PACMAN: Automazione della Configurazione di Rete in GARR, tra Sfide Tecnologiche e Cambiamento Culturale

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ITNOG9

Agenda

- GARR-T IP/MPLS Backbone Network
- Before PACMAN
- Why We Needed Automation
- The PACMAN Framework
- Operational Workflow
- Cultural Shift in the NOC Team
- Challenges Faced
- Current Status and Roadmap

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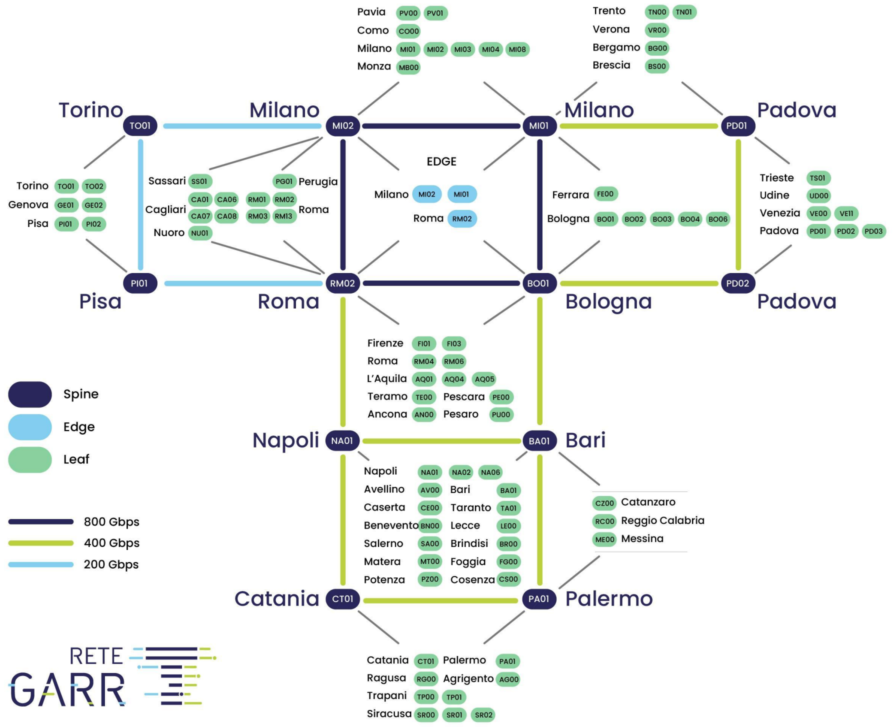
GARR-T IP/MPLS Backbone Network

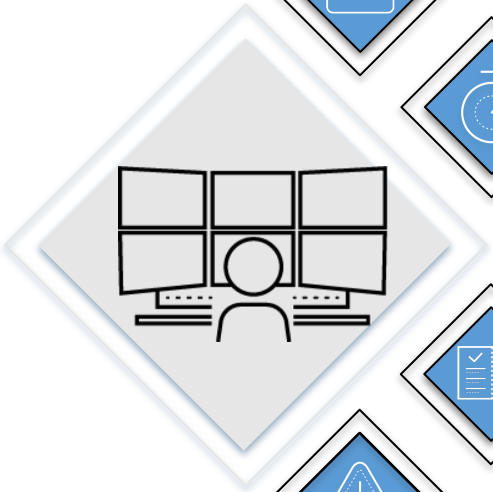
GARR-T IP/MPLS Backbone Network - Context



Device Type	#
JRR200	4
MX10003	4
MX204	78
MX304	6
MX480	31
PTX10001	8
PTX10004	4
TOT	**135**

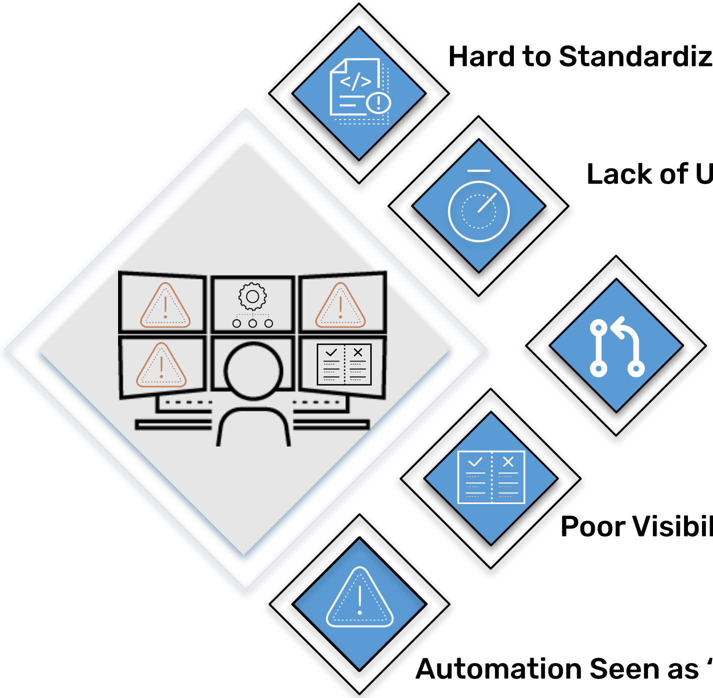
The Pre-PACMAN Era

Pre-PACMAN Workflow – Manual Operations



- CLI as the Primary Interface (SSH into Devices)
- Operators Worked Device-by-Device
- Copy-Paste from Internal Knowledge Base
- Configuration Drift and Inconsistency across Devices
- Error-Prone and Time-Consuming Tasks

Pre-PACMAN – The Limits of Manual CLI Work



Hard to Standardize or Reuse Configs

Lack of Users Configuration Services

No Peer Review

Poor Visibility into What Changed and Why

Automation Seen as “Nice to Have”, Not Core

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Why We Needed Automation

Operational Challenges Without Automation

Growing Complexity

Device sprawl and growing service complexity (e.g. firewall, routing)

Misconfiguration Risks

Manual changes increase the risk of errors

Poor Traceability

Hard to track who did what and when and why

Slow Turnaround

Manual tasks slow down provisioning and changes

Goals That Automation Could Help Us Reach

Consistency across Configurations

Ensure uniform and predictable configurations

Fast Traceability

Every change is tracked with complete visibility

Faster Turnaround Times

Rapid and error-free deployments

Scalability of Network Operations

Grow the network without increasing operational burden

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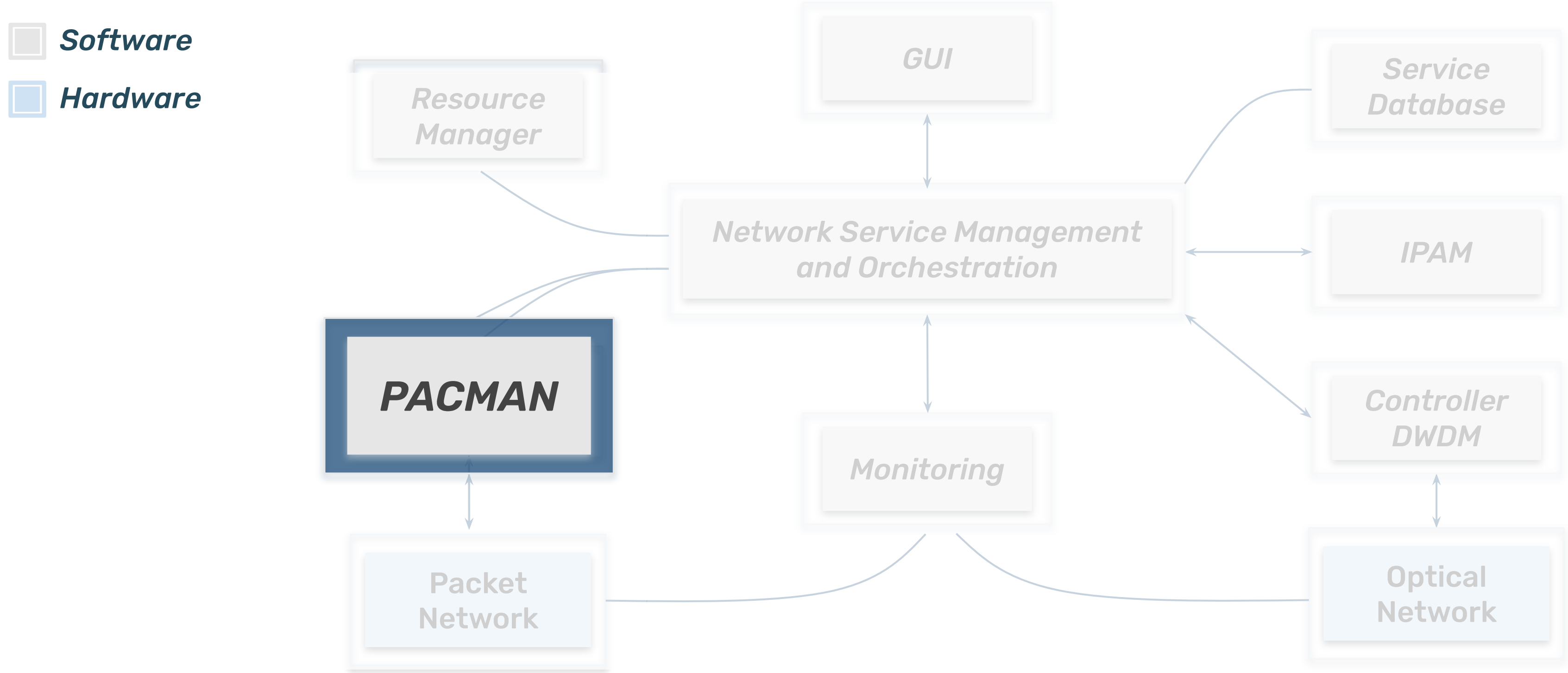
PACMAN: PAcket layer Configuration MANager

Network Service Orchestrator

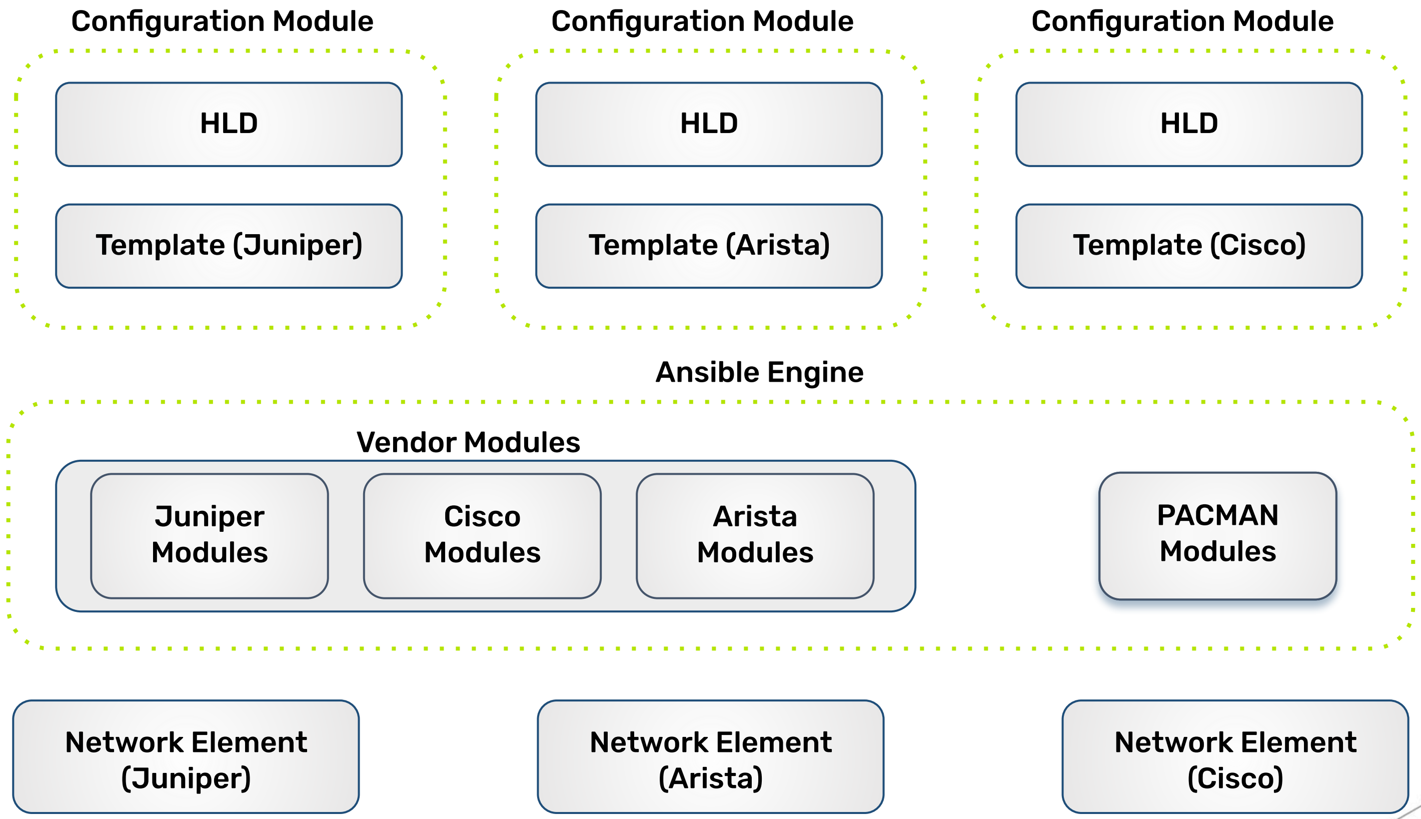


PACMAN

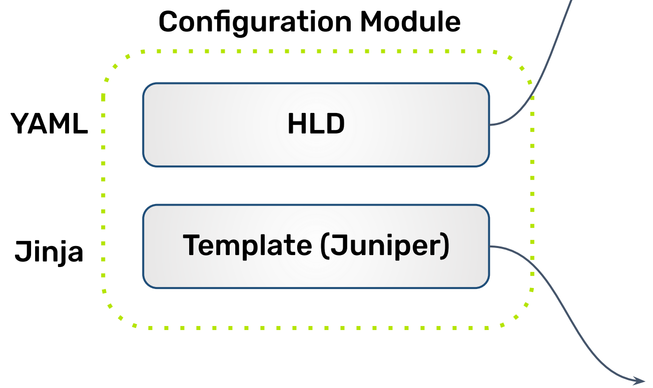
Packet Layer Configuration Manager

Automation	Compliance	CI/CD	Change tracking	Scalability
Advanced Configuration Automation with Ansible	Validation of Designed vs Running Configurations	Native Integration into CI/CD Pipelines	Change tracking through a NetBox plugin	Modular and Suitable for Distributed, Large-Scale Networks

PACMAN – Architecture



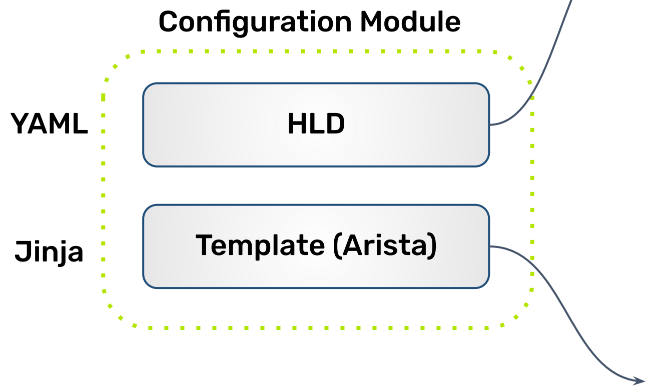
PACMAN – Architecture



```
bb_intf:
  et-0/0/0:
    bb_ip_v4: 185.191.181.237/31
    bb_ip_v6: 2001:760:ffff:ffbb:0:0:181:237/127
    description: link1
  et-0/0/1:
    bb_ip_v4: 185.191.181.252/31
    bb_ip_v6: 2001:760:ffff:ffbb:0:0:181:252/128
    description: link2
```

```
{# ---------------------------- #}
{#   BackBone Interfaces         #}
{# ---------------------------- #}
{% for intf_k, intf_v in bb_intf.items() %}
    set interfaces {{ intf_k }} apply-groups grp-intf-backbone
    set interfaces {{ intf_k }} description "{{ intf_v.description }}"
    set interfaces {{ intf_k }} unit 1 description "{{ intf_v.description }}"
    set interfaces {{ intf_k }} unit 1 family inet address {{ intf_v.bb_ip_v4 }}
    set interfaces {{ intf_k }} unit 1 family inet6 address {{ intf_v.bb_ip_v6 }}
    set class-of-service interfaces {{ intf_k }} apply-groups grp-cos-intf-backbone
    set protocols isis interface {{ intf_k }}.1
    set protocols lldp interface {{ intf_k }}
{% endfor %}
```

PACMAN – Architecture



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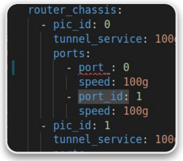
    bb_ip_v4: 185.191.181.252/31
    bb_ip_v6: 2001:760:ffff:ffbb:0:0:181:252/128
    description: link2
```

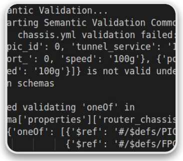
```
{# ----------------------------- #}
{#   BackBone Interfaces         #}
{# ----------------------------- #}
{% for intf_k, intf_v in bb_intf.items() %}
  interface Ethernet{{ intf_k }}
    description {{ intf_v.description }}"
    mtu 9000
    no switchport
    flow tracker sampled ftr1
    ip address {{ intf_v.bb_ip_v4 }}
    ipv6 address {{ intf_v.bb_ip_v6 }}
    isis enable EVPN_UNDERLAY
    isis metric 50
    isis network point-to-point
{% endfor %}
```

Operational Workflow

PACMAN in Daily Operations – From Design to Deployment

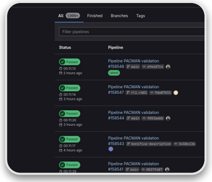


```
router_chassis:
  - pic_id: 0
    tunnel_service: 100
    ports:
      - port_ : 0
        speed: 100g
      - port_id: 1
        speed: 100g
  - pic_id: 1
    tunnel_service: 100
```



```
antic Validation...
arting Semantic Validation Comm
  chassis.yml validation failed:
pic_id': 0, 'tunnel_service': '1
ort_': 0, 'speed': '100g'}, {'po
ed': '100g'}]} is not valid unde
n schemas

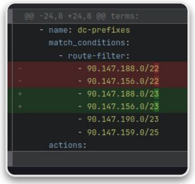
ed validating 'oneOf' in
ma['properties']['router_chassis
{'oneOf': [{'$ref': '#/$defs/PIC
             {'$ref': '#/$defs/FPC
```



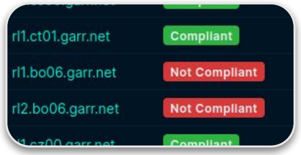
```
All 1,000+   Finished   Branches   Tags

Filter pipelines

Status              Pipeline
Passed              Pipeline PACMAN validation
00:11:13            #158548  main  e9e487c4
2 hours ago         latest
Passed              Pipeline PACMAN validation
00:11:14            #158547  rl1.rm01  9da87031
3 hours ago
Passed              Pipeline PACMAN validation
00:11:20            #158544  main  f053a6bb
3 hours ago
Passed              Pipeline PACMAN validation
00:11:17            #158543  bonifica-description  5458c136
4 hours ago
Passed              Pipeline PACMAN validation
00:11:29            #158541  main  0027f687
```



```
@@ -24,8 +24,8 @@ terms:
      - name: dc-prefixes
        match_conditions:
          - route-filter:
-             - 90.147.188.0/22
-             - 90.147.156.0/22
+             - 90.147.188.0/23
+             - 90.147.156.0/23
              - 90.147.190.0/23
              - 90.147.159.0/25
        actions:
```



rl1.ct01.garr.net	Compliant
rl1.bo06.garr.net	Not Compliant
rl2.bo06.garr.net	Not Compliant

IDE → **Validation / Deploy** → **CI/CD** → **Gitlab** → **Runtime**

IDE: Real-time feedback & fixes for network operator

Validation / Deploy: Local sanity check. Semantic and syntactic validation.

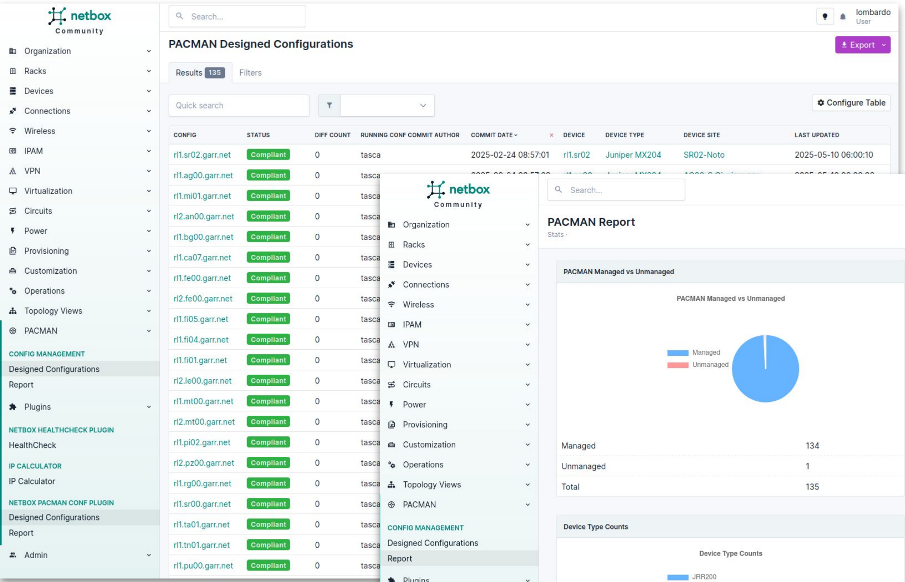
CI/CD: Feedback delivered directly into teams' CI/CD pipelines

Gitlab: Merge Request reviews and fixes delivered directly into GitLab repo

Runtime: Drift Detection ensures Pacman remains the single source of truth

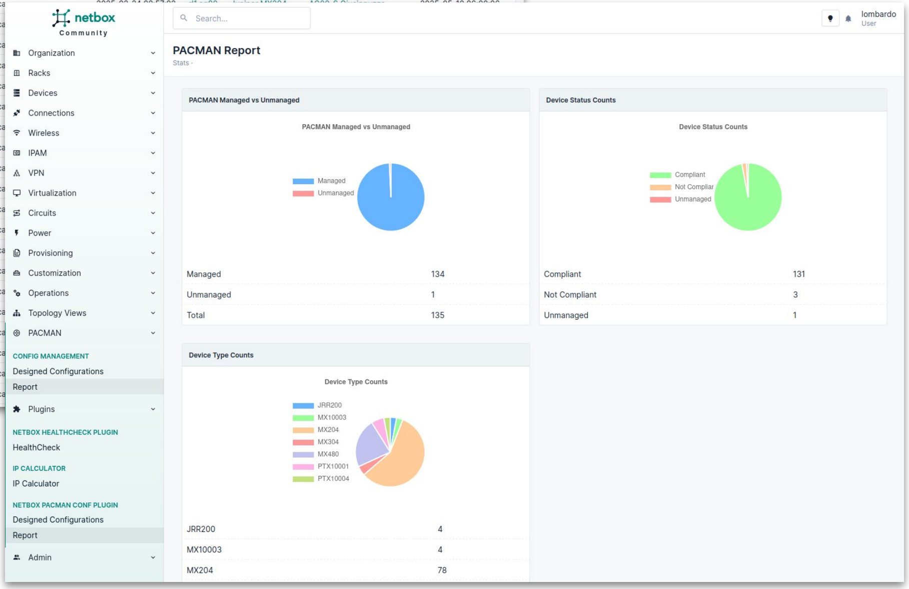
← **Code to Network Config** →

PACMAN Automation & NetBox Integration



PACMAN Designed Configurations

CONFIG	STATUS	DIFF COUNT	RUNNING CONF COMMIT AUTHOR	COMMIT DATE	DEVICE	DEVICE TYPE	DEVICE SITE	LAST UPDATED
rl1.sr02.garr.net	Compliant	0	tasca	2025-02-24 08:57:01	rl1.sr02	Juniper MX204	SR02-Noto	2025-05-10 06:00:10
rl1.ag00.garr.net	Compliant	0	tasca					
rl1.mi01.garr.net	Compliant	0	tasca					
rl2.an00.garr.net	Compliant	0	tasca					
rl1.bg00.garr.net	Compliant	0	tasca					
rl1.ca07.garr.net	Compliant	0	tasca					
rl1.fe00.garr.net	Compliant	0	tasca					
rl2.fe00.garr.net	Compliant	0	tasca					
rl1.fi05.garr.net	Compliant	0	tasca					
rl1.fi04.garr.net	Compliant	0	tasca					
rl1.fi01.garr.net	Compliant	0	tasca					
rl2.le00.garr.net	Compliant	0	tasca					
rl1.mt00.garr.net	Compliant	0	tasca					
rl2.mt00.garr.net	Compliant	0	tasca					
rl1.pi02.garr.net	Compliant	0	tasca					
rl2.pz00.garr.net	Compliant	0	tasca					
rl1.rg00.garr.net	Compliant	0	tasca					
rl1.sr00.garr.net	Compliant	0	tasca					
rl1.ta01.garr.net	Compliant	0	tasca					
rl1.tn01.garr.net	Compliant	0	tasca					
rl1.pu00.garr.net	Compliant	0	tasca					



PACMAN Report
Stats ·

PACMAN Managed vs Unmanaged

Managed	134
Unmanaged	1
Total	135

Device Status Counts

Compliant	131
Not Compliant	3
Unmanaged	1

Device Type Counts

JRR200	4
MX10003	4
MX204	78

✔ **Scheduled Jobs on AWX**
PACMAN is executed automatically on AWX using scheduled jobs.

✔ **Automated Config Validation**
The "plan" is run across all devices to detect config drifts.

✔ **Compliance Evaluation**
Diffs are collected, and the last commit author is checked.

✔ **Git Integration**
Results (diffs, designed configs, metadata) are pushed to a Git repository.

✔ **NetBox Plugin Sync**
PACMAN plugin automatically imports data into NetBox.

✔ **Full Visibility**
Operators get complete visibility into compliance status and change history.

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Team Involvement & Responsibilities

NOC Team

Design Configurations

Reviews Diffs

Approve or Deploys Changes

Automation Team

Extends the Core Framework for New Vendors/Devices

Maintains Templates and Rules

Management

Observes Compliance Trends

Leverages PACMAN Data for Almost Real-Time Visibility and Investigation

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Challenges Faced

Key Obstacles Encountered While Adopting PACMAN

Modernizing Ops: From Commands to Code

Cultural Shift

Operators were used to CLI, not Git, Docker or YAML

Initial resistance to adopting GitOps practices

PACMANization of Existing Infrastructure

Large-scale refactoring of existing device configurations

Created per-device YAML models to reflect actual configuration intent

Cross-team Misalignment

DevOps, NOC, and Network Engineering had different workflows and goals

YAML Standardization

Defining strict schema rules and naming conventions was crucial

How We Overcame the Challenges

Progressive Training on Git, Ansible, Schema Modeling

Refactored Configurations to Ensure Consistency with Design Rules

Iterative Improvement of Validation Logic and CI/CD Jobs

Centralized Visibility through the NetBox Plugin with Diff Tracking and Compliance Dashboards

Current Status and Roadmap

Current Status and Future Plans

Entire GARR-T network devices are fully “pacmanized”

PACMAN fully manages the configuration of all network devices.

PACMAN is now integrated into daily operations

Via scheduled jobs and automated compliance checks

Total devices managed: ~160

With numbers continuously growing

GARR pacman 100% compliant

Future Plans:

- Extend automation to include customer-premises routers managed by GARR
- Integrate with a Workflow Orchestrator (WFO) to manage broader automation pipelines
- Implement automatic remediation to align non-compliant devices with the designed configuration

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Thank You!