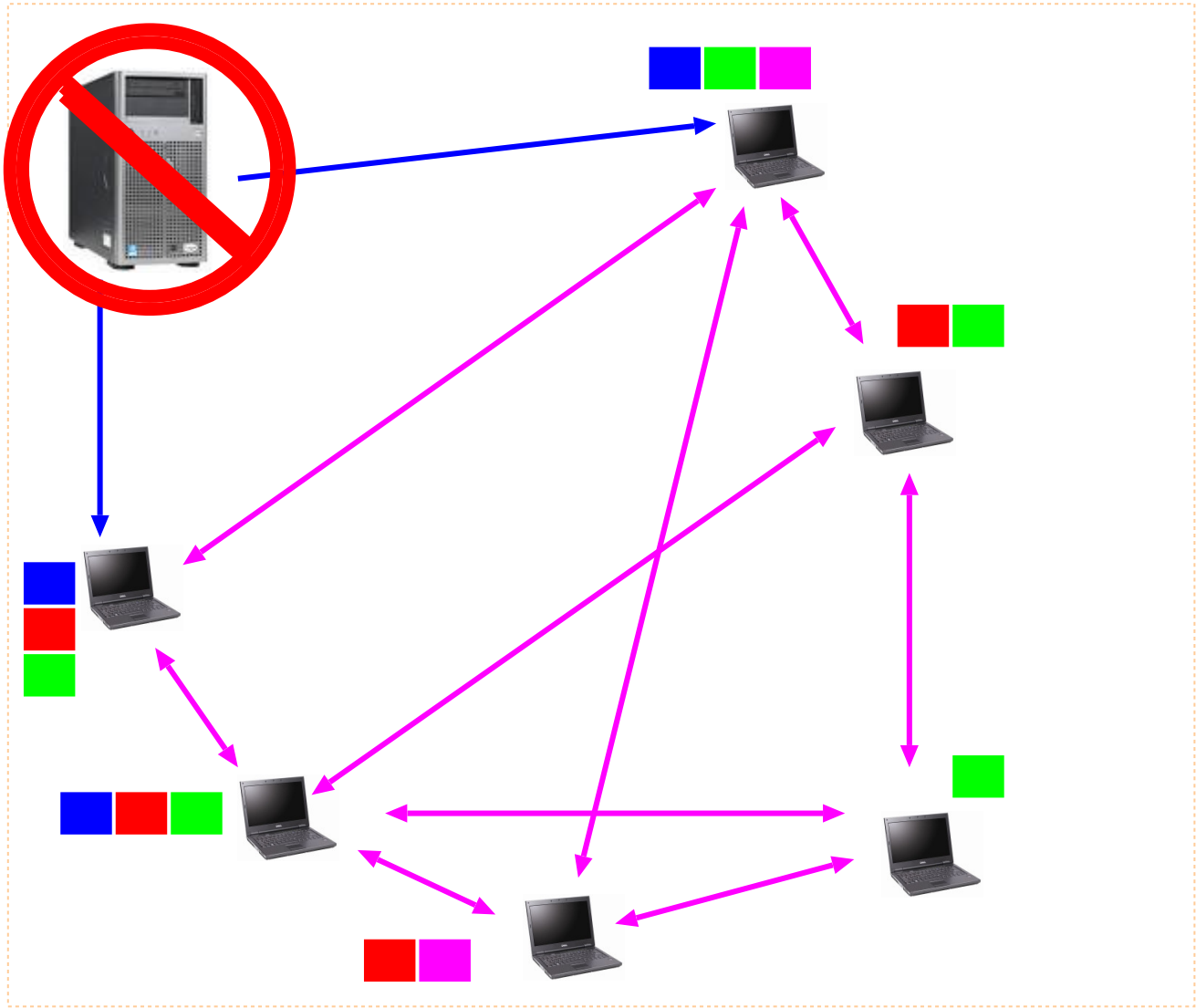

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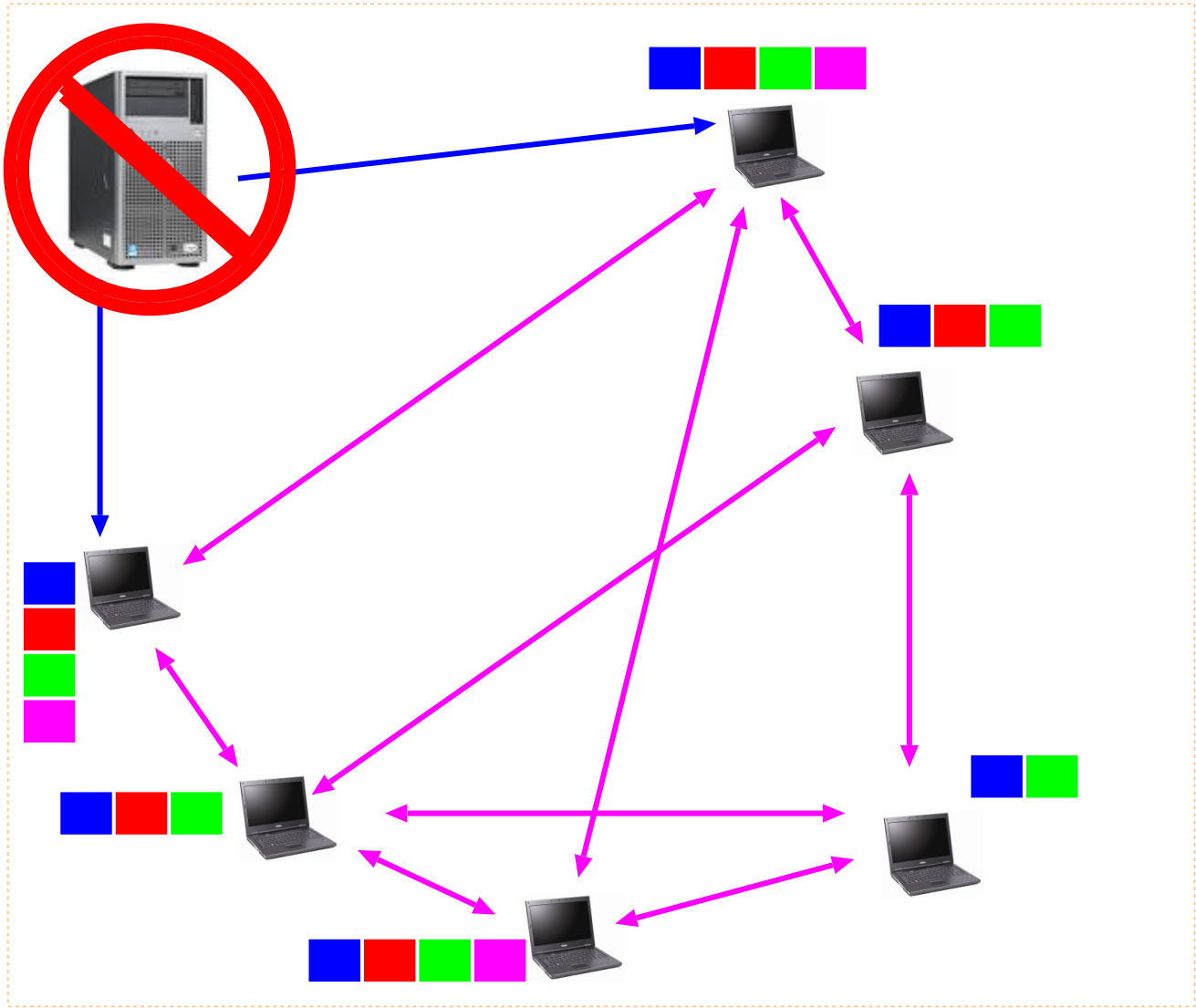

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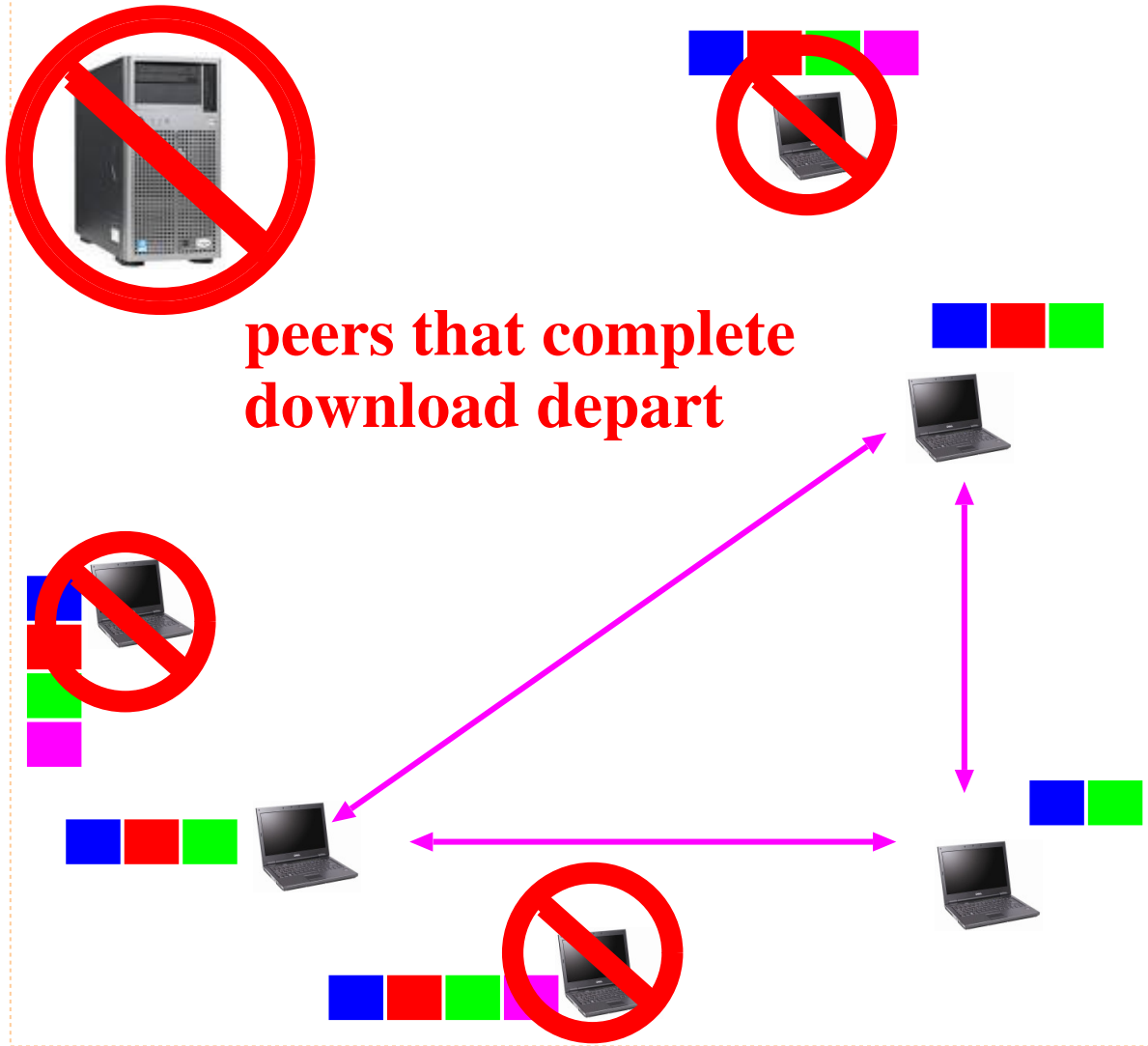

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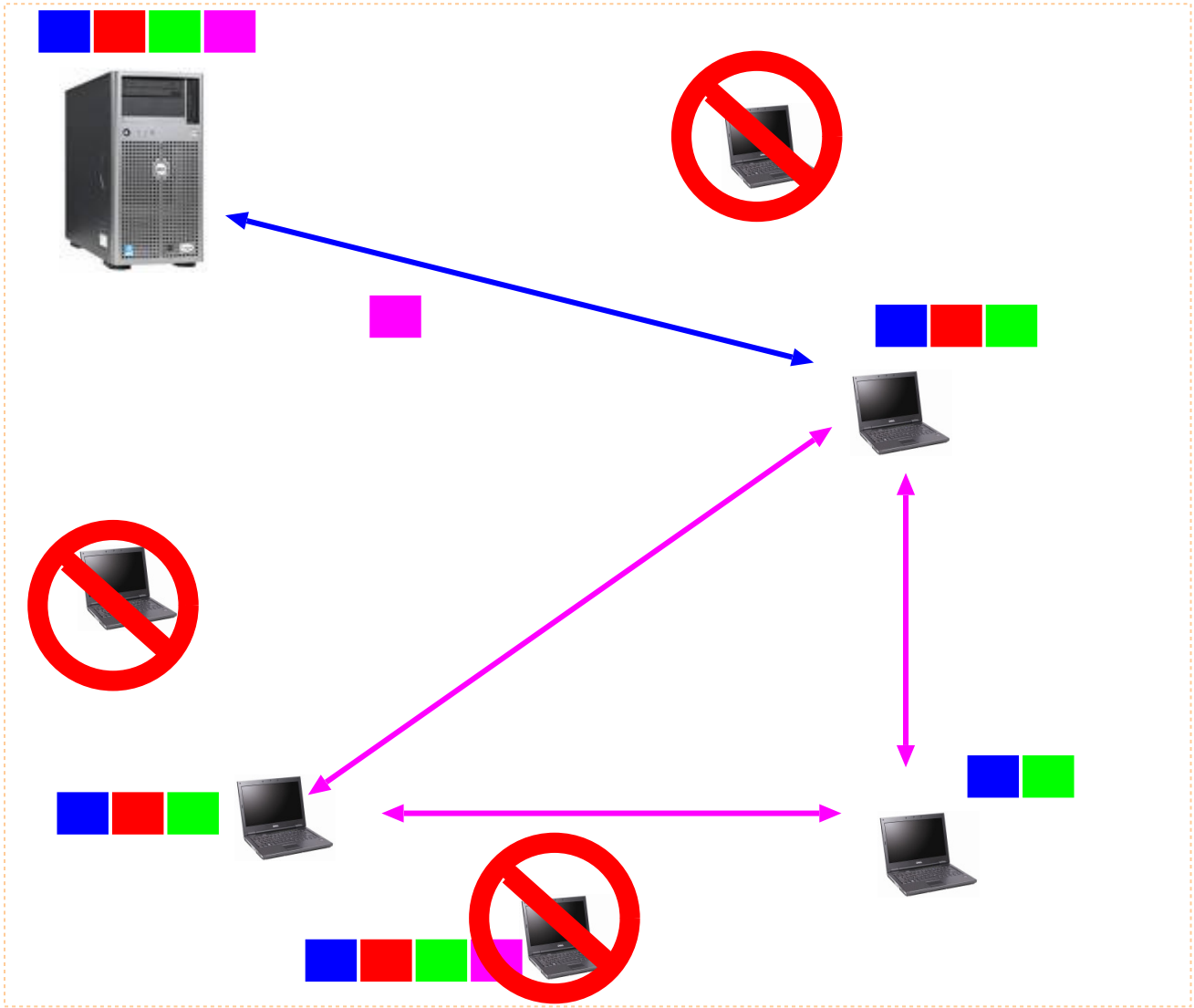
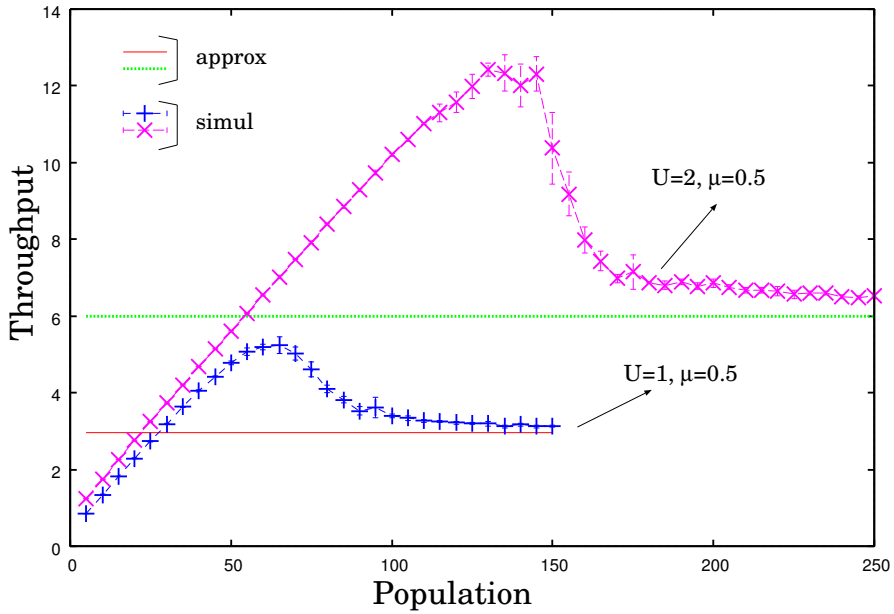


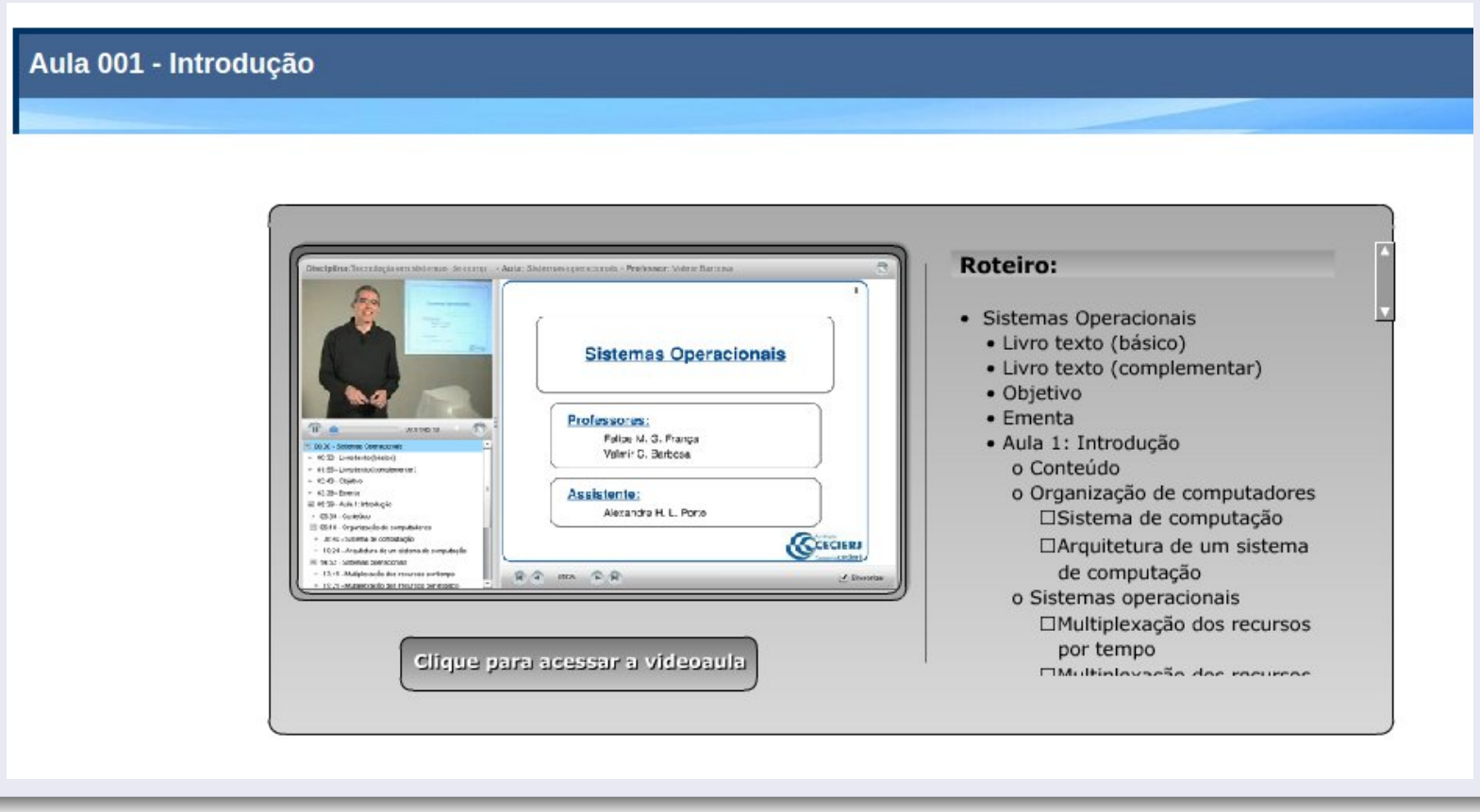
P2P
Scalability

- Does the solution scales with number of users? Are there fundamental limitations?



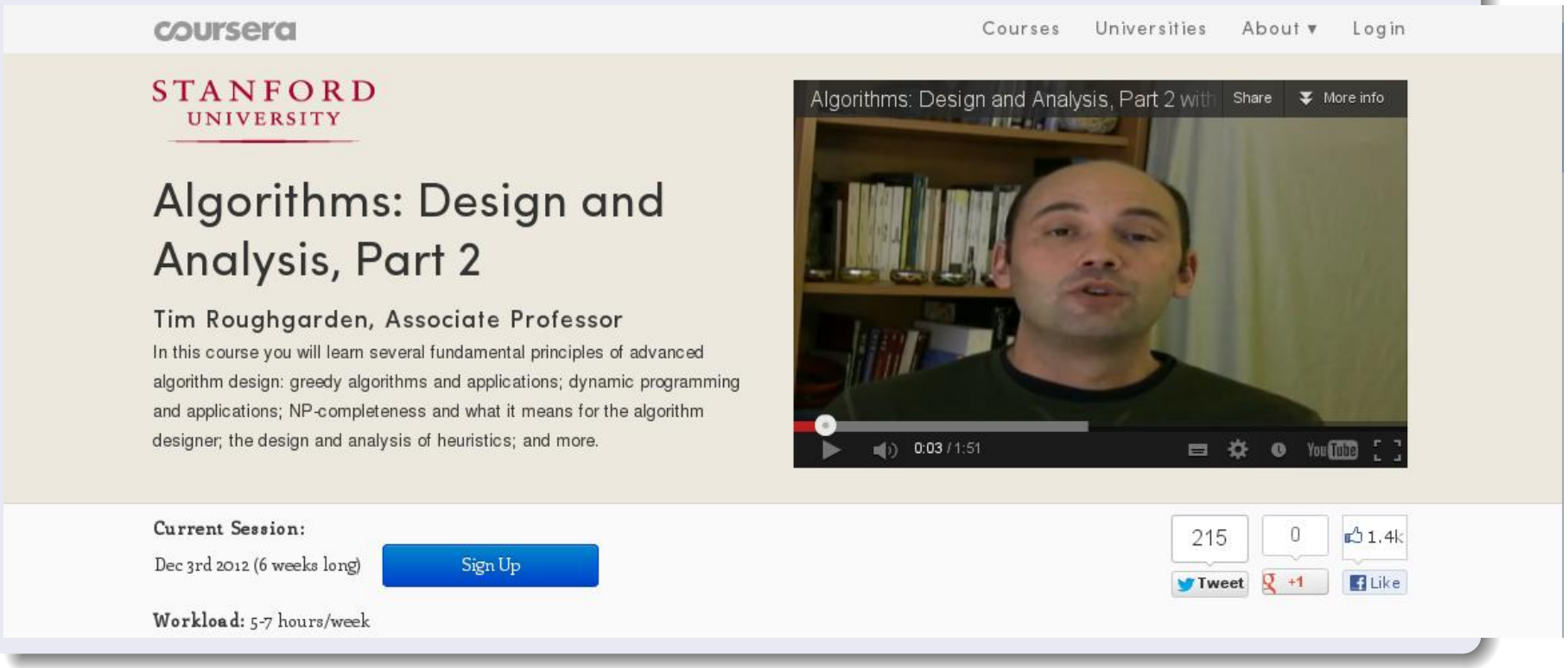
Videoaulas
Exemplos

CEDERJ



Videoaulas
Exemplos

COURSERA - Exemplo de videoaula no exterior



Videoaulas
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site: Videoaula@RNP

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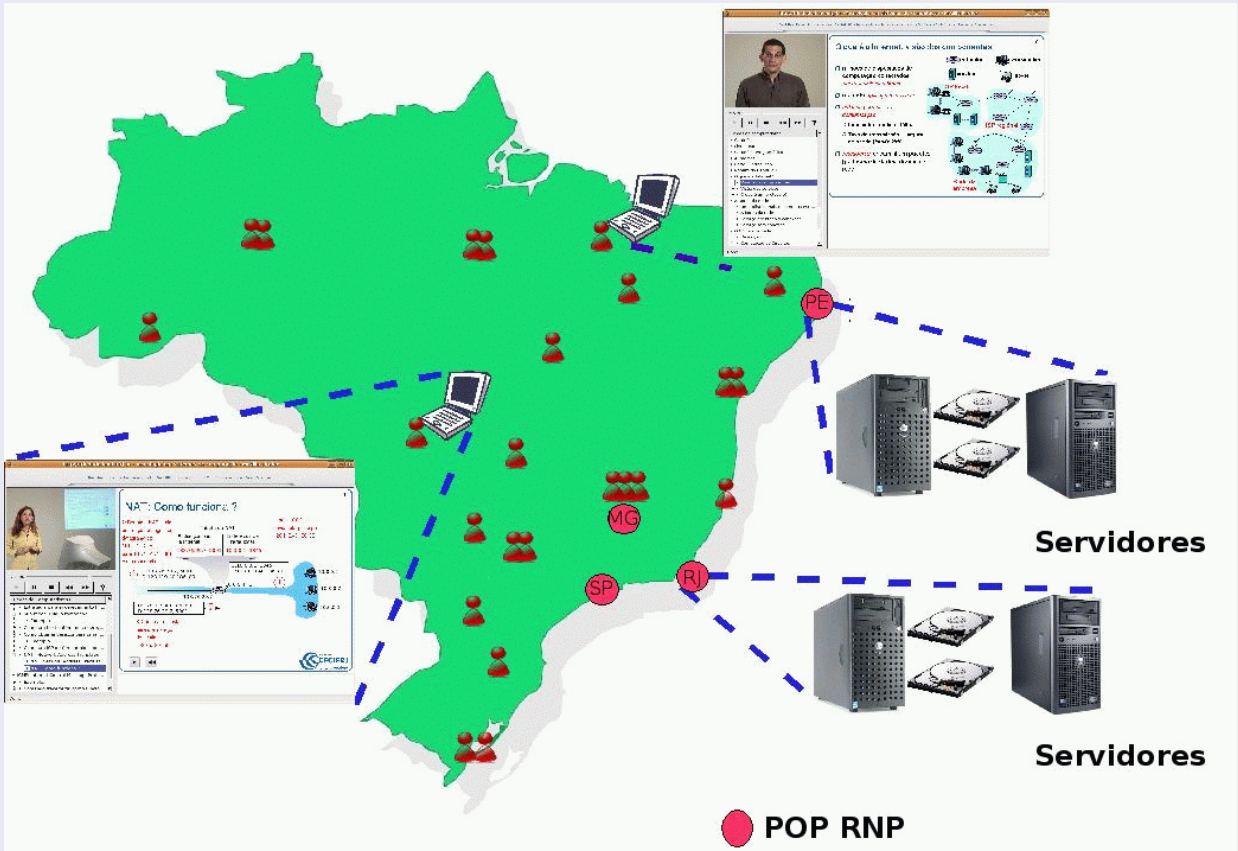
RNP-CEDERJ



A Few Topics

Wireless networks, Cellular networks including 5G and beyond, Vehicular networks, Dynamic spectrum sharing, Interference management and mitigation, MIMO-based networking, Mobile sensing and applications, Mobility management and models, Innovative Internet architectures, Internet of Things and Cyber-physical systems, Software-defined Networking and Radio, Optical networks, Overlay and peer-to-peer networks, Energy efficiency in networks, Machine Learning and AI for networks, Datacenter networking, Localization and location-based services, Multimedia networking, Network management, Network measurement and analysis, Network security and privacy . . .

Futuro

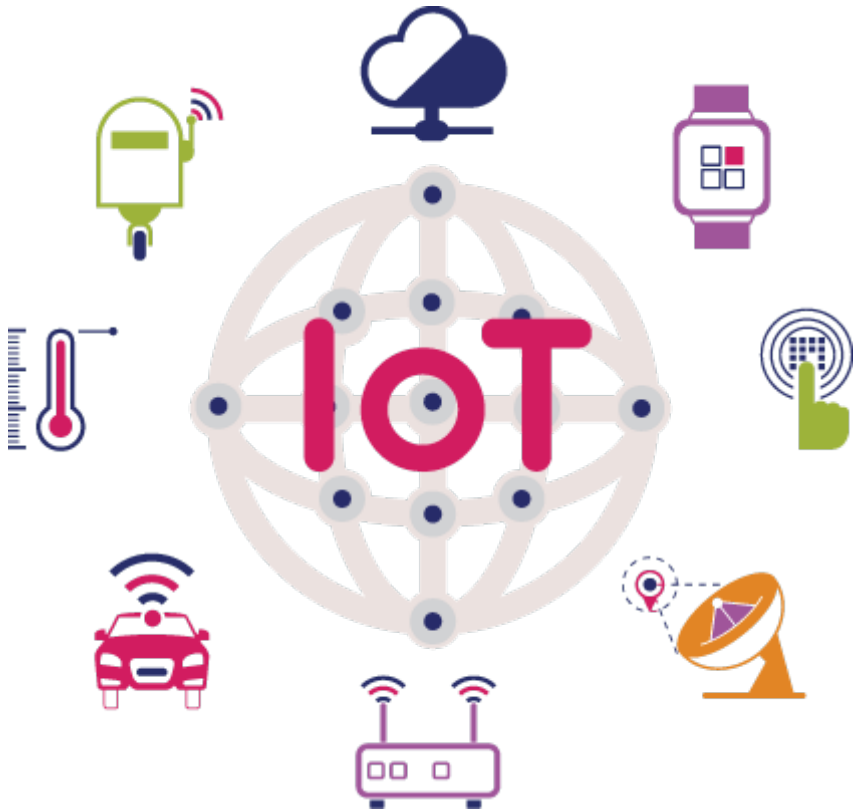
O Futuro (???)

IoE

The Internet of Everything

"the intelligent connection of people, process, data and things."

Internet of Things
xxx

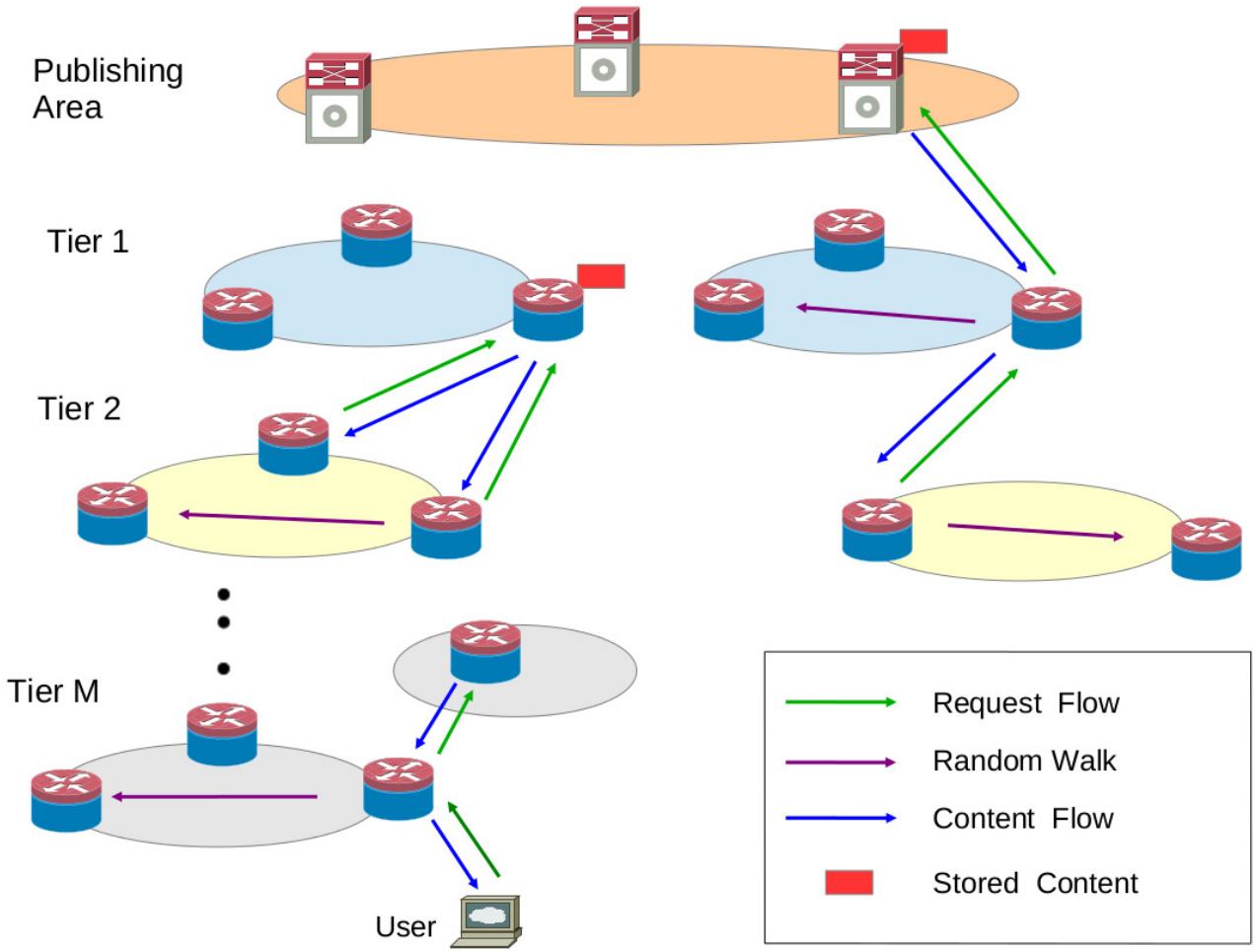


Vehicular Networks

Information Centric Networks

- Addresses scalability challenges for content dissemination
- ICNs: focus is on content, rather than on hosts
- Issues: Cache-network architecture, etc

Information Centric Networks



Internet Quântica

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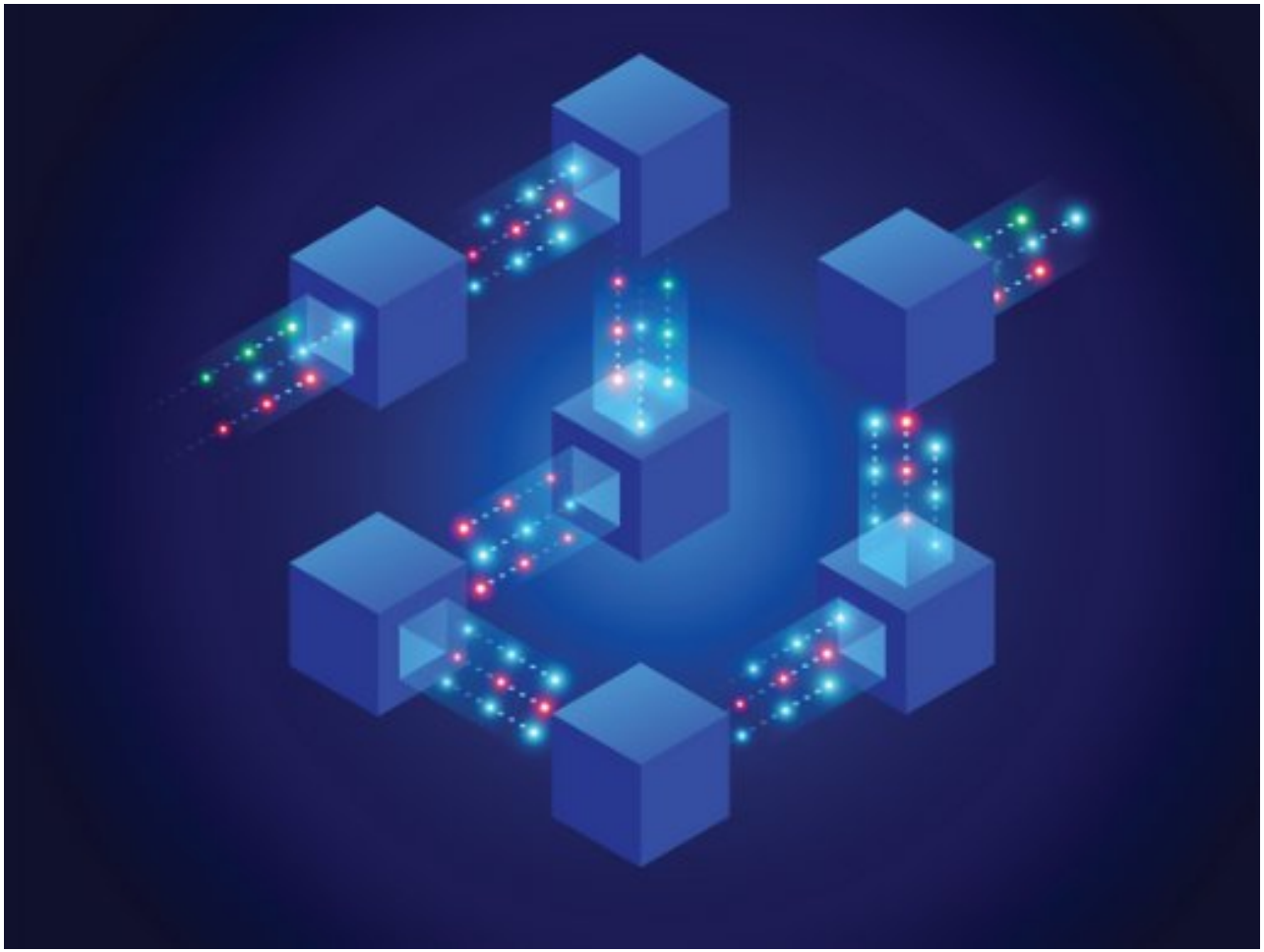

Internet Quântica

- quantum memories to store qubits
- generate link Bell states (entanglements)
- transfer quantum states directly between nodes
- propagate entanglements
  - destructive Bell state measurement

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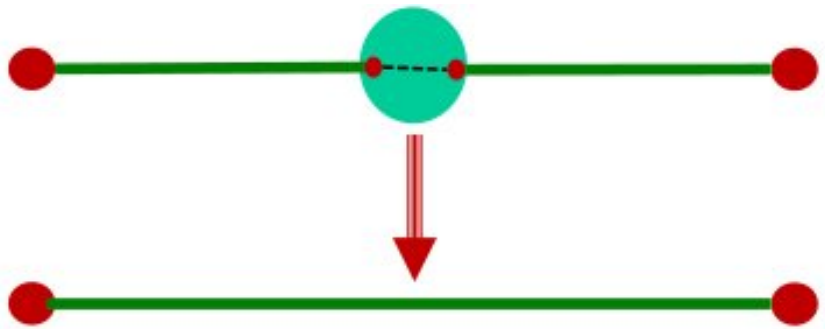

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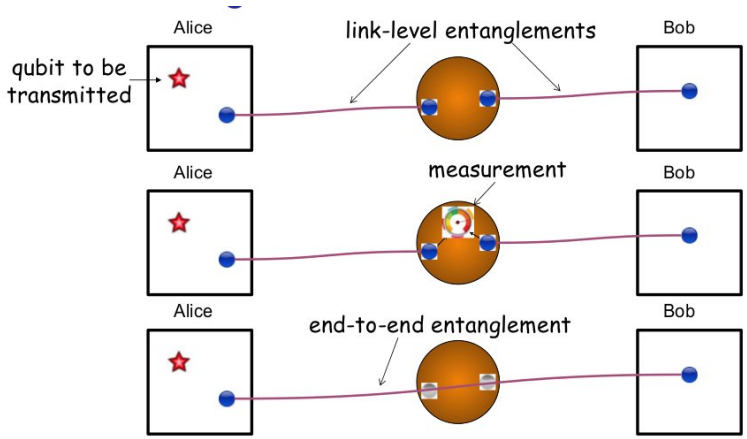

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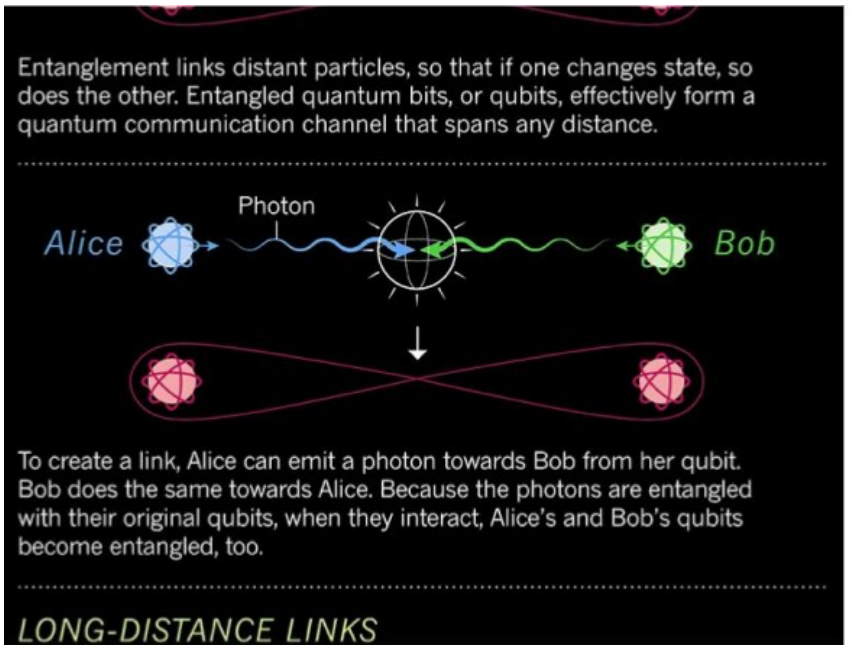

Some Projects of our Group

Current Projects of our Group

Motivation

- Measurement, modeling and analysis have been essential areas of research since the dawn of the Internet.
- UCLA was the ARPANET Network Measurement Center.

Motivation

H. James Harrington: former IBM, CEO Harrington Management Systems, author, etc

Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it.

Objective

- Focus: lightweight measurements performed at home gateway routers.
- . . . and data analysis.
- Home routers are conduit to home devices → ideal place to implement measurement functionalities.
- Project: collaboration among Brazil and the USA (UFRJ and UMass), Gigalink and Anlix incubated at UFRJ for data gathering and analysis.

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Three issues:

Issue 1: Automatically detect problems in the network.

Issue 2: Assess quality of experience (QoE) of residential users.

Issue 3: Analyze traffic: try to find traffic profiles.

Issue 4: investigate DDoS detection at the network edge.

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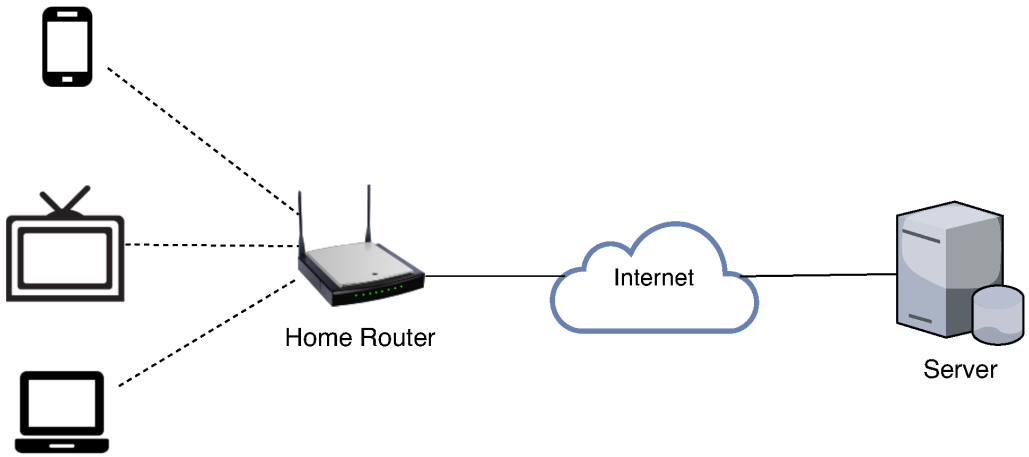
Measurement Infrastructure

Measurement Infrastructure

- Partnership University + ISP + startup at COPPE/UFRJ
- Data collection campaign at the network edge
- Almost 4,000 homes collecting data (and growing)



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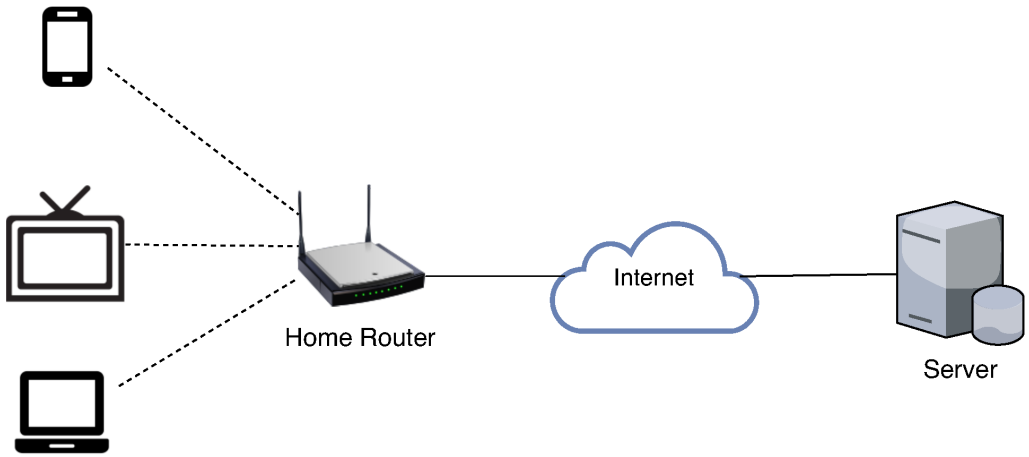

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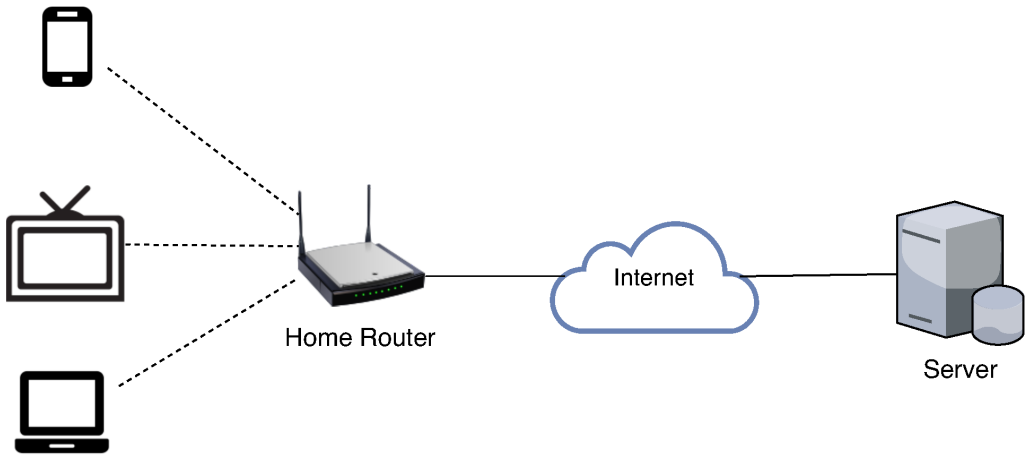
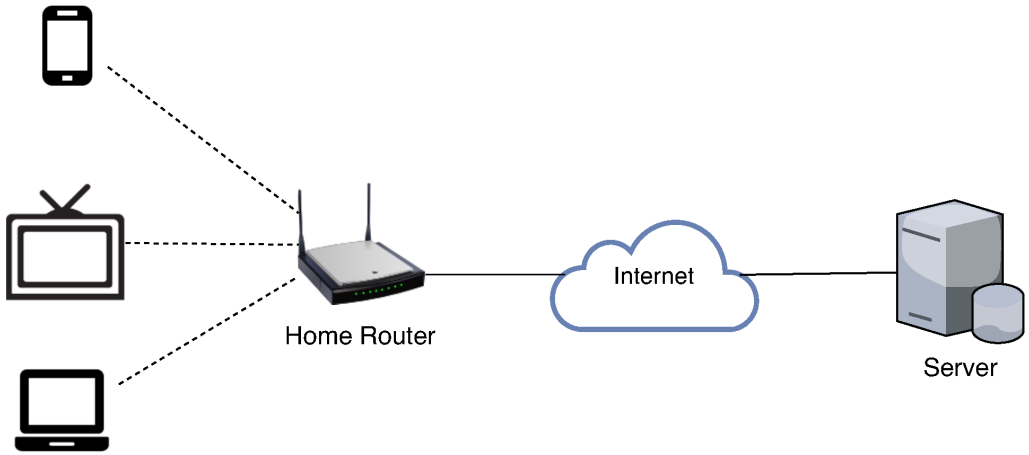


Measurement Infrastructure
Data

- Traffic (byte counts and packet count): download/upload
- loss rate, latency
- processor load, etc.
- WiFi: transmission rate, SNR, etc.
- measurement intervals: 1 minute: Large number of time series



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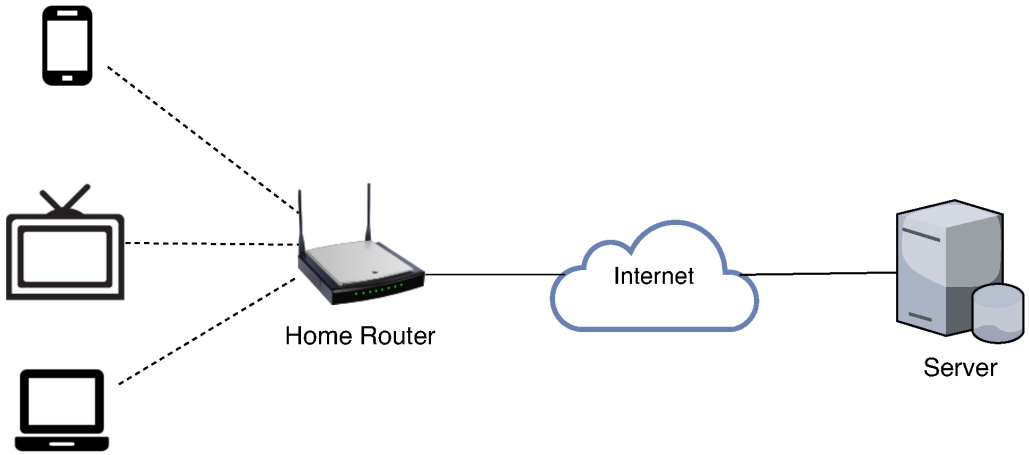

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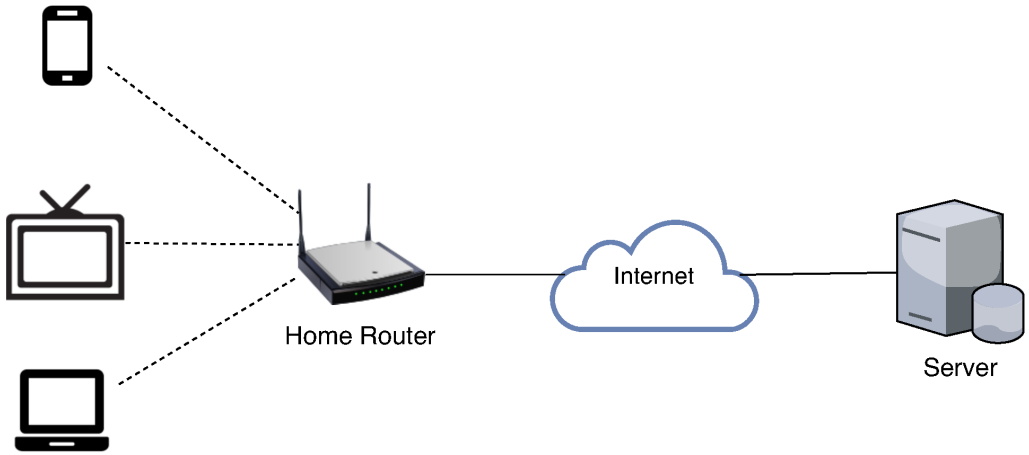

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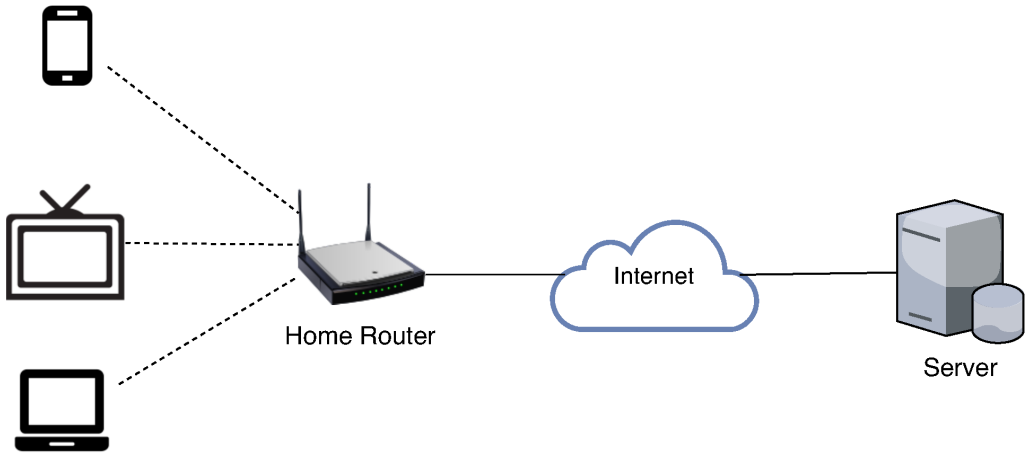

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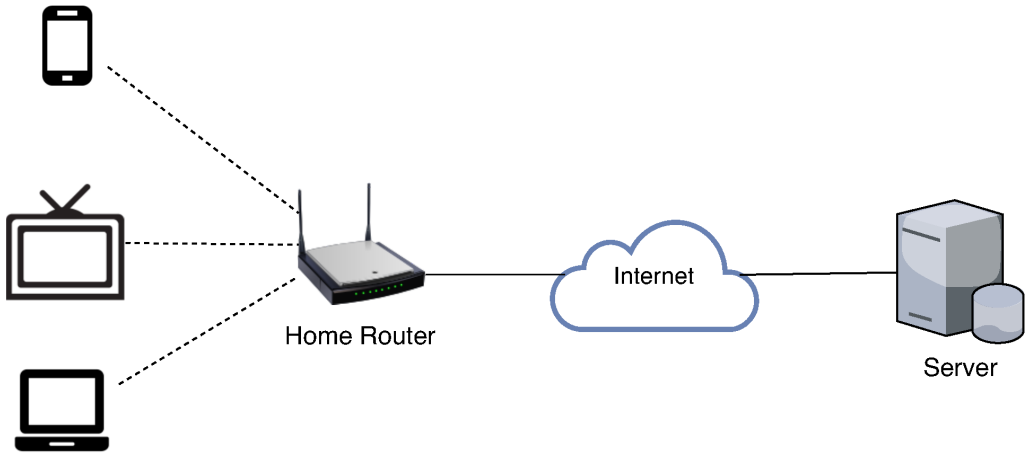
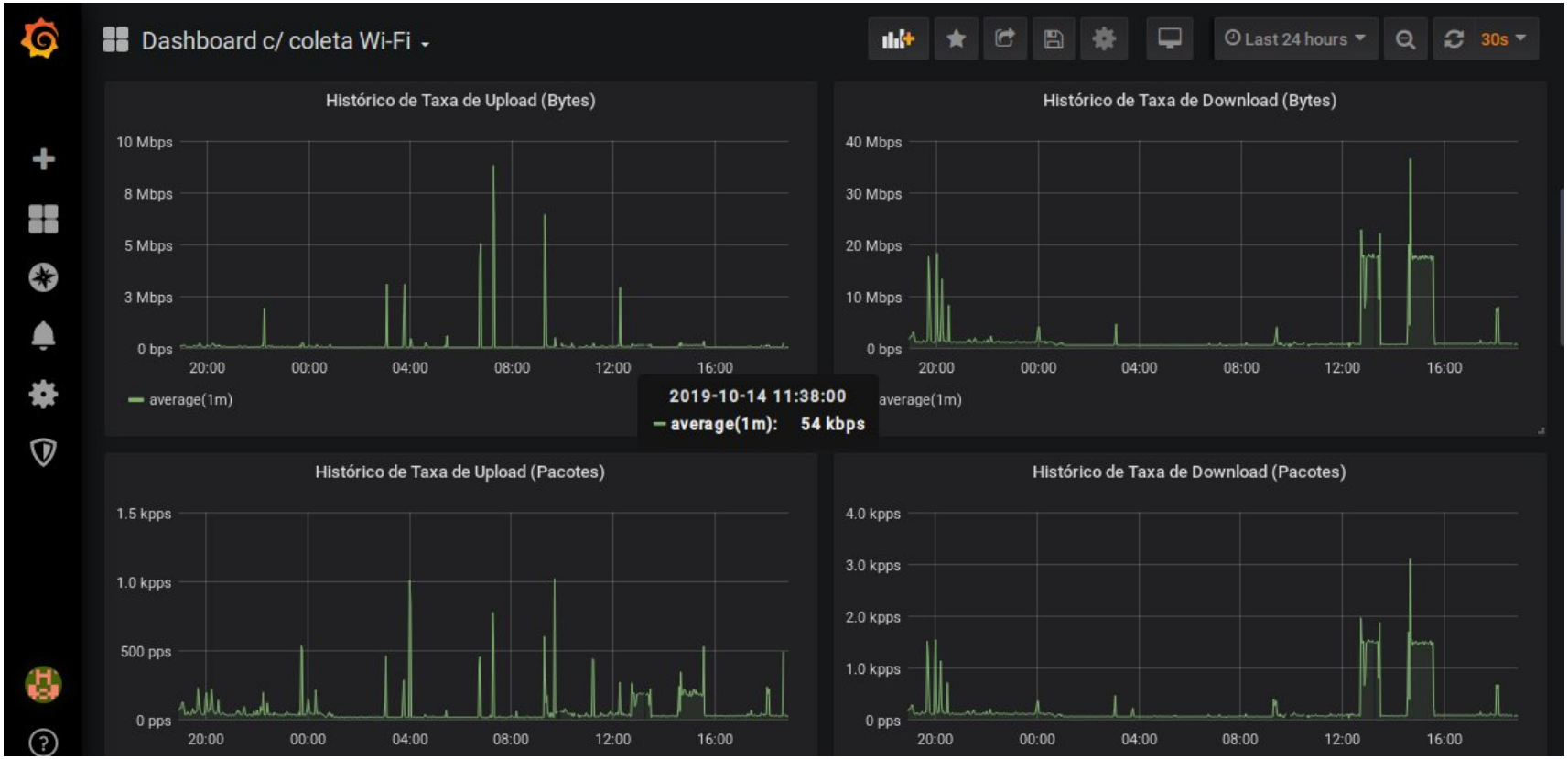
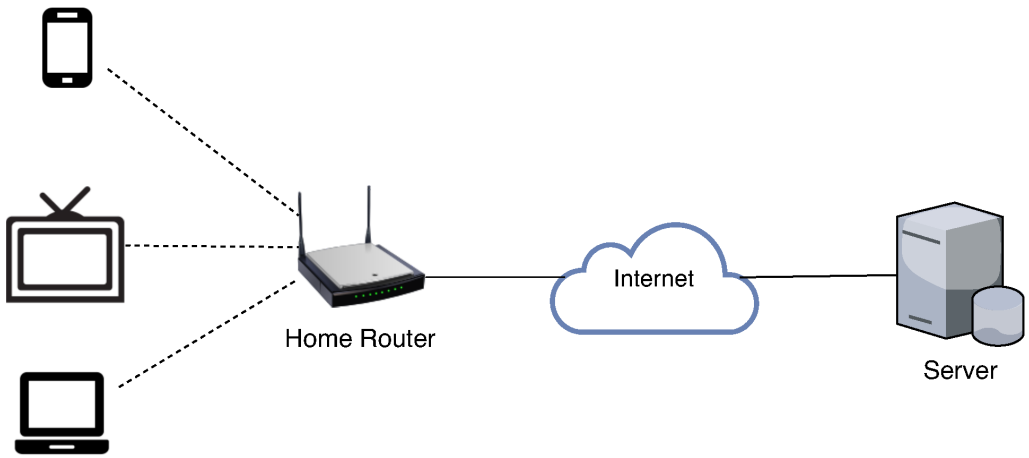


Example: data collection infrastructure



Goals

- Perform extensive data analysis: Machine Learning techniques
- Apply unsupervised learning techniques of spatial/temporal patterns to identify anomalous behavior.
- Identify changes (traffic, etc.) and automatically infer possible causes of these changes.
- New perspectives to understanding behavior of domestic networks



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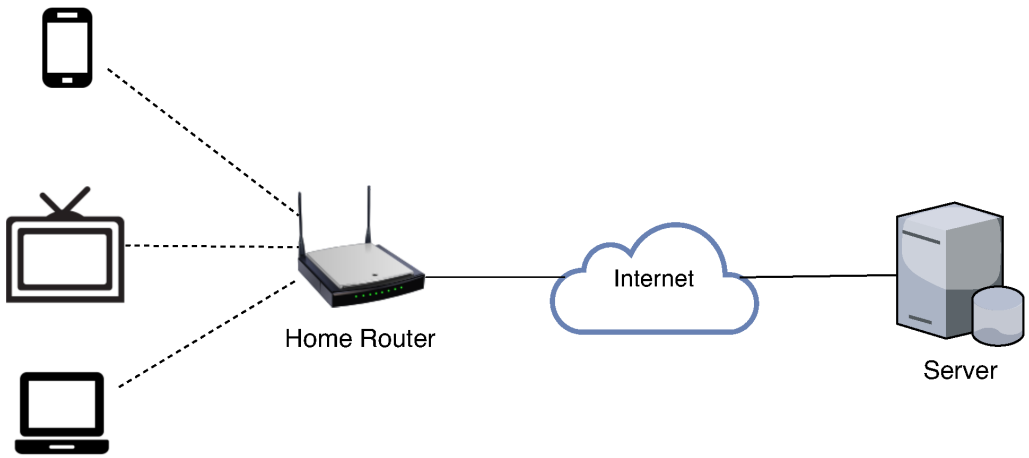

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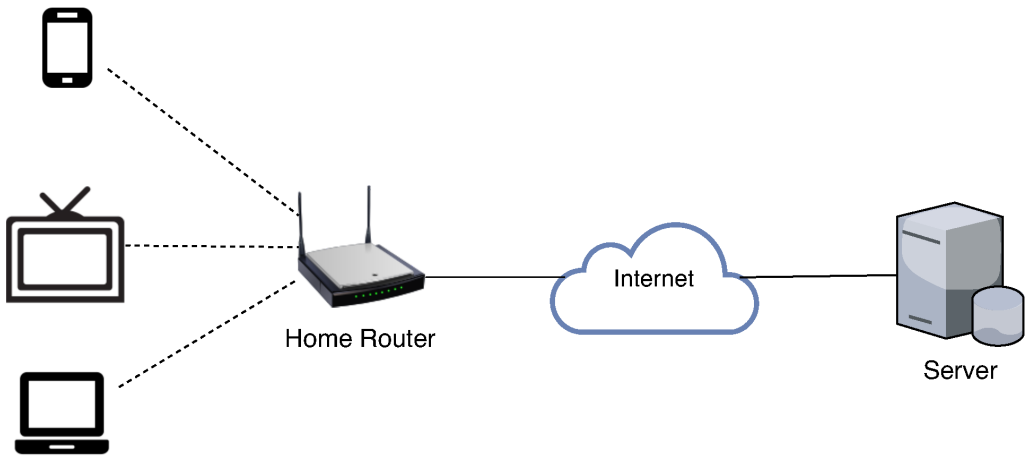

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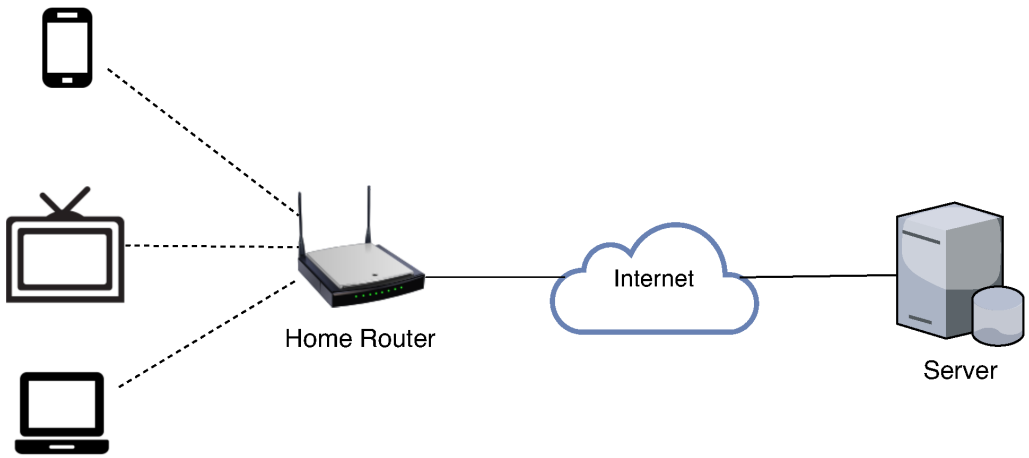

A lightweight approach for DDoS detection at home gateways

Objective

- DDoS attacks are prevalent!
  more than 1/3 of class C active networks were targeted by this kind of attacks (2015 and 2017)
- Continuing report updates (2018/2019):
  "*. . . despite the law enforcement efforts, DDoS attacks remain a real threat to business*", DDoS report May 21, 2019.
- How to detect problems and react fast?

DDoS detection

- **Simplicity:** Methodology – simple enough to scale;
- **Locality:** Detection of problems close to the source;
- **Efficiency:** fast attack identification;
- **Minimalism:** collect a minimum amount of information at the home-routers.
  (avoid interfering with performance and invading users' privacy.)

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Lightweight Approach For DDoS detection

- **Question**:
  Is it feasible to detect DDoS attacks, in an extremely lightweight fashion, **without relying on information from packet headers**?
- **Methodology**
  - Machine learning techniques!

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A few Results

Example: Classification Results

Botnet	Accuracy	Precision	Recall	F1 Score
Mirai/BASHLITE	0.999688	0.997151	0.992361	0.994751

- Different types of attacks (e.g. TCP ACK flood, etc.). Real attack code.
- Considered different ML models
- Detecting DDoS attacks requires identification of subtle patterns in the baseline home-user traffic.
- Did not use packet headers

A change point detection problem

Inferring network problems and QoE from the edge

Inferring network problems from the edge

- **Objective**:
  - automatic problem identification:
    Congestion, equipment problems, attacks
  - Temporal pattern identification from data collected
- **Issues**:
  - Is the user QoE affected?
  - Can we correlate QoS metrics with technical call to ISP call center?

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Inferring network problems from the edge
Methodology

- Machine learning approaches for detecting and locating network problems.
- Construct models to detect statistical changes: Change Point Detection problem.
- Spatial-time correlations using ISP network topology.
- Locate root causes
- QoE

Inferring network problems from the edge
Dataset and model

- 2485 clients between 08/08/2018 e 23/09/2018
- Packet loss model.
- 51041 time series for training.
  25700 time series for testing.

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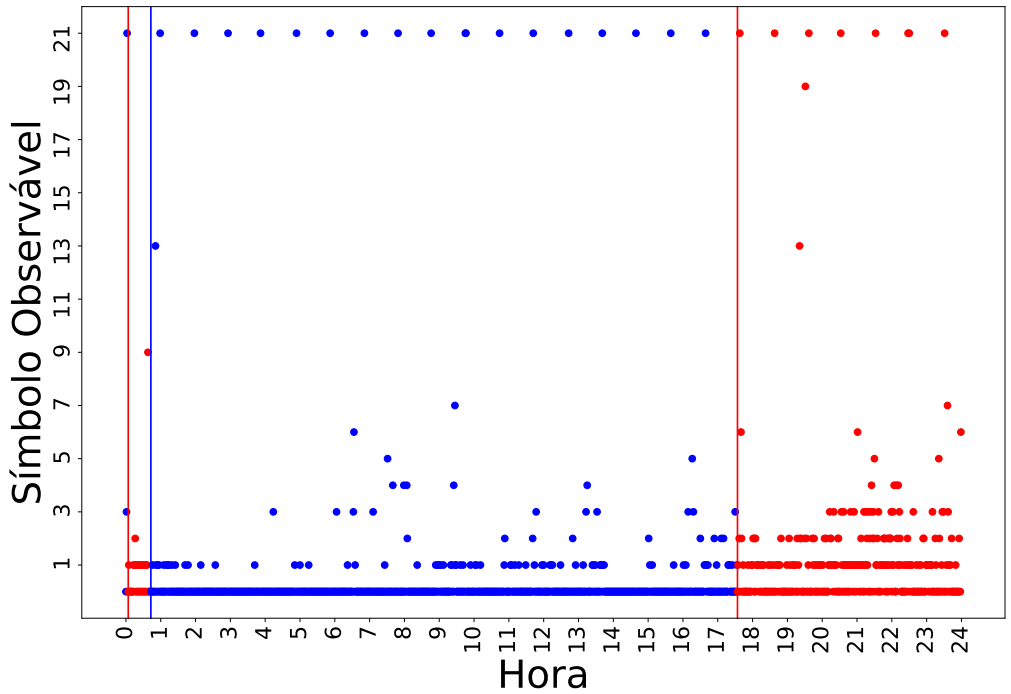

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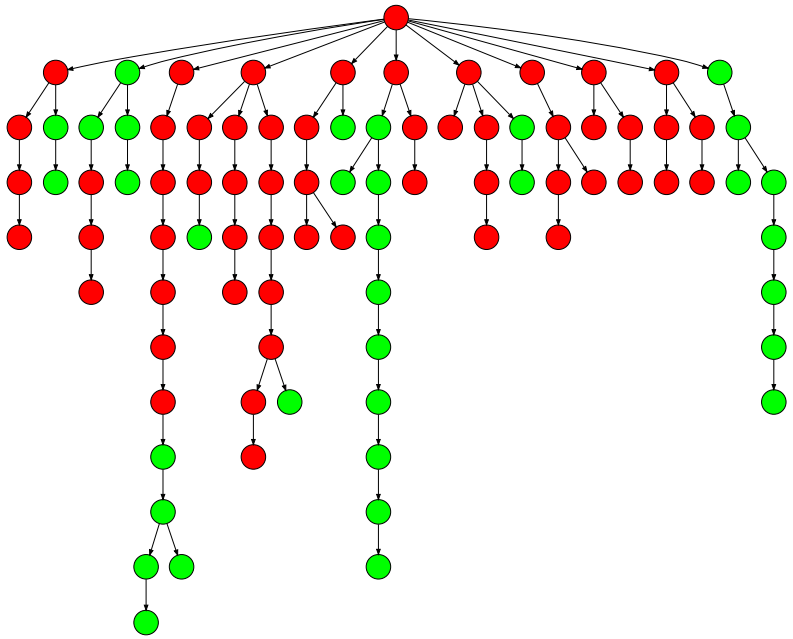

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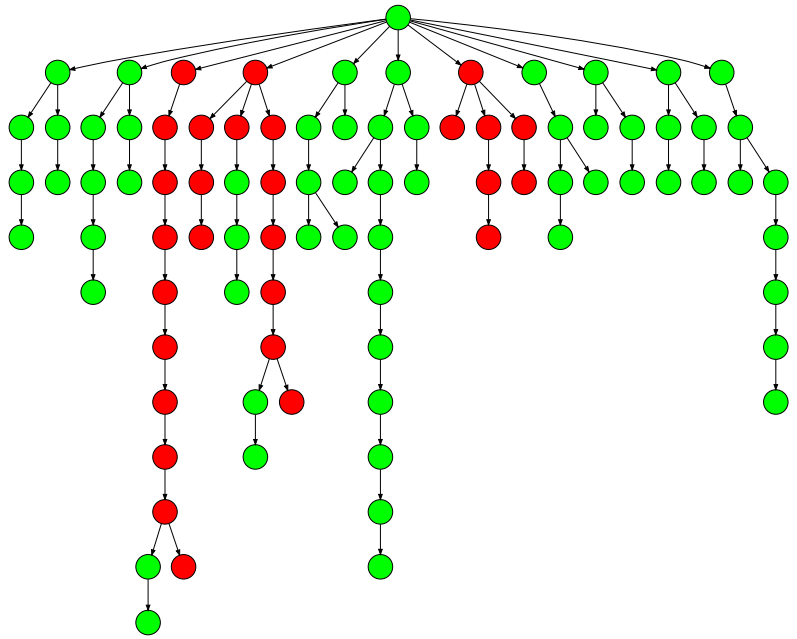

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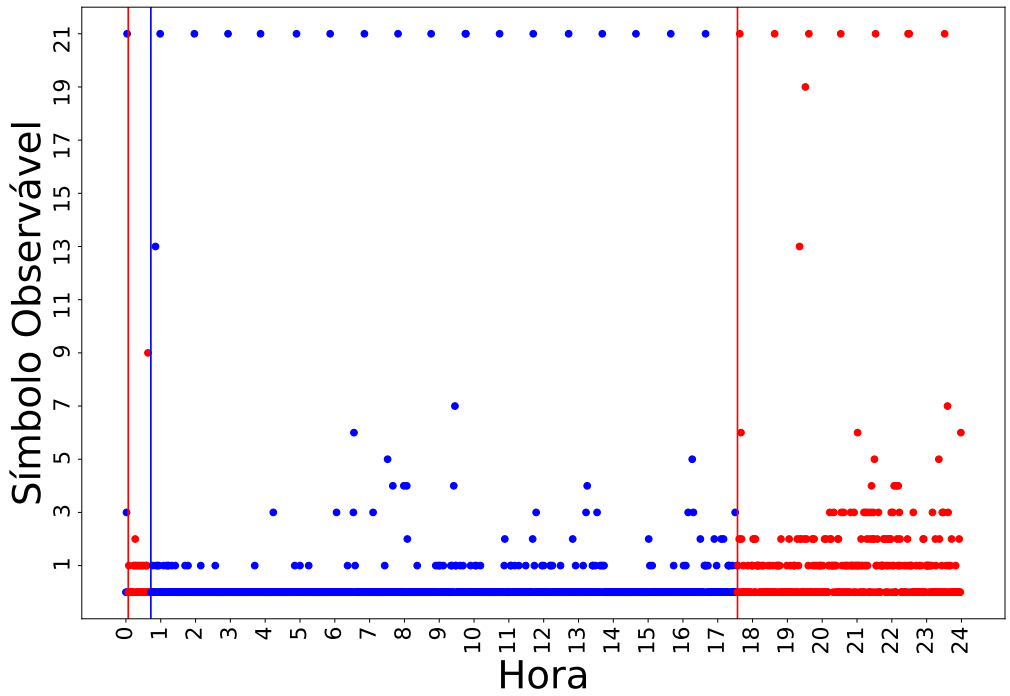

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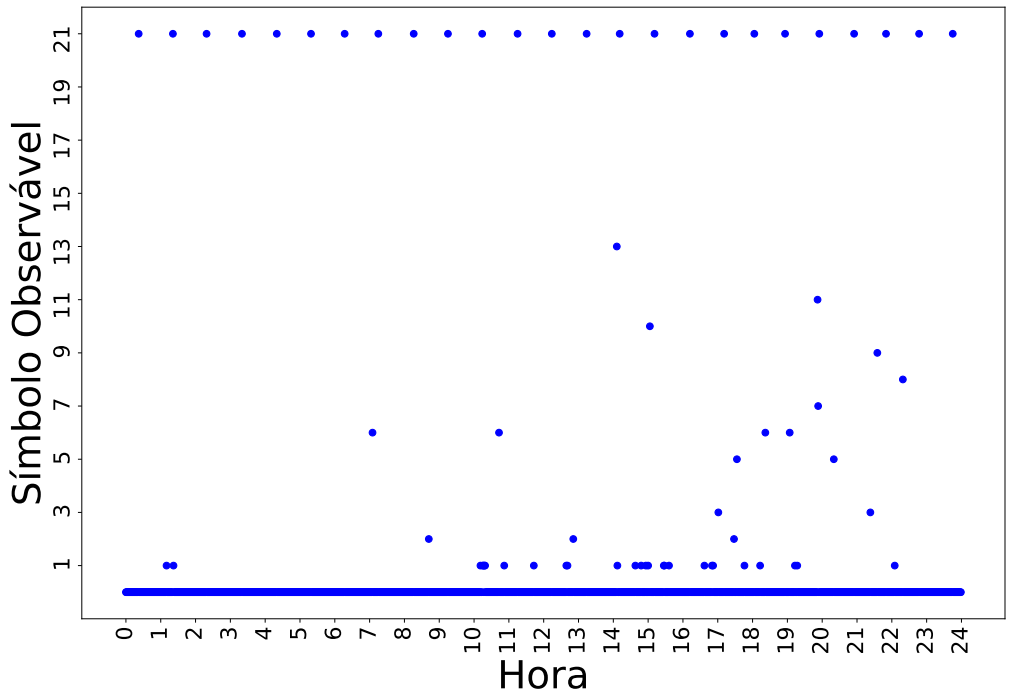
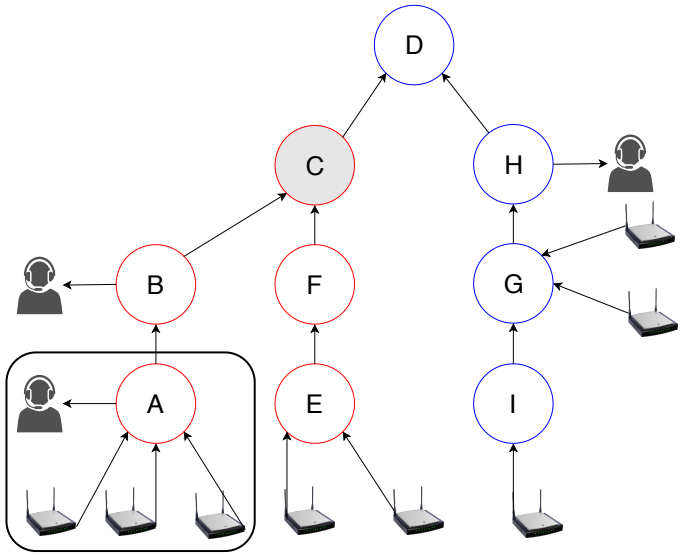


Additional Results

- Considering phone calls to the Call Center (technical complaints), associated with nodes connected to home-router performing measurements:
  The method identified 95% of phone calls.



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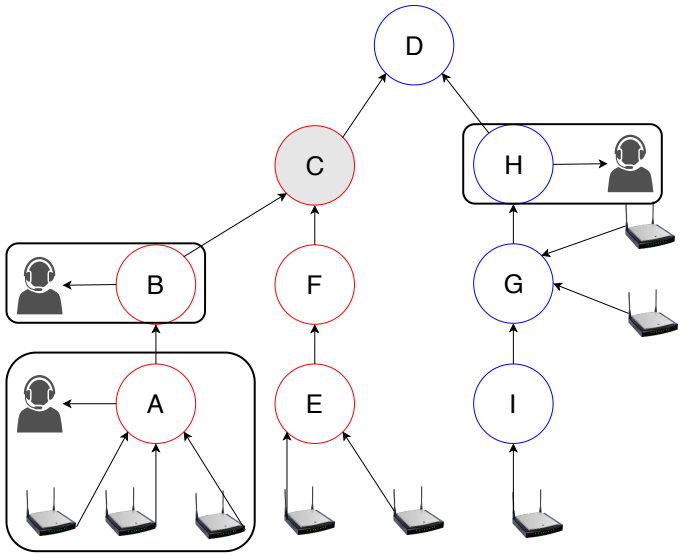

Learning Traffic Profiles from the Edge

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- **Objective**:
  - Understand characteristics of traffic generated by home users
  - How to extract meaningful features from dataset, preserving users' privacy (e.g., assuming that traffic is fully encrypted)
- **Methodology**: based on Machine learning techniques

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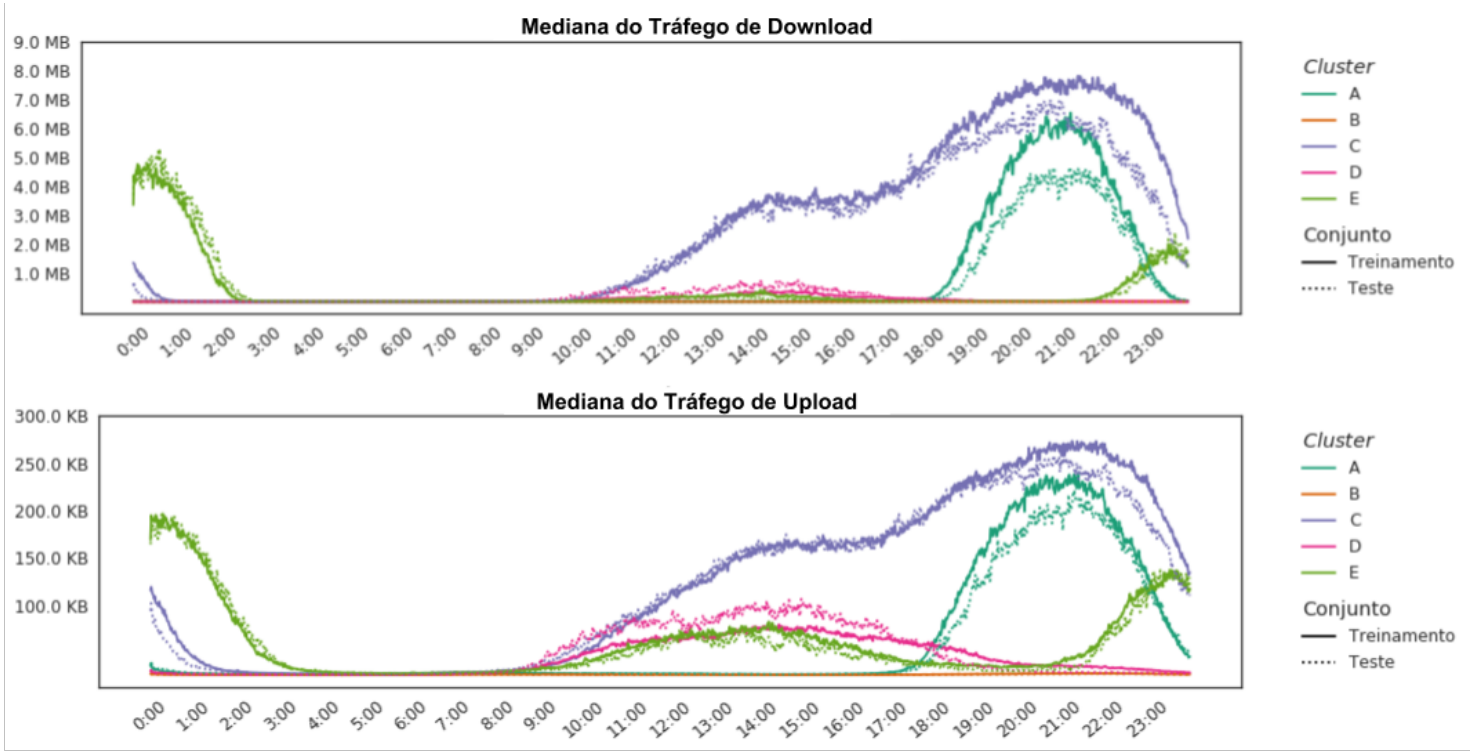
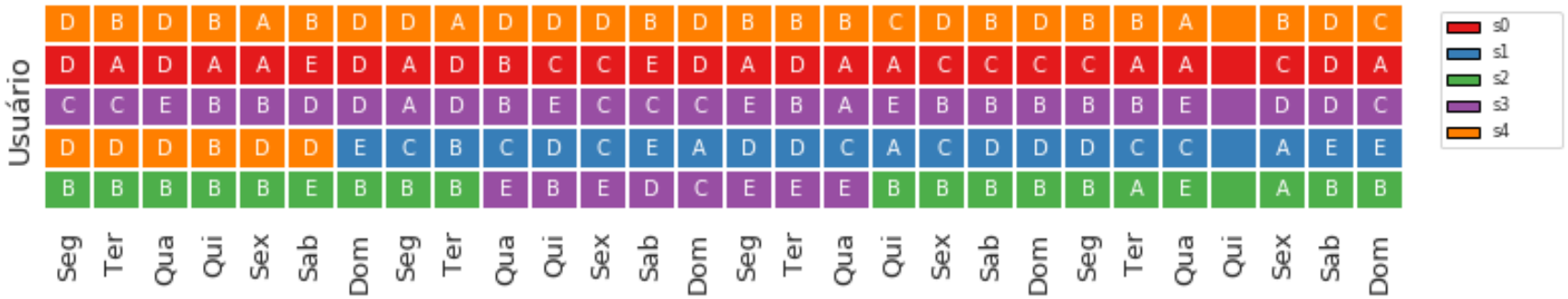
Learning Traffic Profiles from the Edge

- Median download and upload traffic per minute for all *user-day* of each cluster.



Learning Traffic Profiles from the Edge

- User profile for a month.
  (A, B, C, D, E are clusters - *user-day* pattern).



Obrigado

OBRIGADO

PERGUNTAS?

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