# IP design and exploitation of Geneva city transport network

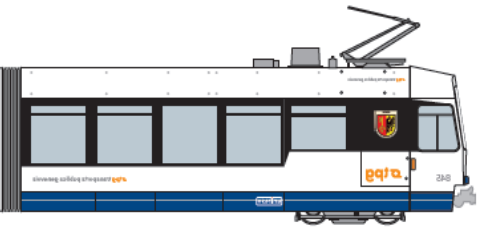
## Unified communication for the TPG fleet

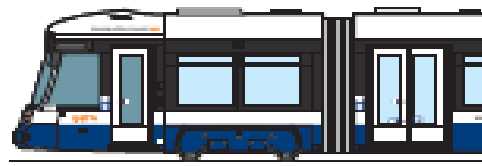
**SIT / Grégoire Huet 14.11.2019**

# About

## Transports Publics Genevois

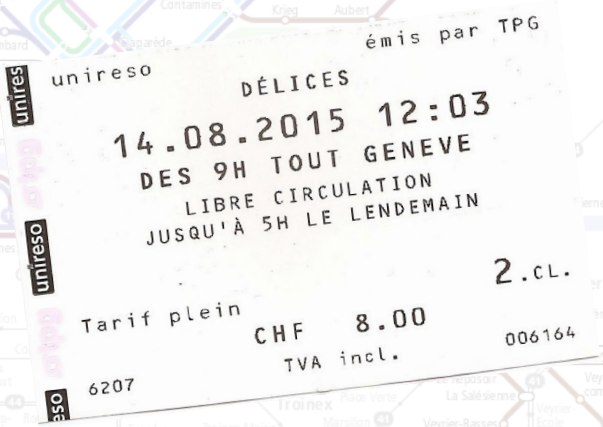
- Created in 1977, from a 1899 company, operations are back to 1833
- ~2000 employees, including ~1350 for exploitation (with drivers)
- ~430 MCHF turnover
- Wholly owned by the *État de Genève*





# Public Transportation Network

- 426 Km of lines (5 x tramway, 6 x trolley, 52 x bus, plus nightly lines)
- 220 millions of rides in 2018 / About 600k rides per day
- 659 vehicles in 2018 = 117 trams, 90 trolleys, 452 autobuses
- Around 30 millions Km per year in total




# The fleet

## A diversity of vehicles



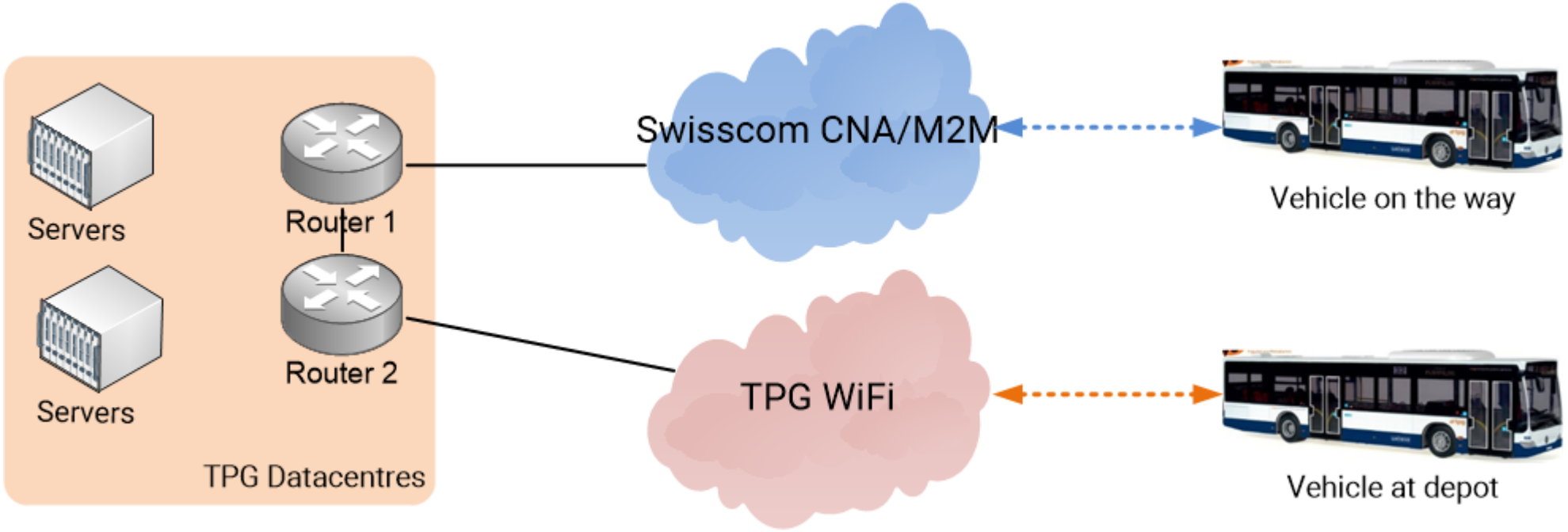

# Vehicles connectivity

## TPG vehicles need connectivity

- Need to supply IP services in the vehicles
  - Ticket machines, inside/outside displays, driving assistance
  - Number of embedded services to grow in the future (video..)
- A fleet of about 700 mobile routers
  - They are Linux PC with a GUI and a suit of network tools
- A mobile “LTE” network
  - The Swisscom Corporate Network Access, with its strength and weaknesses
    - A private virtual network on the 3G/4G infrastructure to connect on-the-road vehicles
- The WiFi enterprise network
  - Under full control
    - Used to join the vehicles at the depots ; without data consumption limits

# Duality of communications

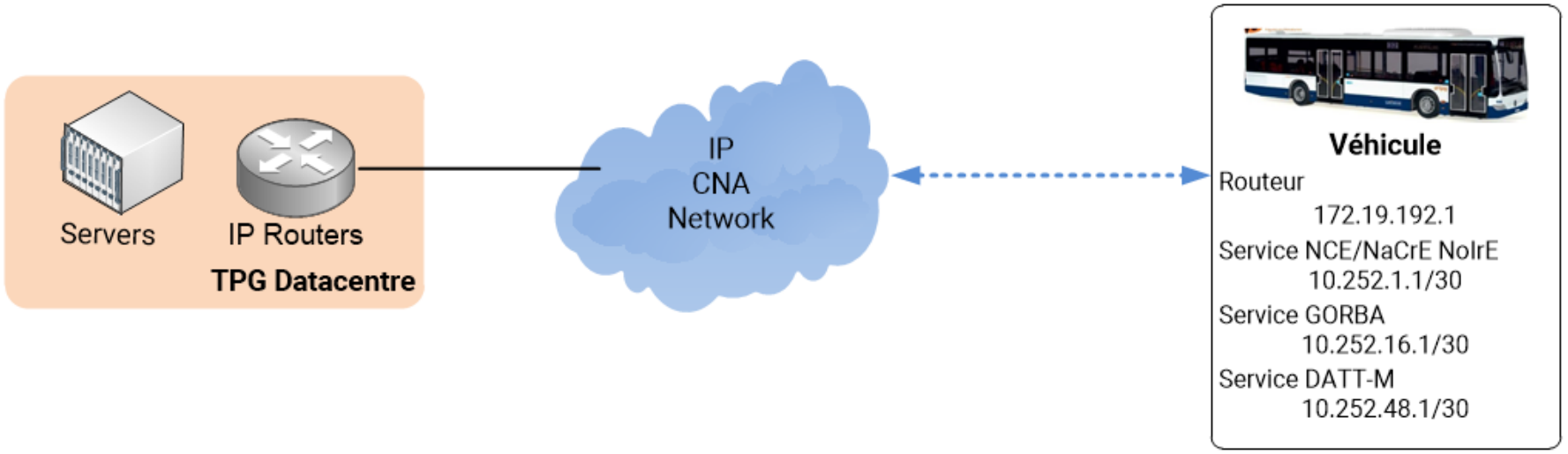
## Need to communicate in every circumstance




- A vehicle's IP address changes depending of its place
  - Need to follow this IP ensure the communication continuity
- No problem when at depot, limitation on the Swisscom CNA
  - Need of surpassing the routing limitation to follow the IP addresses of the embedded services.

# The mobile network constraint

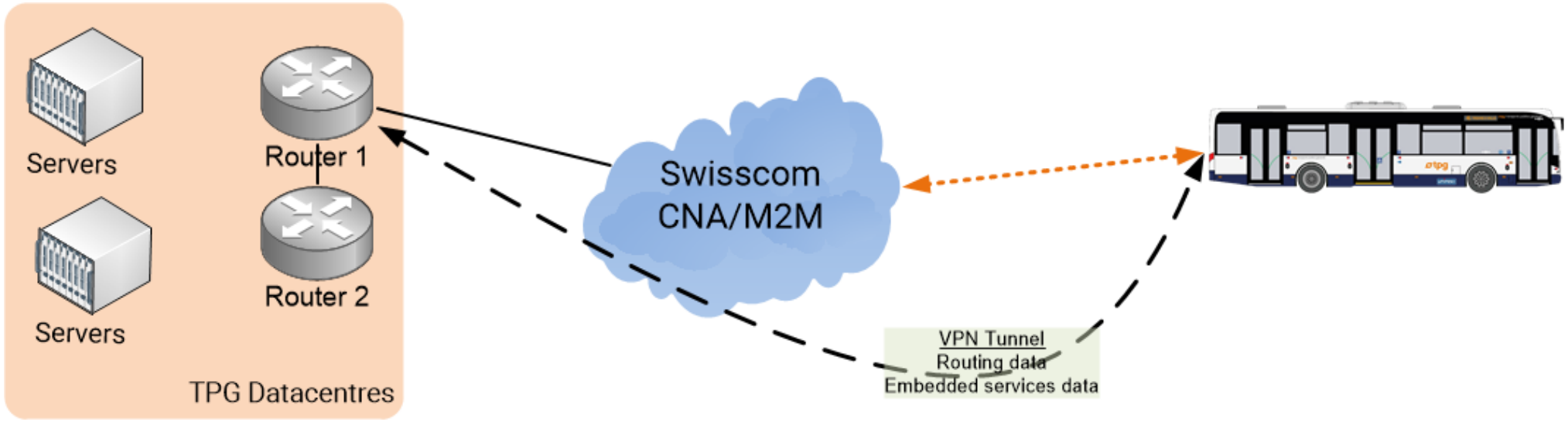
## Restricted routing on the LTE network




- There is a routing limitation on the mobile 3G/4G network
- Not like a regular MPLS VPNv4 network
- One endpoint only has one IP
  - Only one route allowed per vehicle ! But a number of services to provide !
  - NBMA limitations

# An overlay network

## A VPN tunnel to each vehicle

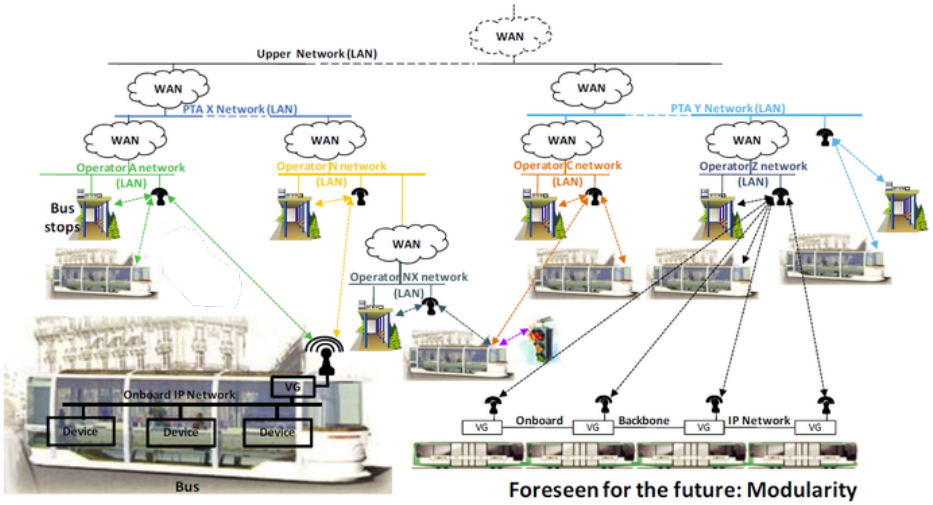


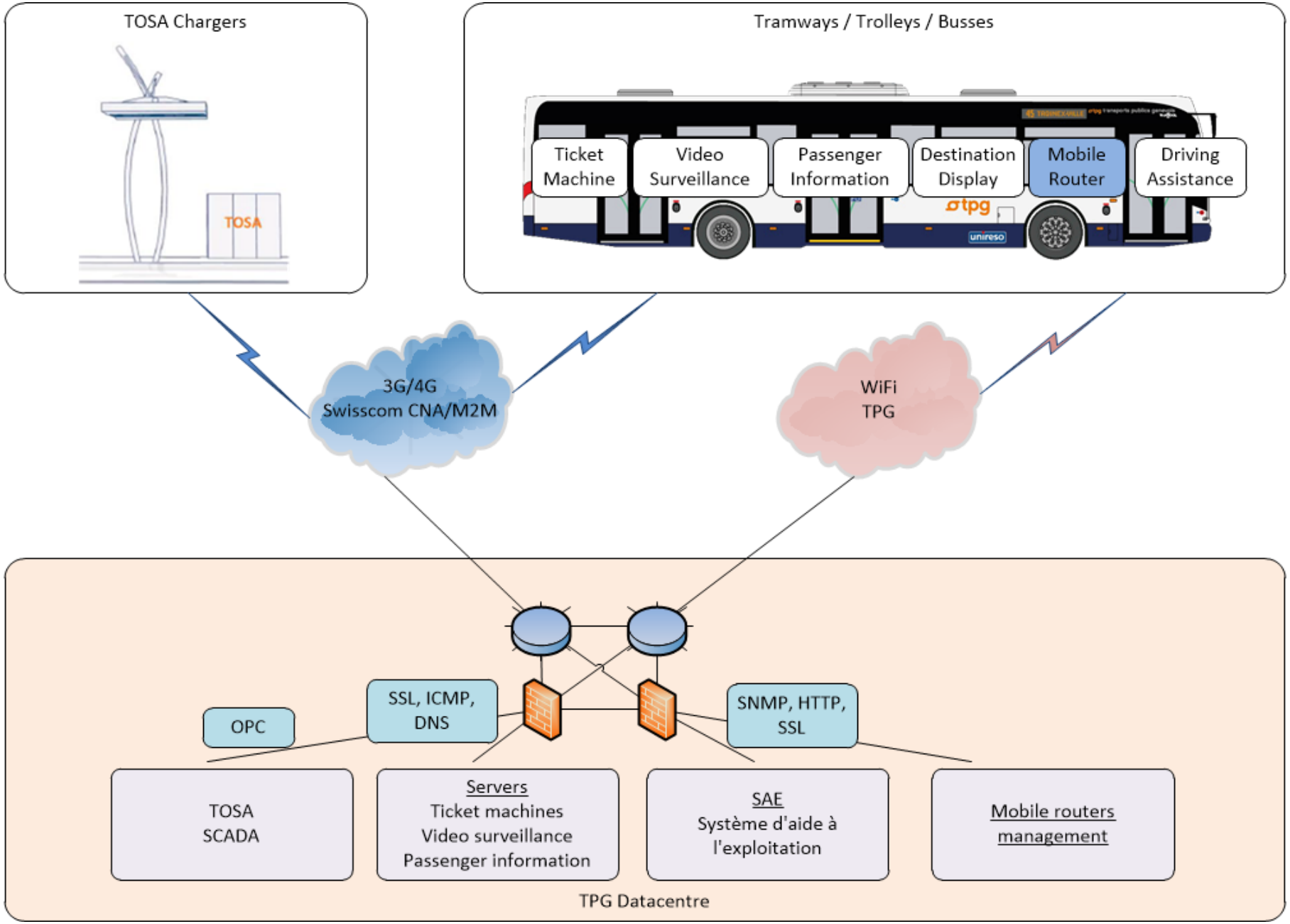

- RFC3344 “Mobile IP” implemented by NetModule
  - To assign a mobile router a constant IP
  - Standard, simple, doing the job... But end-of-life by several vendors !
  - Builds a simple VPN between the datacentre and each mobile router
    - All the VPN form an “overlay” network on top of Swisscom GSM private network
    - The routing limitation of the LTE network are exceeded

# A need to conform to standards

- ITxPT
  - Standardization effort in public transports IT
    - Standard hardware and architecture
    - Prevent vendor lock-in
  - Cabling, connectors
  - Secure IP connectivity
- IETF standards
  - Internet Engineering Task Force
  - Use of protocols described in RFCs

INFORMATION TECHNOLOGY for PUBLIC TRANSPORT




TOSA Chargers
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Tramways / Trolleys / Busses
Ticket Machine
Video Surveillance
Passenger Information
Destination Display
Mobile Router
Driving Assistance
3G/4G
Swisscom CNA/M2M
WiFi
TPG
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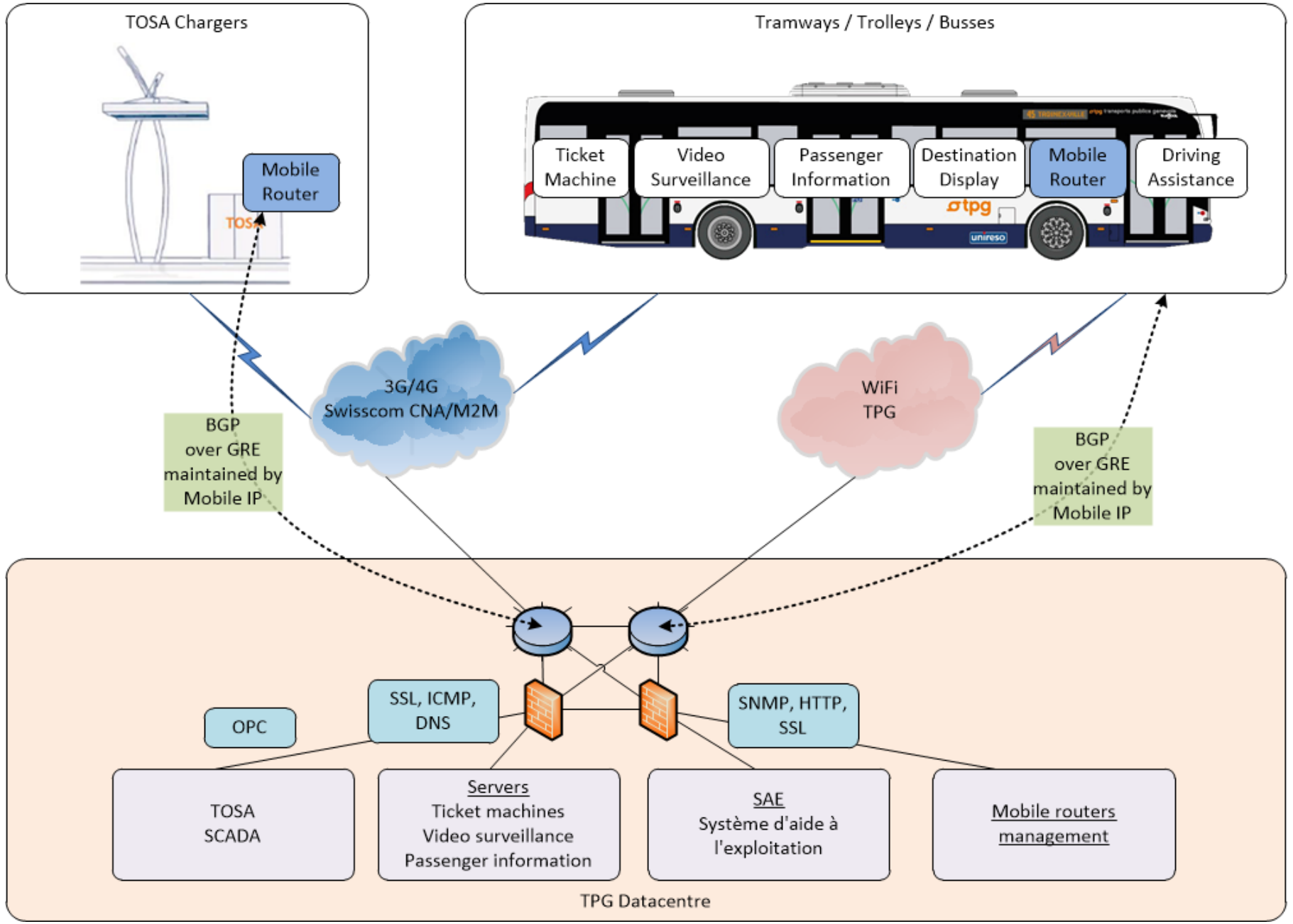
Système d'aide à l'exploitation
Mobile routers management
TPG Datacentre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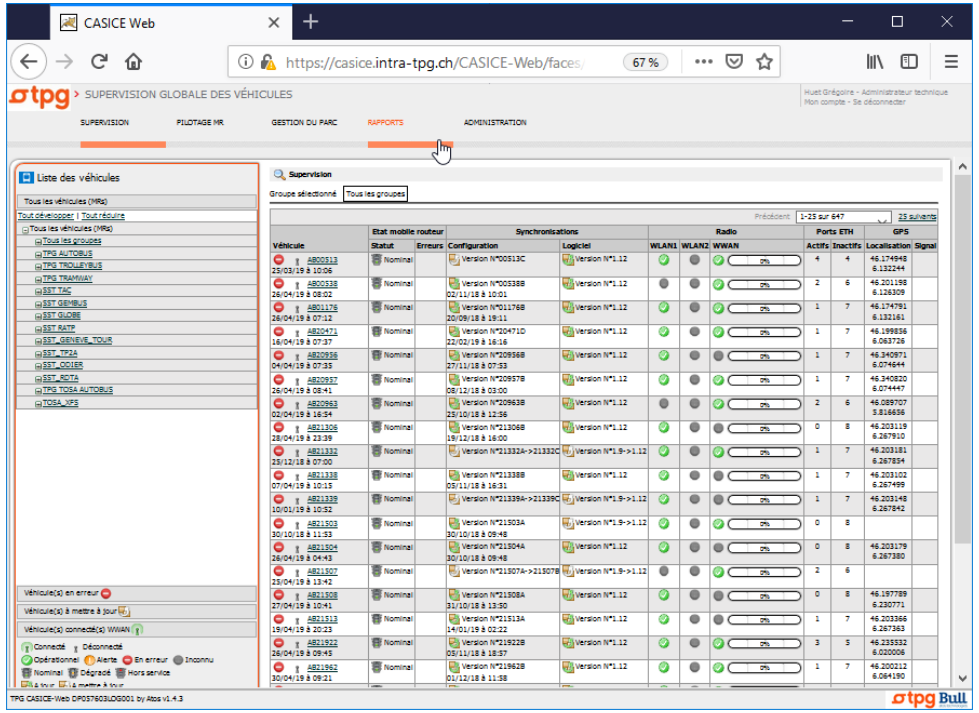
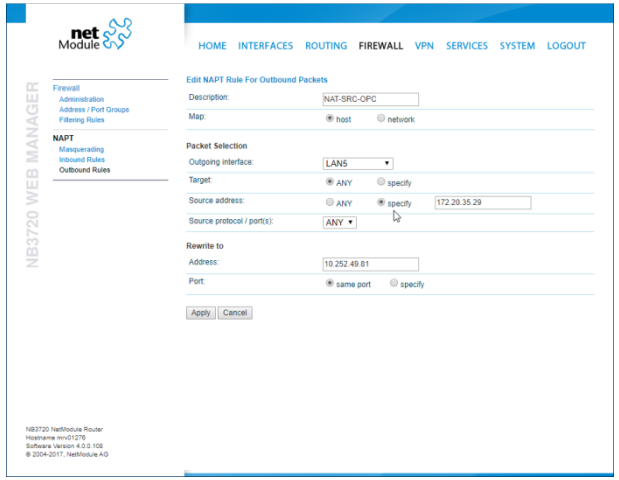
# The legacy

- On the datacentre side
  - Supervision and configurations management tool
  - Termination on Cisco ASA
    - No support for GRE




- Fleet
  - Manageable Mobile Routers
    - SNMP, Web, propriétary shell commands
  - Heterogeneous
    - VHC, TOSA, xFS, F2G

# Implementation : the headend

## Datacentre side

- Setup of two dual-routers clusters
  - In place of a pair of firewalls
  - One cluster (2 routers) for LTE
  - One cluster for WiFi
  - Solution subject to evolution
    - Mobile IP protocol to replace
      - OpenVPN
    - Mobile IPv6
      - Depending of the mobile router manufacturer support
- Configurations generation
  - The whole fleet has been pre-configured on the datacentre side
    - The tunnels are waiting for the vehicles to connect

# Implementation : on the vehicles

## Migration of the mobile routers

- A number of parameters to change on every vehicle
  - To be done while in production (exploitation)
  - NTP, MIP, BGP, NAT, IP computation, DNS, OSPF
- Adapting the whole fleet by hand is impossible / given time
- Dev of a script to adapt the mobile routers configurations
  - Python, shell, Apache
- Setup of an automation tool to manage the fleet
  - Ansible : mainly because of “no agent” needed
  - Simple “playbooks” (no Python on mobile routers)
  - Capacity to target the vehicles per groups

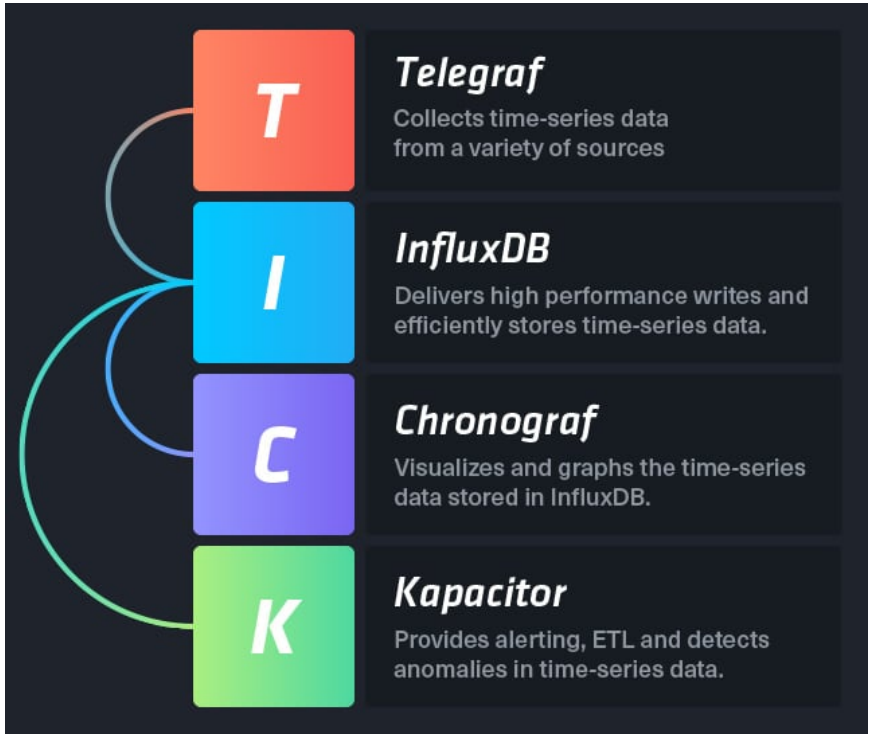
# Monitoring

## Identifying problems, keeping an history

- TOSA charging stations are very sensitive
  - In particular the *Terminal Feeding Stations*
  - Monitoring & alerting Icinga (Common tool for Infrastructure, VM,...)

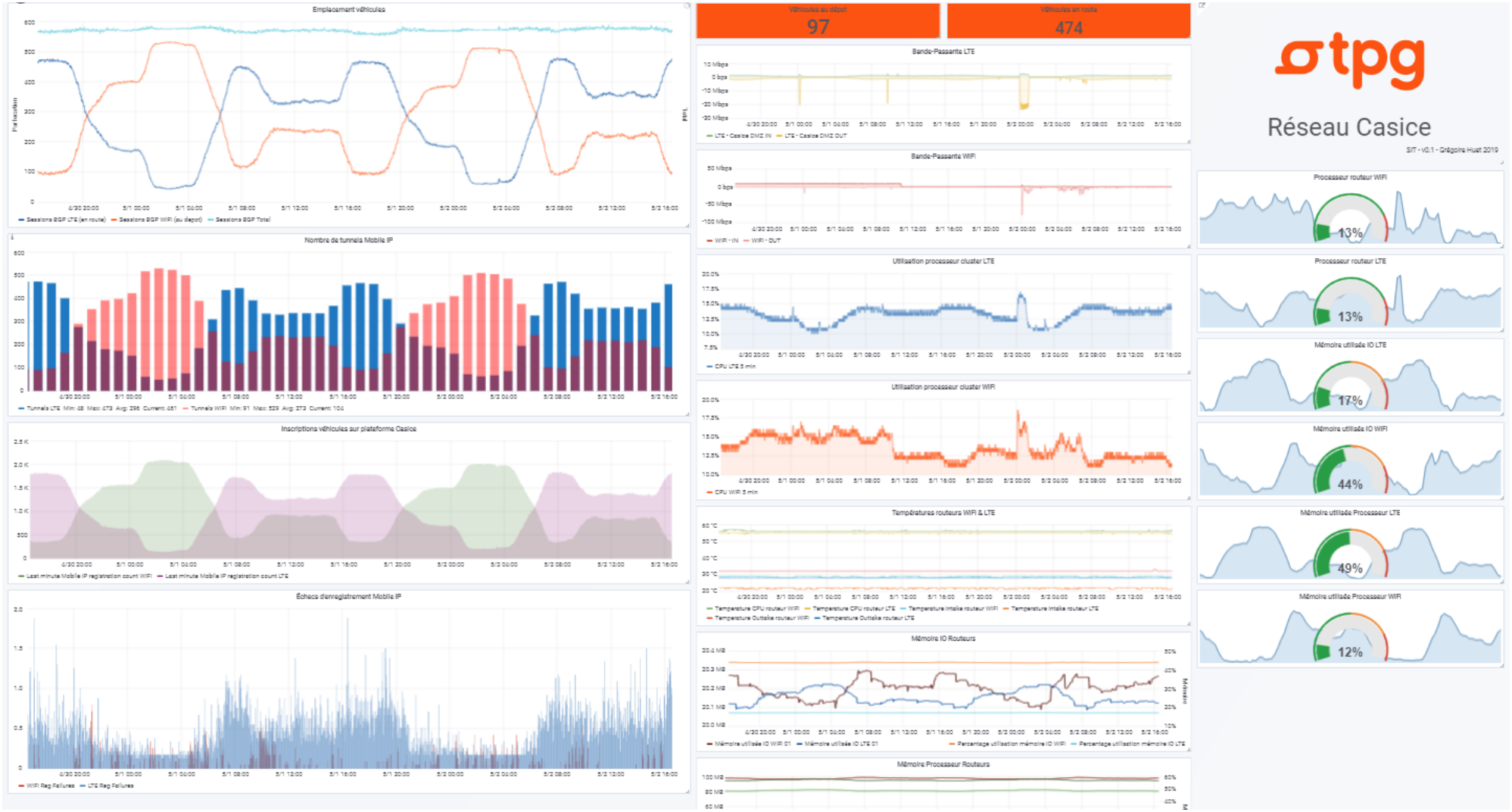
- Visualisation tool based on dashboards
  - Concise and useful information
  - Easily customisable

```
[[inputs.snmp.table]]
  name = "bgpPeers"
  inherit_tags = [ "hostname" ]

[[inputs.snmp.table.field]]
  name = "bgpPeerState"
  oid = "BGP4-MIB::bgpPeerState"

[[inputs.snmp.table.field]]
  name = "bgpPeerRemoteAddr"
  oid = "BGP4-MIB::bgpPeerRemoteAddr"
  is_tag = true
```



# Monitoring

## Dashboard – Datacentre side

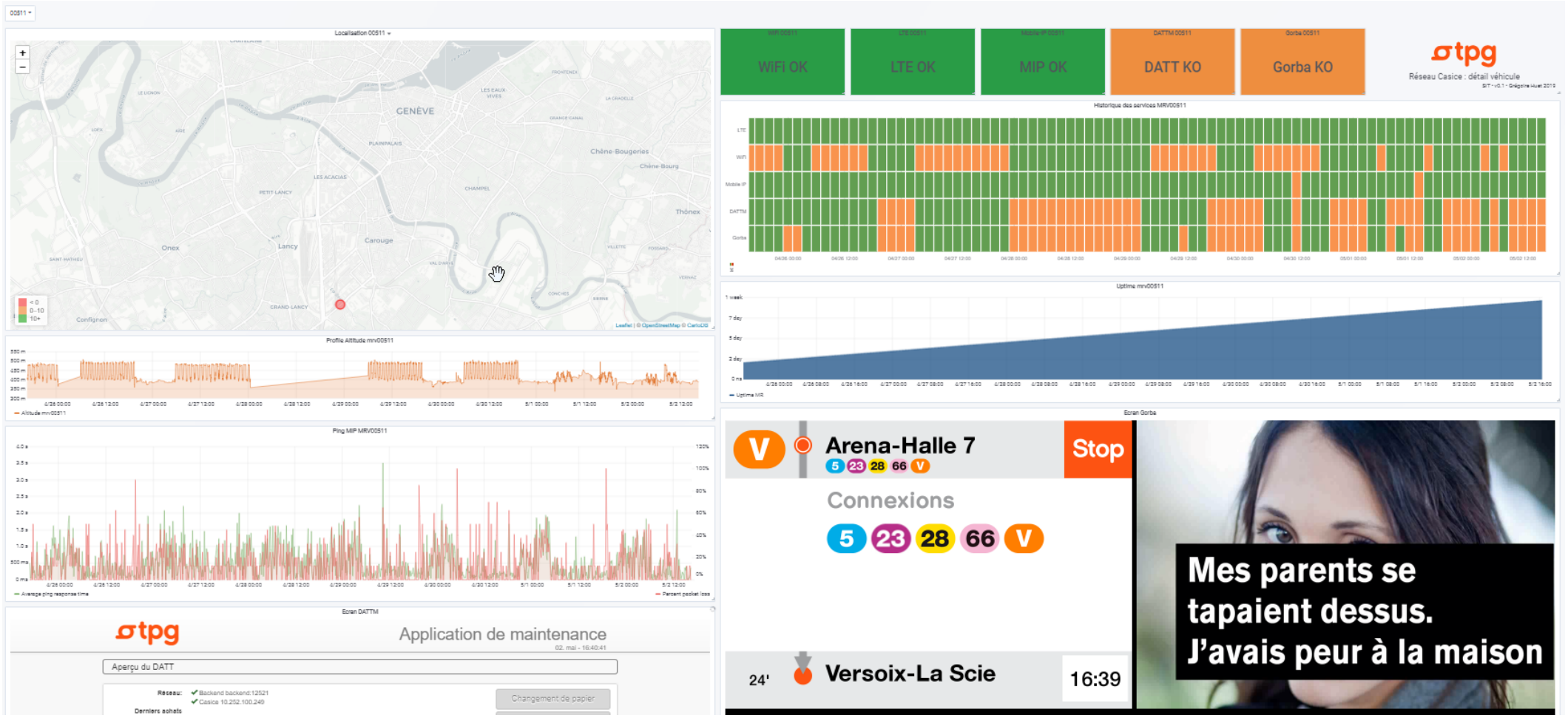


# Monitoring

## Dashboard– Per vehicles series

# Monitoring

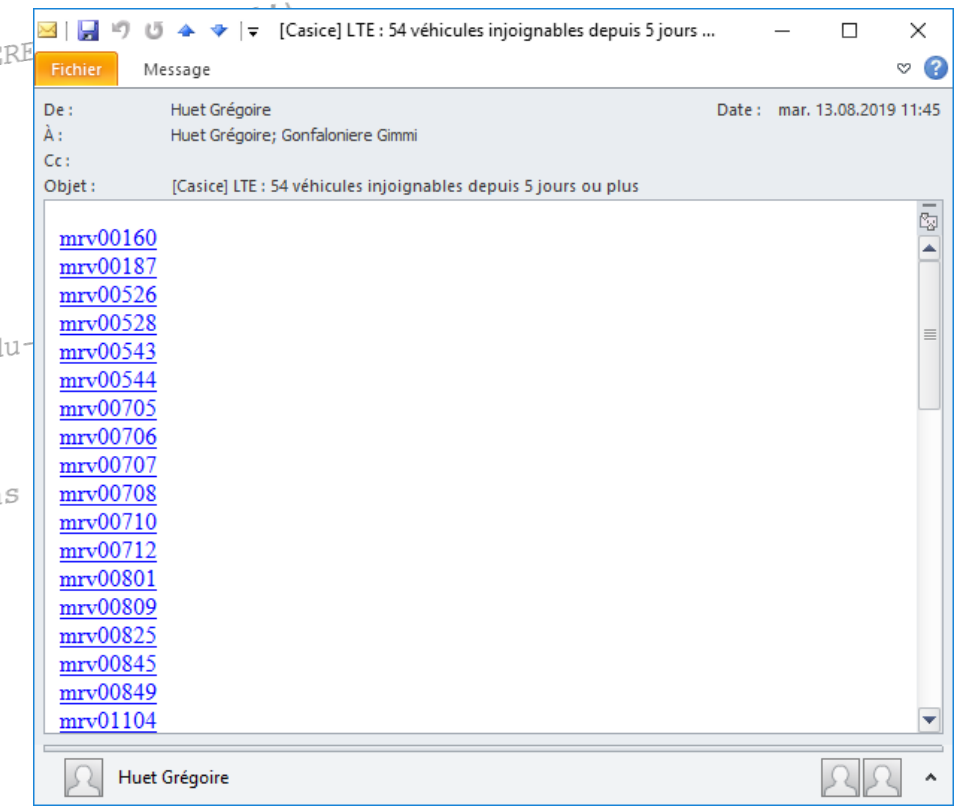
## Dashboard– Per vehicle



# Reporting

## To answer difficult questions

- « I want a daily report by email of all vehicles which did not connect to 3G/4G for 5 days or more.»
  - ***Kapacitor*** monitors time series in batch or “real-time”
  - Provides a monitoring programing language
  - Anomaly detection / Machine learning
  - Dynamic monitoring : no treshholds, possibility the refer to the preceding values in order to alert
  - Integration to multiples alerting systems



# Thank you