

A hand is pointing towards a glowing globe that is covered in a network of lines, representing a global network or data flow. The background is dark blue with a subtle grid pattern.

*Automatic root cause (anomaly) detection – 3GPP ETSI 4G LTE RAN KPIs*

*Machine learning model*

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# Agenda

## 1. Motivation

- Context: “Why optimize 4G networks?”
- Automation: “Why *AI/machine learning*?”
- Objective

## 2. Case study

- Network performance metrics and evaluation criteria
- 4G LTE 3GPP solution
- Anomaly and network issues

## 3. Development

- 4G solution
- Data strategy
- Machine learning algorithm selection
- Proof of concept (*PoC*)

## 4. Results

- *Cell I example*
- *Cell II example*

# 1. Motivation

## Why optimization?

- Maximize MNO OPEX and CAPEX
  - Seasonality
  - Traffic behavior and user type
  - Network engineering resource strategy
- QoS improvement and user live network experience

Expansion  
&  
Deployment

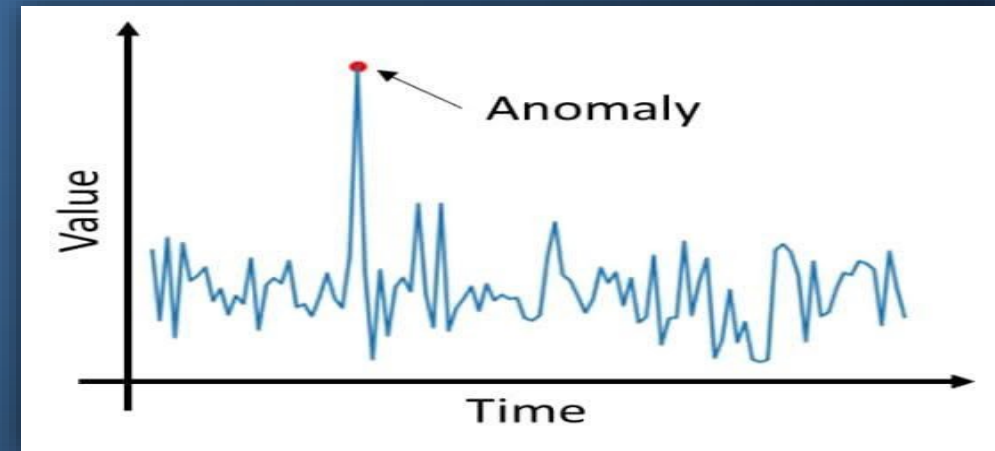
Optimization  
management

Design/Planning

Source: GSMA Mobile Economy – Global, June 2020

## Why automate?

- Human error → Process loop impact
- Complexity → Heave amount of data and parameters to analyze and improve
- Autonomous network concept → Digital transformation
- Increase cost efficiency and resource productivity
- **Automatic anomaly detection/root cause → AI/Machine Learning**



Source: How Machine Learning Can Enable Anomaly Detection, 2020

# 1. Motivation

## Objective

**ML model for 4G 3GPP Radio Network Performance management (automatic anomaly detection)**

- **Identify network performance anomalies**
- **Identify potential root cause (diagnostics)**
- **Automate the process (digital transformation)**
- **Increase efficiency (time reduction per activity)**

**→ ICT (Telco) + IA**

## 2. Study case

### Network performance metrics and evaluation criteria for 3GPP 4G LTE Radio Acces Network (RAN)

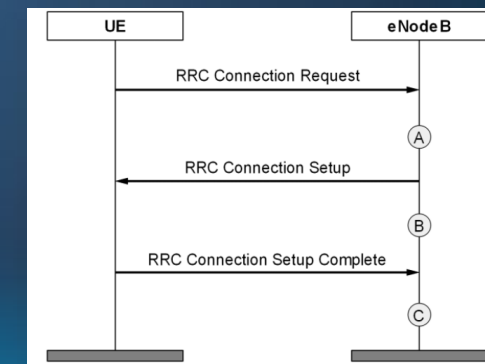
- 3GPP ETSI TS 132 451 → "User experience and QoS based on Key Performance Indicators"

- Accessibility
- Retention capacity
- Integrity
- Traffic
- Utilization

<b>Name</b>	<i>Average Uplink Interference</i>
<b>Object</b>	4G Cell
<b>KPI Formula</b>	<i>UL.Interference.Avg (unique counter)</i>
<b>Unit</b>	Power (dBm) <i>KPI – Uplink interference</i>

<b>Name</b>	<i>Max User Number</i>
<b>Object</b>	4G Cell
<b>KPI Formula</b>	<i>Max.User.Number (unique counter)</i>
<b>Unit</b>	N/A <i>KPI – User traffic</i>

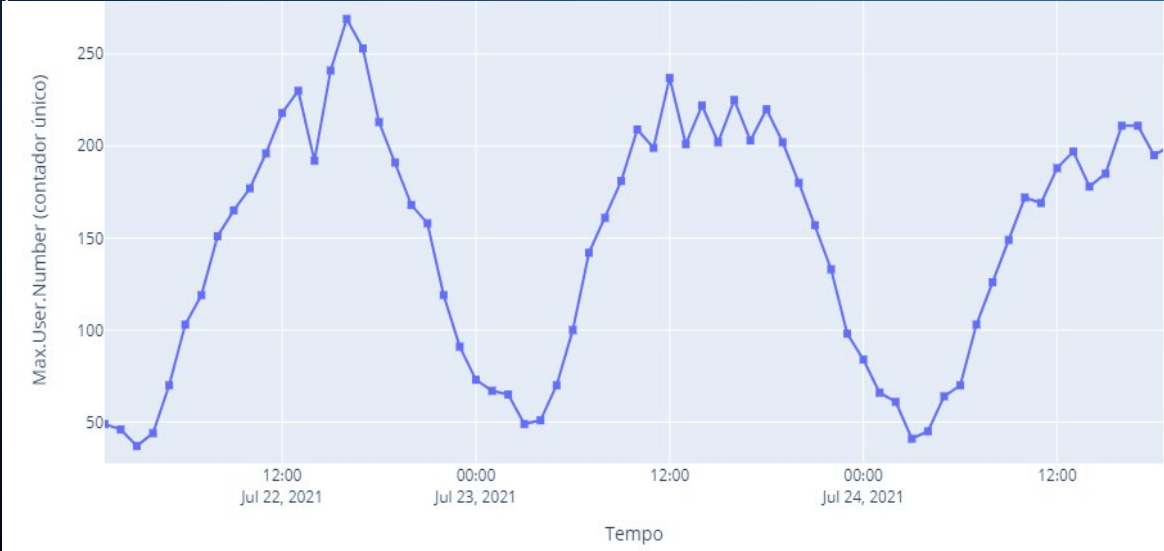
<b>Name</b>	<i>RRC Setup Success Rate</i>
<b>Object</b>	4G Cell
<b>KPI Formula</b>	$RRC\_SSR = \frac{RRC.Connection.Success}{RRC.Connection.Attempt} \times 100\%$
<b>Unit</b>	Percentage (%) <i>KPI - Accessibility</i>



## 2. Case study



Counters aggregation (formula) and commercial network acceptance based on technical performance metrics



Traffic behavior(seasonality)



Counters of different categories (e.g. network failure, external events, etc)

Time (mm/dd/yyyy) hh:mm	4G Cell	Counter1	Counter2	...	Counter or KPI formula of interest
6/01/2021 12:00	Cell1	1424	422	...	0
6/01/2021 12:00	Cell2	533	328	...	6
...	...	...	...	...	...
8/14/2021 21:00	Cell1	1621	457	...	7
8/14/2021 21:00	Cell2	1111	127	...	9

Global standard 3GPP → Time series, extracted by hour



## 2. Case study

### 4G common anomalies and network issues

- Hardware malfunction on live network (site to backhaul-core)
- Human error → Network parameterization
- External interference, decreasing the performance of 4G active carrier
- 4G network traffic congestion

# 3. Development

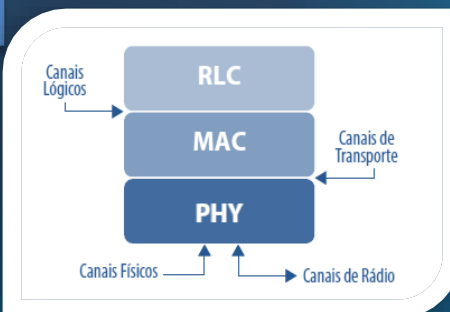
## 4G Solution – Access Network:

- LTE 1800MHz – 3GPP Band 3 FDD
- BW = 10MHz
- 1 antenna per sector
- 1 LTE cell per sector
- 3 antennas per eNodeB
- 256QAM algorithm switch downlink feature
- 64QAM uplink



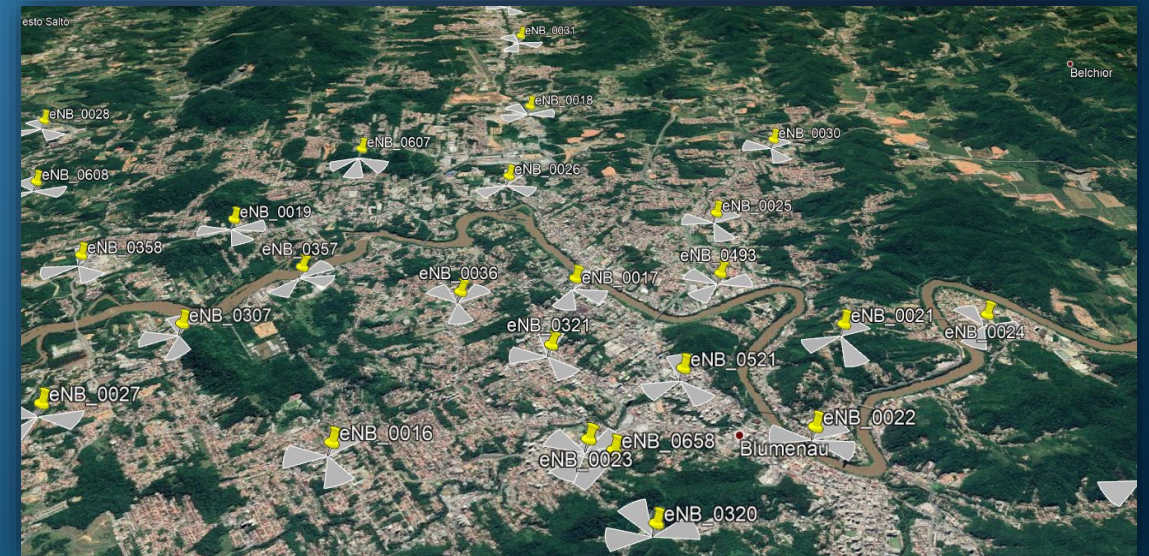
eNodeB (4G site)

Backhaul network



## Scenario:

- Blumenau city – SC (South Brazil)
- 2020/H2
- Total of 95 performance indicator counters → KPI formula of interest is *RRC Setup Success Rate* (97.5% acceptance metric)
- Collected for two 4G cells (*Cell1* e *Cell2*), different sites (06/1/2022 to 8/18/2022)
- 1785 samples (rows) for each 4G cell (*dataset.csv*)





# 3. Development

## Acceptance metric and KPI evaluation criteria for RRC Setup Success Rate (%)

- 3GPP → 97.5% for network acceptance

## Data strategy → Anomaly identification

- Automatic metric labeling (by hour)

Time (mm/dd/yyyy) hh:mm	4G Cell	Counter1	Counter2	...	RRC Setup Success Rate (%)	KPI anomaly?
6/01/2021 12:00	Cell1	1424	422	...	97	1
6/01/2021 12:00	Cell2	533	328	...	99	0
...	...	...	...	...	...	...
8/14/2021 21:00	Cell1	1621	457	...	100	0
8/14/2021 21:00	Cell2	1111	127	...	75	1

### 3. Development

#### Machine learning model selection → Supervised classification (binary)

- Naive Bayes
- Decision tree

- Python (scikit-learn)
- Feature importance extraction

dataset.csv

Input

ML model

Output

Anomaly (0 or 1) and feature  
Importance extraction

Time (mm/dd/yyyy) hh:mm	4G Cell	Counter1	Counter2	...	RRC Setup Success Rate (%)	KPI anomaly?
6/01/2021 12:00	Cell1	1424	422	...	97	1
6/01/2021 12:00	Cell2	533	328	...	99	0
...	...	...	...	...	...	...
8/14/2021 21:00	Cell1	1621	457	...	100	0
8/14/2021 21:00	Cell2	1111	127	...	75	1

Input

Output

## 4. Results

Proof of concept (*PoC*) → RRC Setup Success Rate (%) for new data (*Cell1* e *Cell2*)

Model	Accuracy	Precision
<i>Decision Tree Classifier</i>	99.64%	96.67%
<i>Naive Bayes</i>	82.42%	18.58%

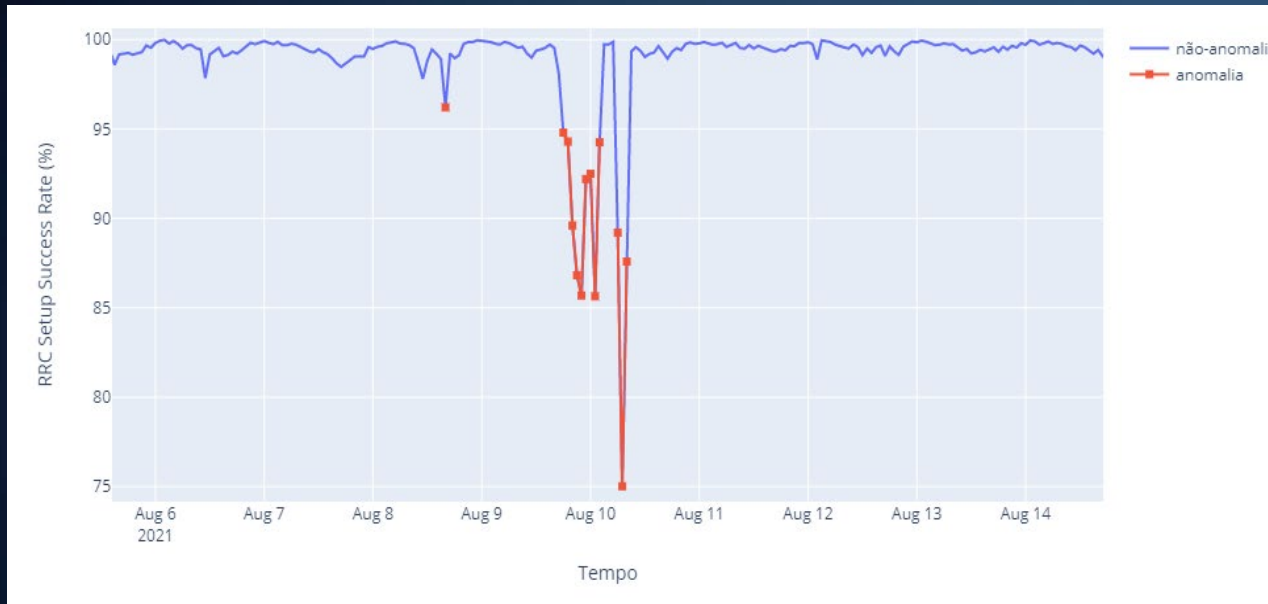
### Notes:

- *Decision Tree* → Better performance (correlated features)
- *Feature importance* extraction as the most correlated root cause

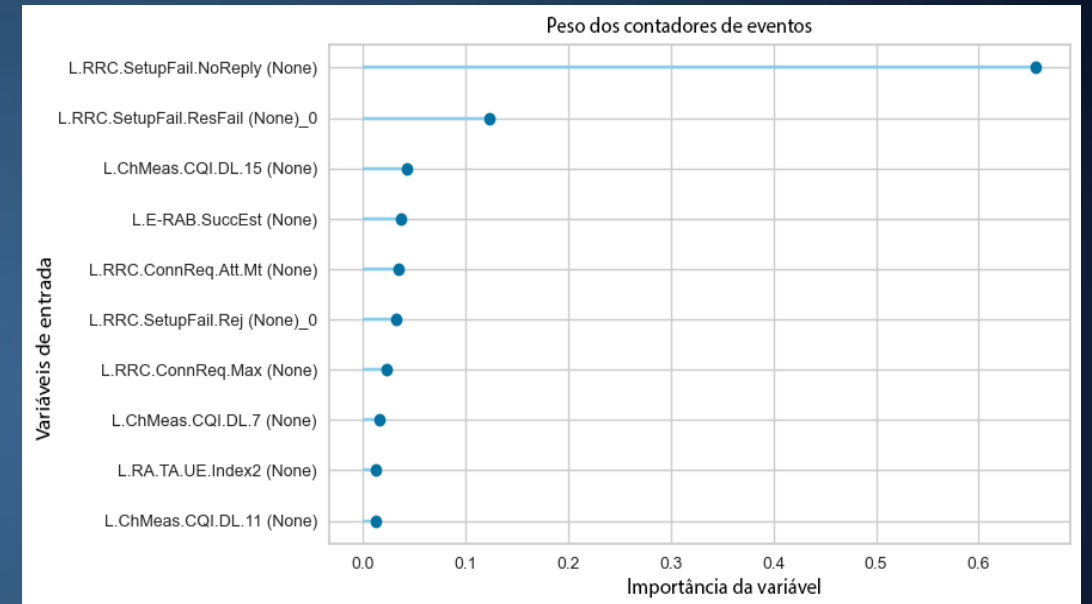


## 4. Results

Proof of concept (PoC) → RRC Setup Success Rate (%) for Cell1



KPI identified as anomaly



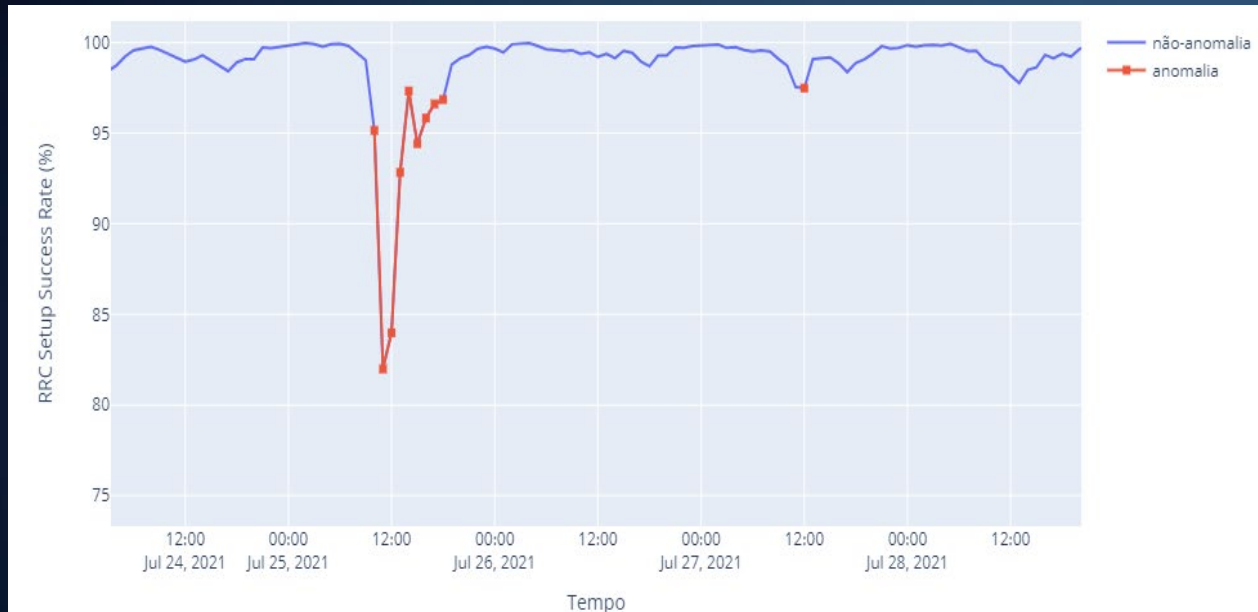
Feature importance

### Notes:

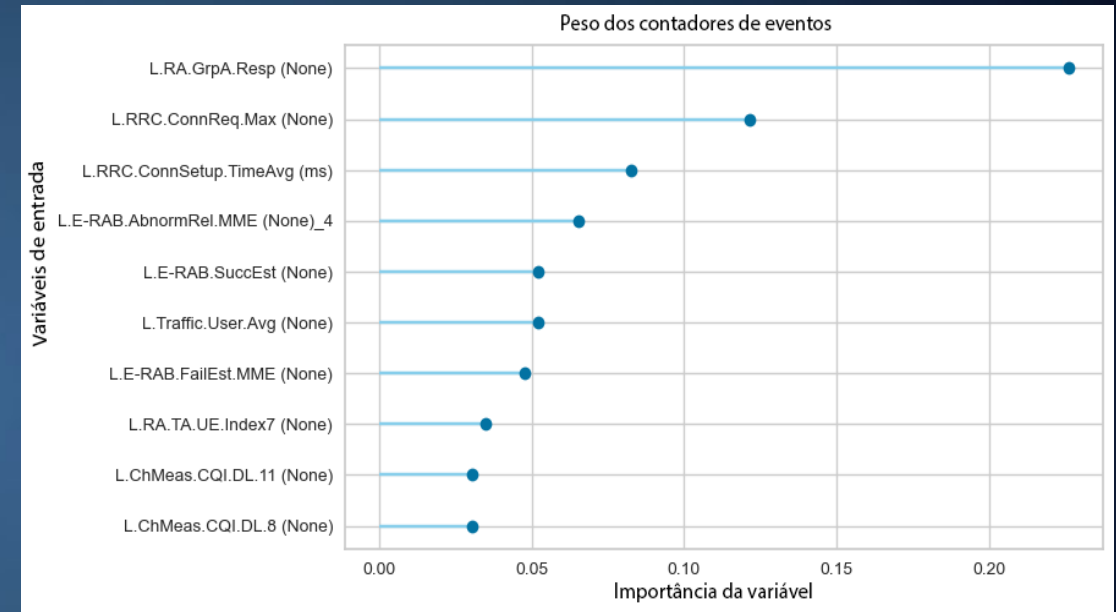
- Possible to identify anomaly and its root cause
- 3GPP → *L.RRC.SetupFailNoReply* counter indicator

## 4. Results

Proof of concept (PoC) → RRC Setup Success Rate (%) for Cell2



KPI identified as anomaly



Feature importance

### Notes:

- Possible to identify anomaly and its root cause
- 3GPP → *L.RA.GrpA.Resp* counter indicator

# Thank you