

BHUTAN NETWORK OPERATORS GROUP · btNOG13

The Network Fix

From Connectivity Gaps to Seamless Link

Smart Grid Section

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Overview

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LEGACY GRID AND SMART GRID TRANSITION

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PROBLEM STATEMENT

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OPERATIONAL CHALLENGES IN
MULTI-VENDOR NETWORK MONITORING

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NETWORK AUTOMATION VIA NMS APP

Legacy Grid of Bhutan



Manual Operation &
Maintenance
Awareness



Limited Grid Visibility
& Situational
Awareness



Time-Consuming
Manual Line Patrol &
Fault Inspection



Modern Grid of Bhutan (Smart Grid)



**Automated Bi-Directional
Remote Monitoring and Control**



**Enhanced Grid Visibility and
Real-Time Situational Awareness**



**Intelligent Fault Detection and
Automated Line Monitoring**



Challenges and Pitfalls in Smart/Modern Grid

- Interoperability Between Multi-Vendor Devices and Legacy Systems
- Limited Communication Network Coverage in Geographically Challenging Areas
- Cybersecurity Threats and Vulnerabilities
- High communication cost

Problem Statement

1

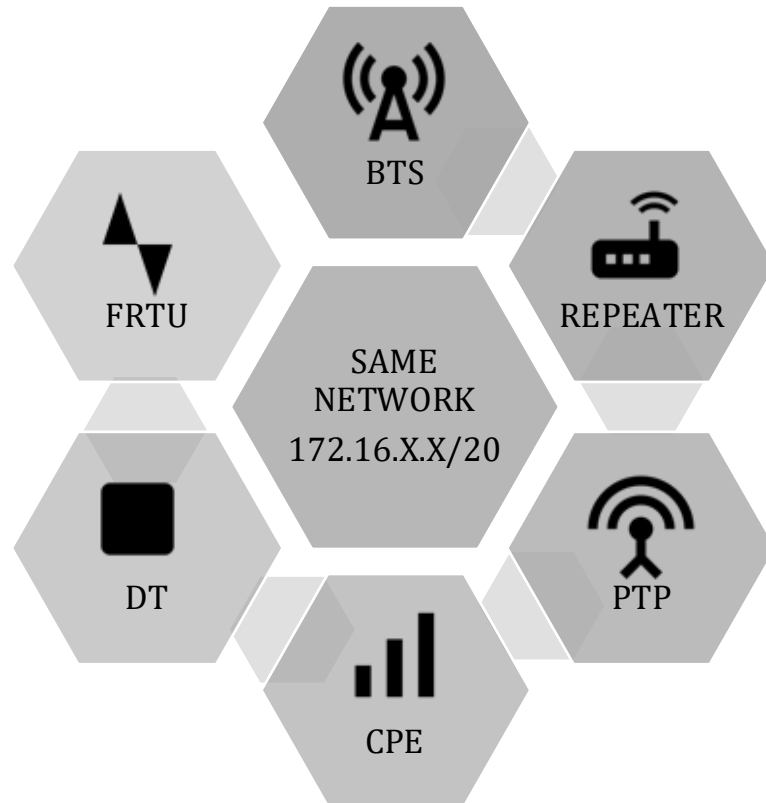
Network congestion

2

Operational Challenges in
Multi-Vendor Network
Monitoring

PROBLEM – Network Congestion

One Flat Subnet, Every Device



ONE SHARED BROADCAST DOMAIN

Every device type: BTS(AP), Repeaters, PTP links, CPE, DT and FRTU - shares one /20.

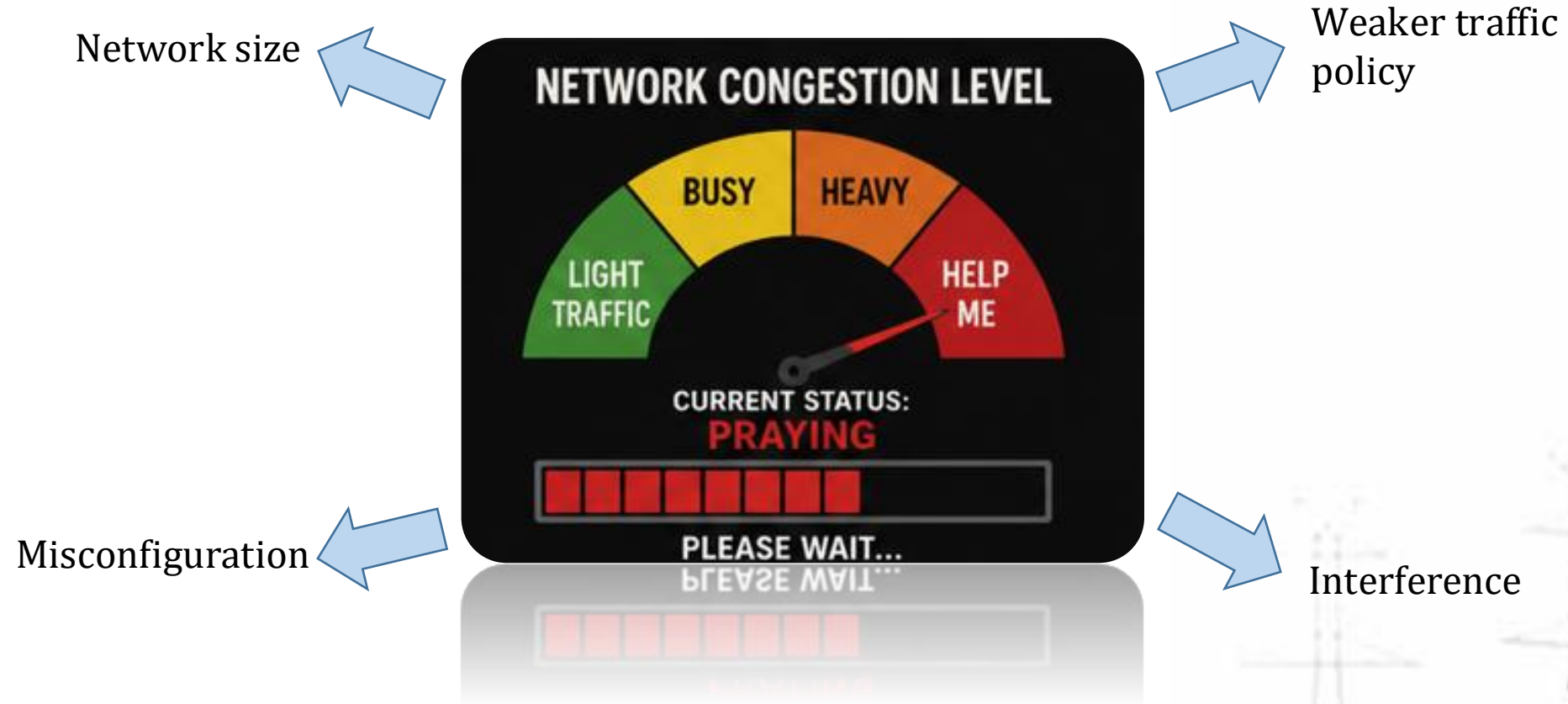
▲ Large broadcast domain

↗ High unnecessary traffic

■ Poor scalability

● Harder troubleshooting

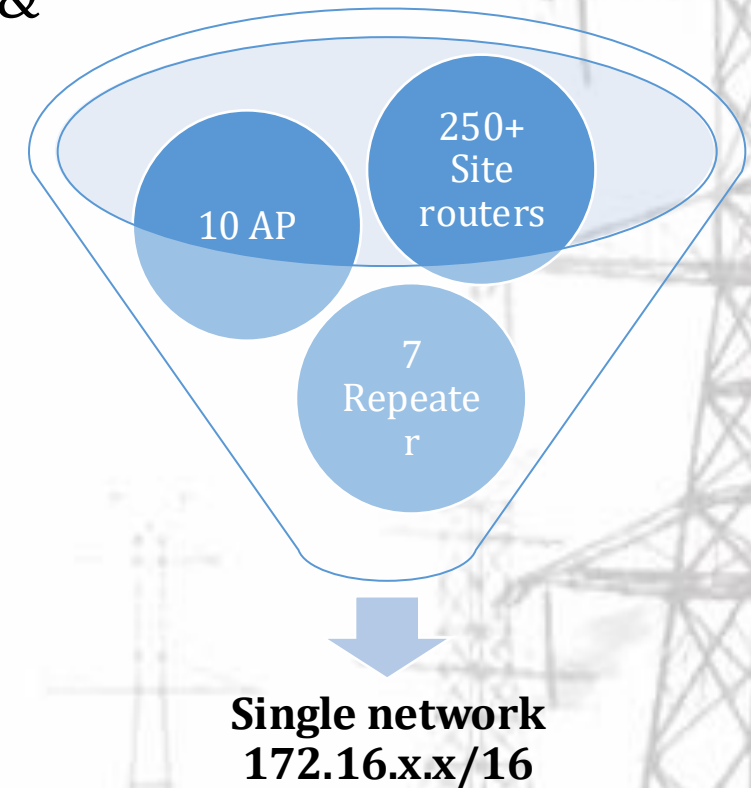
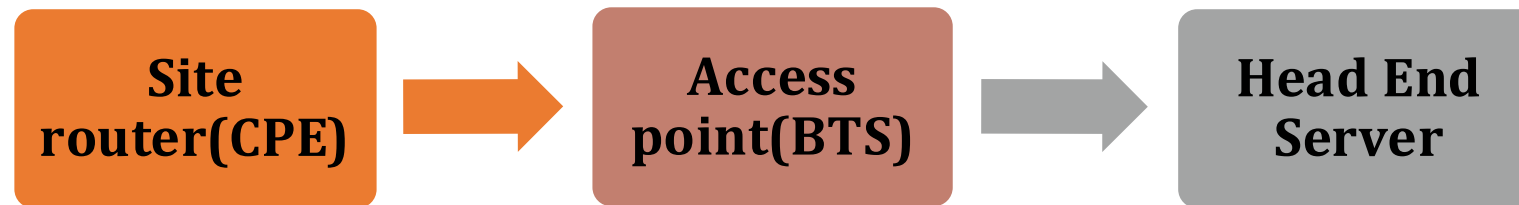
What has lead to network congestion?



Key Observations

Problem/case of Thimphu RF network

- ❑ Connected 250+ power metering sites.
- ❑ Network behaviour: High latency(>100ms), ping delay & packet drop(25%-50%).
- ❑ 75% non-reporting site.



Tracing Congestion: Root cause analysis

Case 1: Core service troubleshooting

Technique	Packet counter state	Service alarm state	PtP (Ping)
Observations	Packet flow state: normal	healthy	No drop

Case 2: AP to Remote CPEs(Allowing all BTS traffic)

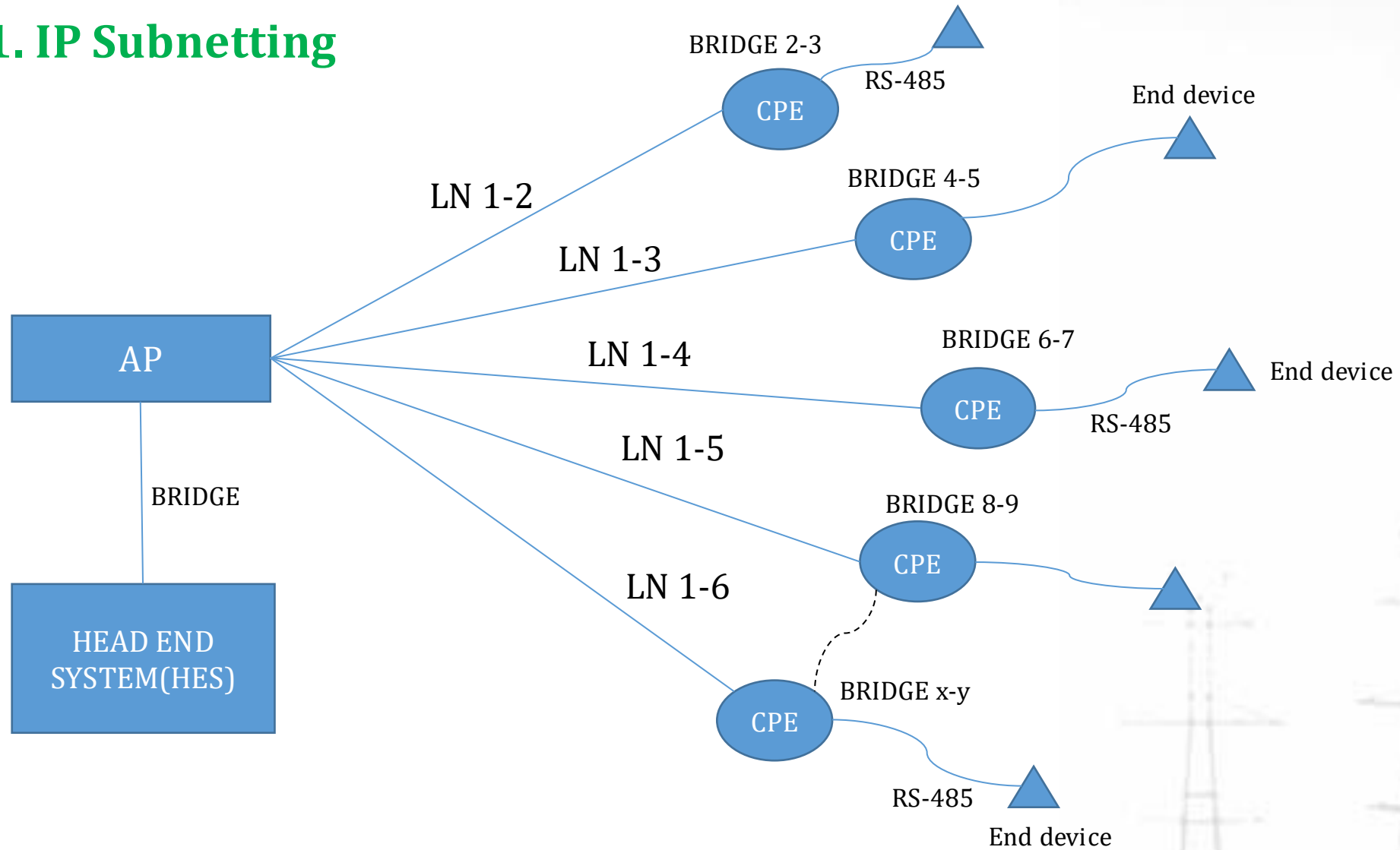
Technique	PtP (Ping)	RSSI	Data reporting state
Observations	25-50% drop	<-90dBm	Fail

Case 3: AP to Remote CPEs(Blocking all BTS traffic, allowing one BTS)

Technique	PtP (Ping)	RSSI	Data reporting state
Observations	No drop	<-90dBm	success

The Solution

1. IP Subnetting



The Solution cont...

1. Access control policy routing

Rule 1: Add rule to allow traffic towards CPE from HES

Source address: HES **dest address:** CPE

Action: Allow

Rule 2: Add rule to allow traffic towards HES from CPE

Source: CPE **dest address:** HES

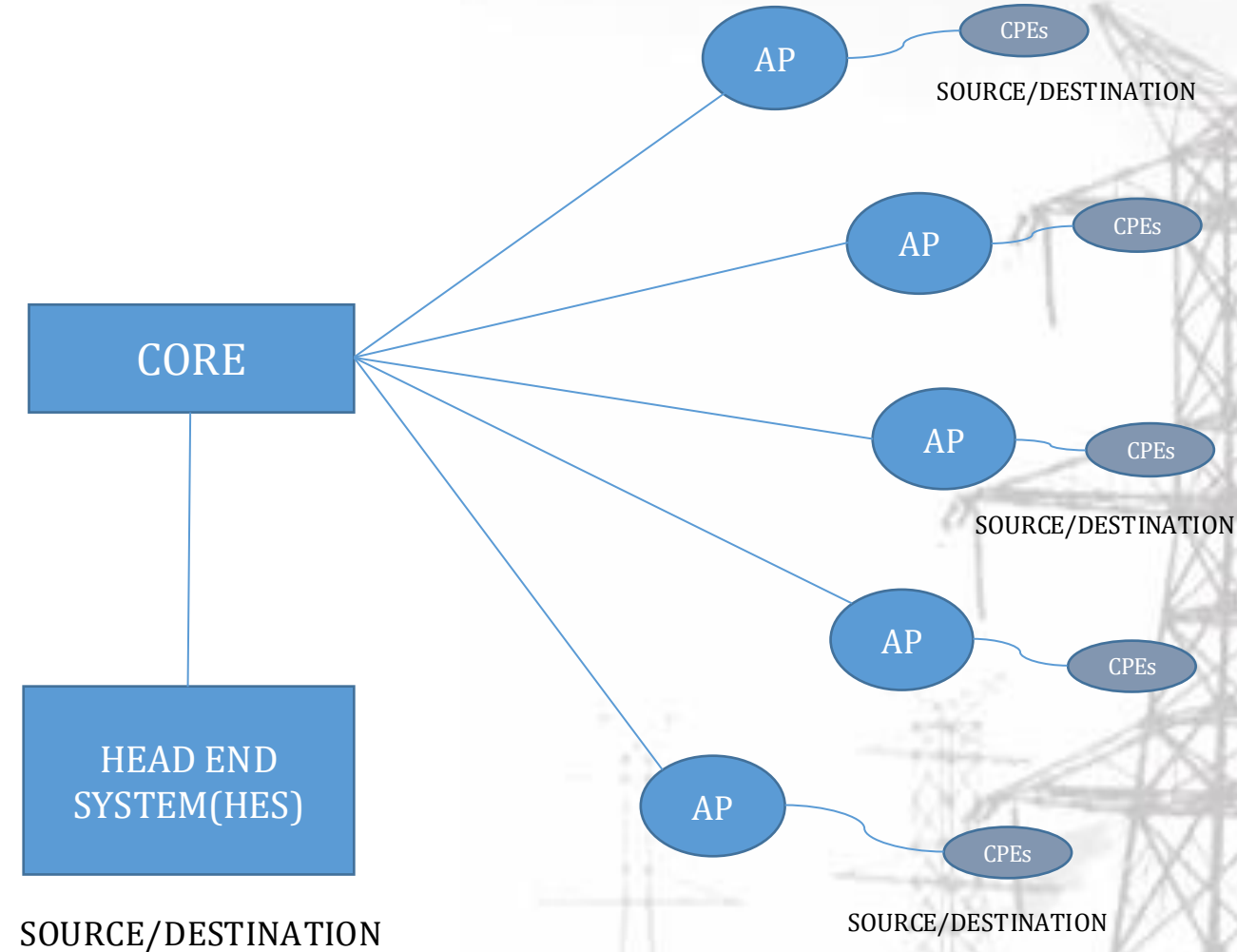
Action: allow

Rule 3: Add third rule to deny all other traffic

Source address: all

Destination address: all

Action: deny



In nutshell

Segmented network

BEFORE

$172.16.x.x / 20$

one large, undivided subnet — all
device types combined

AFTER

BTS

$10.20.x.x / 27$

HES

$10.20.x.x / 27$

CPE

$10.20.x.x / 24$

End device

$10.20.x.x / 24$

Reduced
broadcast
traffic

Better IP
utilization

Simplified
management

Improved
stability



PROBLEM · 2



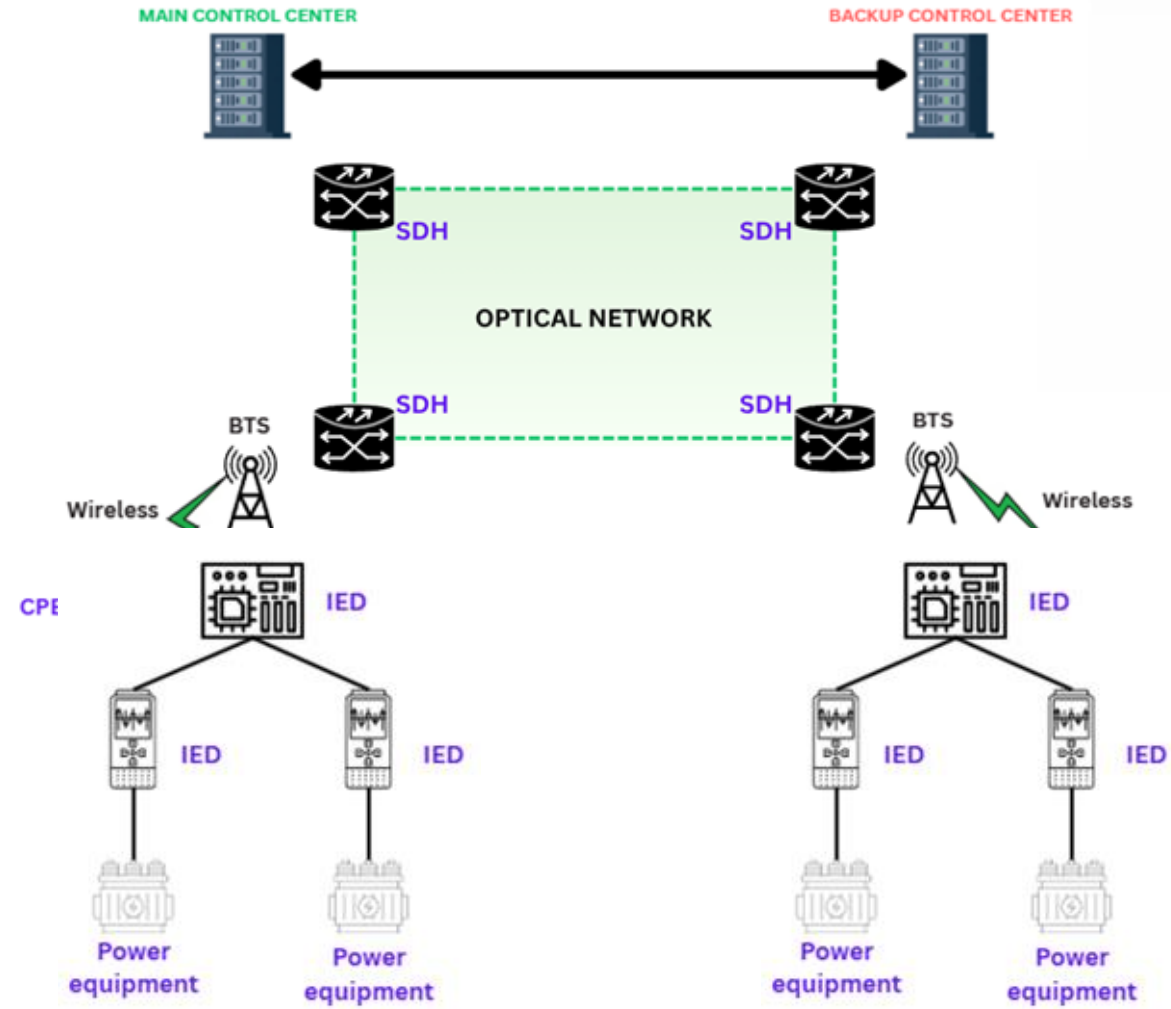
Operational Challenges in Multi-Vendor Network Monitoring



Operational Challenges in Multi-Vendor Network Monitoring

- **Brief Communication Architecture: Optical Network and RF Network**
- **Managing Independent Communication Networks**
- **Manual Monitoring at Scale**
- **Initial Automation Using Batch Scripts via PowerShell/CMD**

Operational Challenges in Multi-Vendor Network Monitoring



Communication Architecture Summary

Operational Challenges in Multi-Vendor Network Monitoring

Data Collection (Field Layer):

- **Power Equipment** (transformers, circuit breakers, etc.) sends raw operational data directly to field-level **IEDs** (Intelligent Electronic Devices).

Last-Mile Wireless Transport (RF Layer):

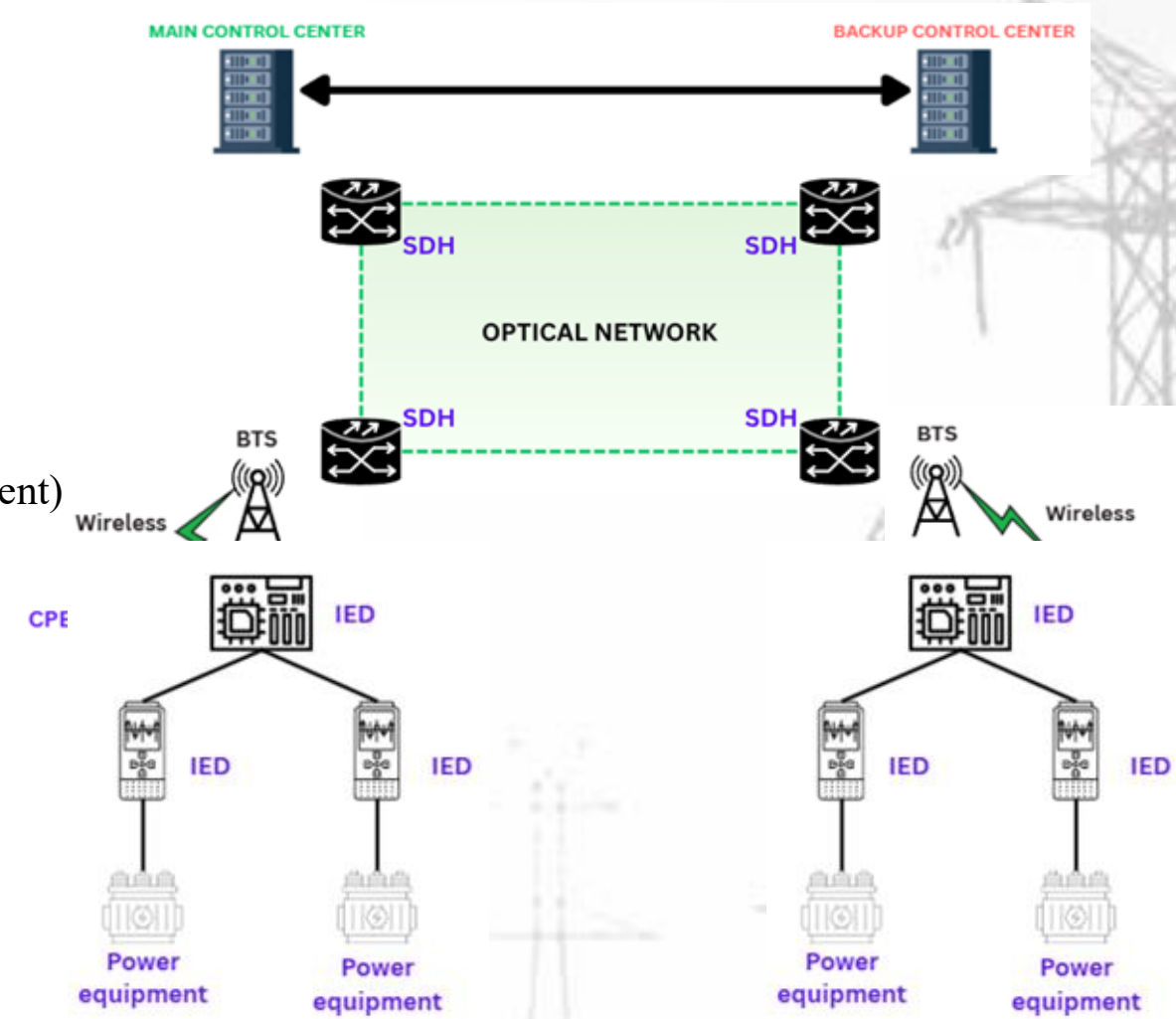
- Local IED data is transmitted via **CPE** (Customer Premises Equipment) over a wireless/RF link to a local **BTS** (Base Transceiver Station).

Core Transport Network (Optical Layer):

- The **BTS** offloads wireless data into an **Optical Network Ring** constructed using **SDH** (Synchronous Digital Hierarchy) nodes.

Centralized Management (Control Layer):

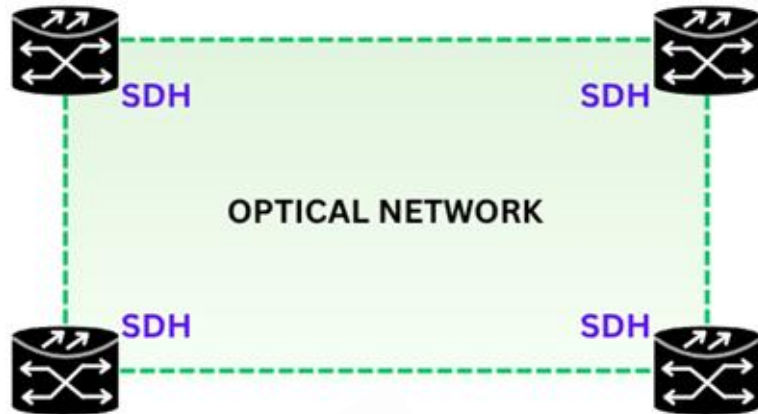
- Data travels through the optical network to the **Main Control Center**.



Communication Architecture Summary

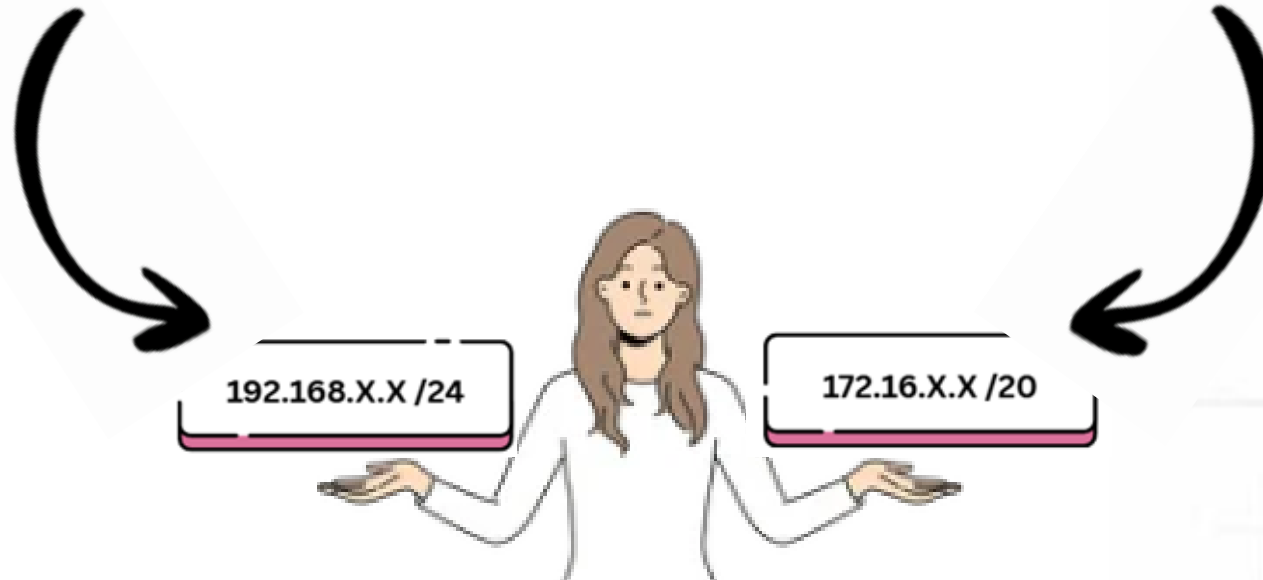
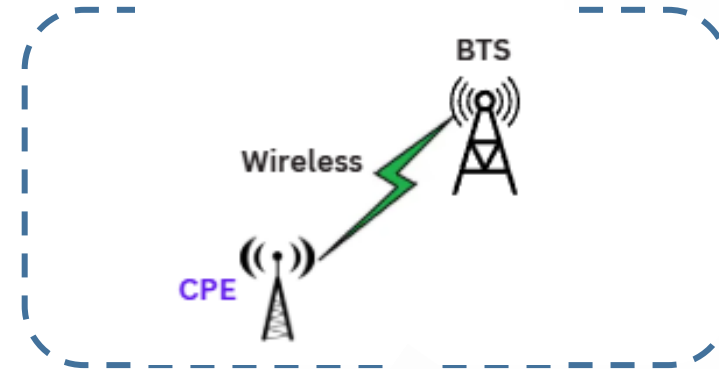
Managing Independent Communication Networks

FIBER OPTIC NETWORK



Different
Network

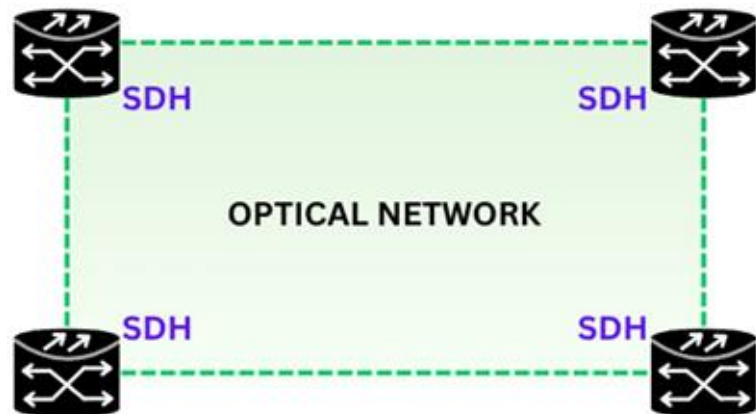
RF NETWORK



Managing Independent Communication Networks

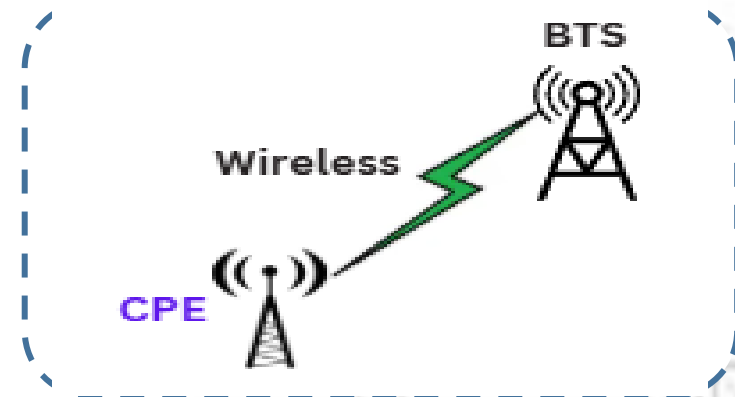
Optical Network

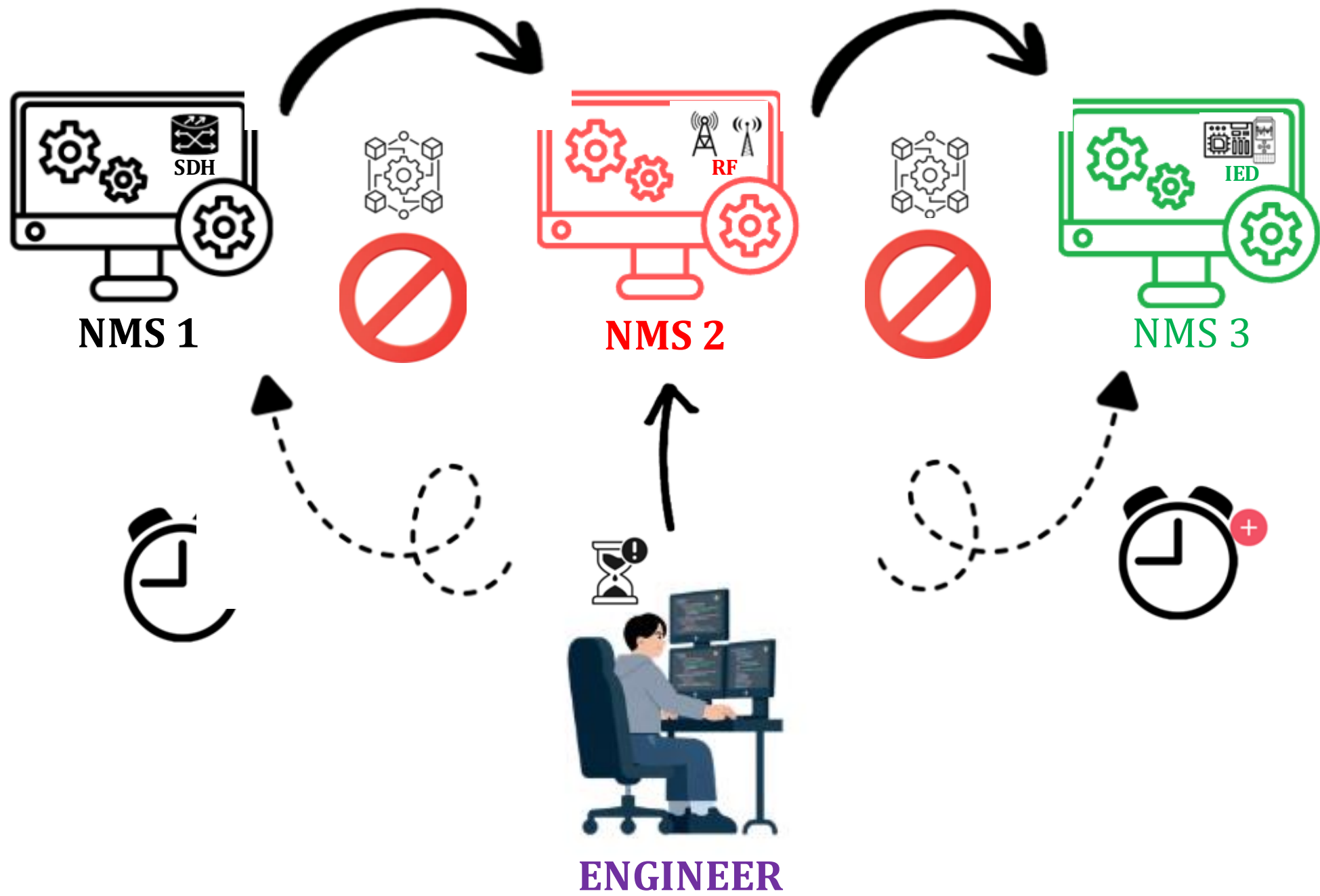
- **Isolated Fiber Architecture:** Operates on dedicated SDH nodes and optical infrastructure.
- **Standalone NMS:** Requires operators to log into a separate, dedicated optical management system.
- **Siloed Management:** Status monitoring, device configuration, and fault diagnosis are restricted strictly to optical parameters.



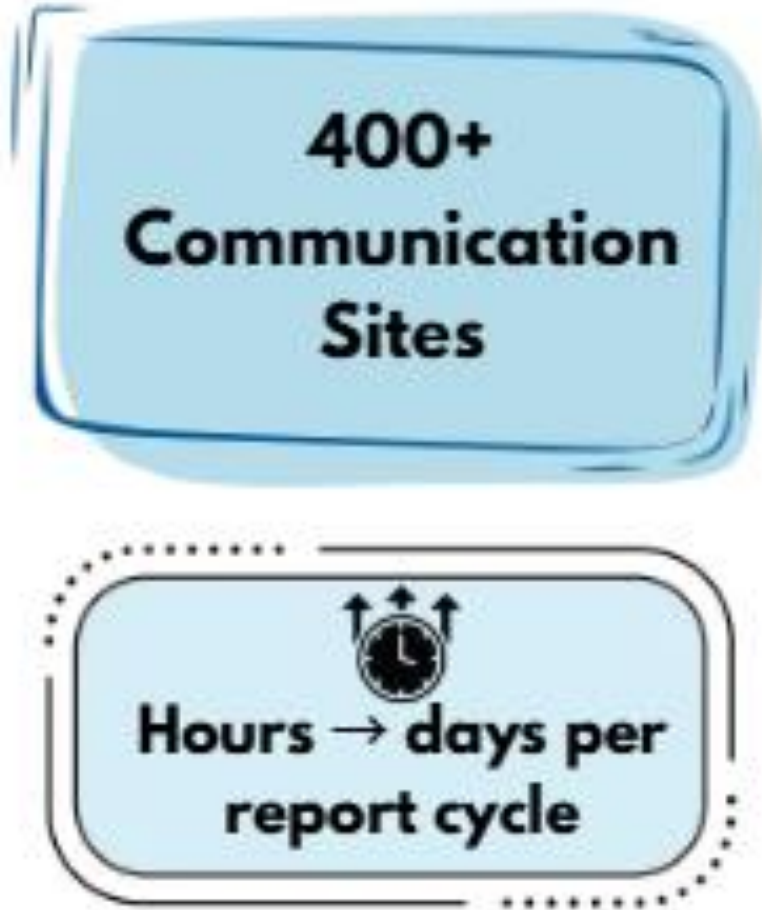
RF Network

- **Independent Wireless Infrastructure:** Operates using dedicated BTS, CPE, and RF link protocols.
- **Separate RF NMS:** Demands access via a distinct wireless management platform.
- **No Unified Visibility:** Engineers must switch systems to view RF status: preventing real-time, simultaneous monitoring across both layers.





Manual Monitoring at Scale



Complex Multi-Layer Infrastructure:

- Network spans **400+ communication sites** involving optical (SDH), wireless (BTS, CPE), and field-level IEDs/devices (RTUs, DT Meters).

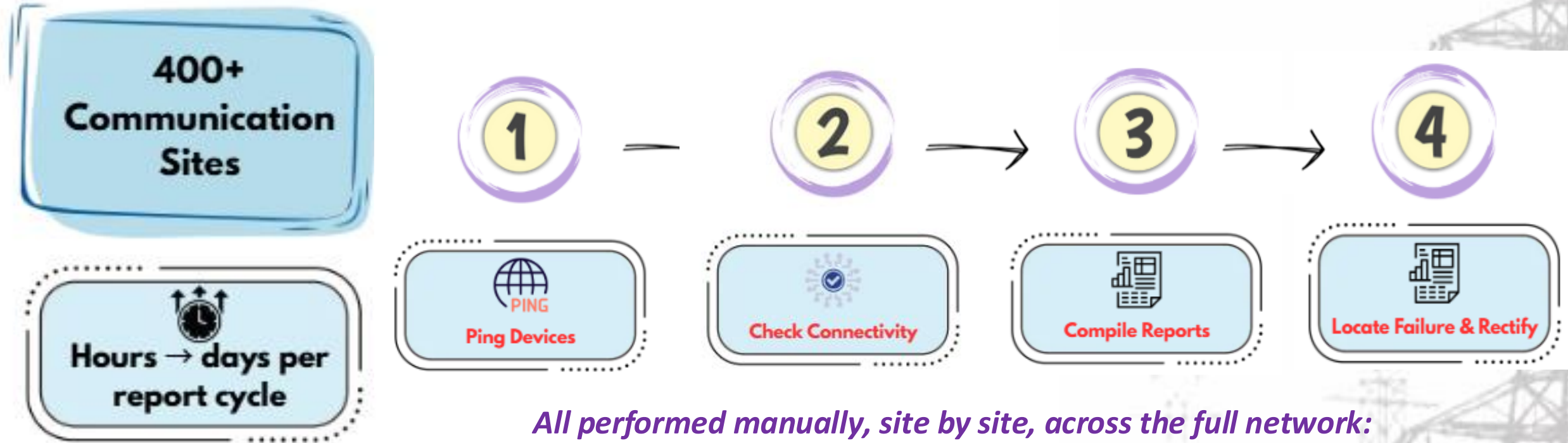
Operational Tasks:

- **Device Status Checks:** Continuously verifying uptime across all nodes across separate platforms.
- **Data Validation:** Confirming active, valid data reception (since an "UP" device may still transmit stale data).
- **Incident Planning:** Identifying offline sites and manually coordinating response/rectification plans.
- **Manual Reporting:** Compiling status logs and sheets by hand for performance tracking.

The Scaling Bottleneck:

- Executing these manual steps across **400+** sites slows operations down exponentially, turning routine report cycles from **hours into days**.

Manual Monitoring at Scale

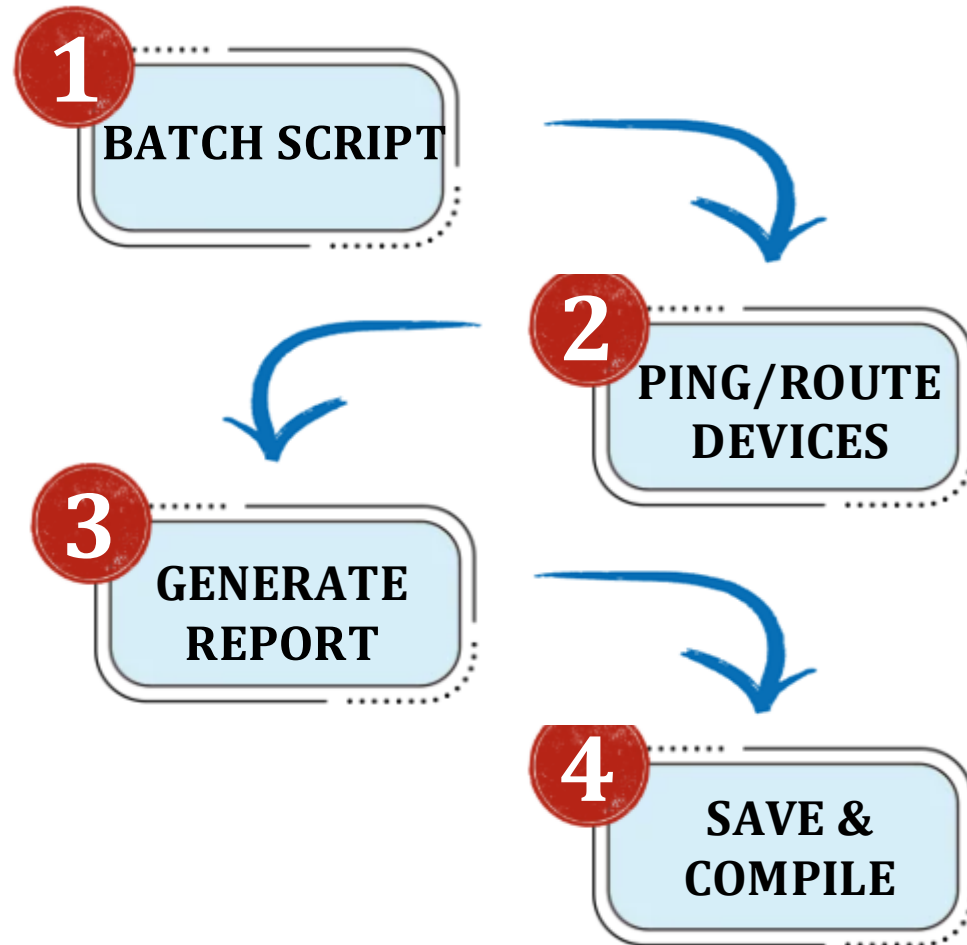


*All performed manually, site by site, across the full network:
every single time.*



First Step Towards Automation

- Initial Automation Using Batch Scripts via PowerShell/CMD*

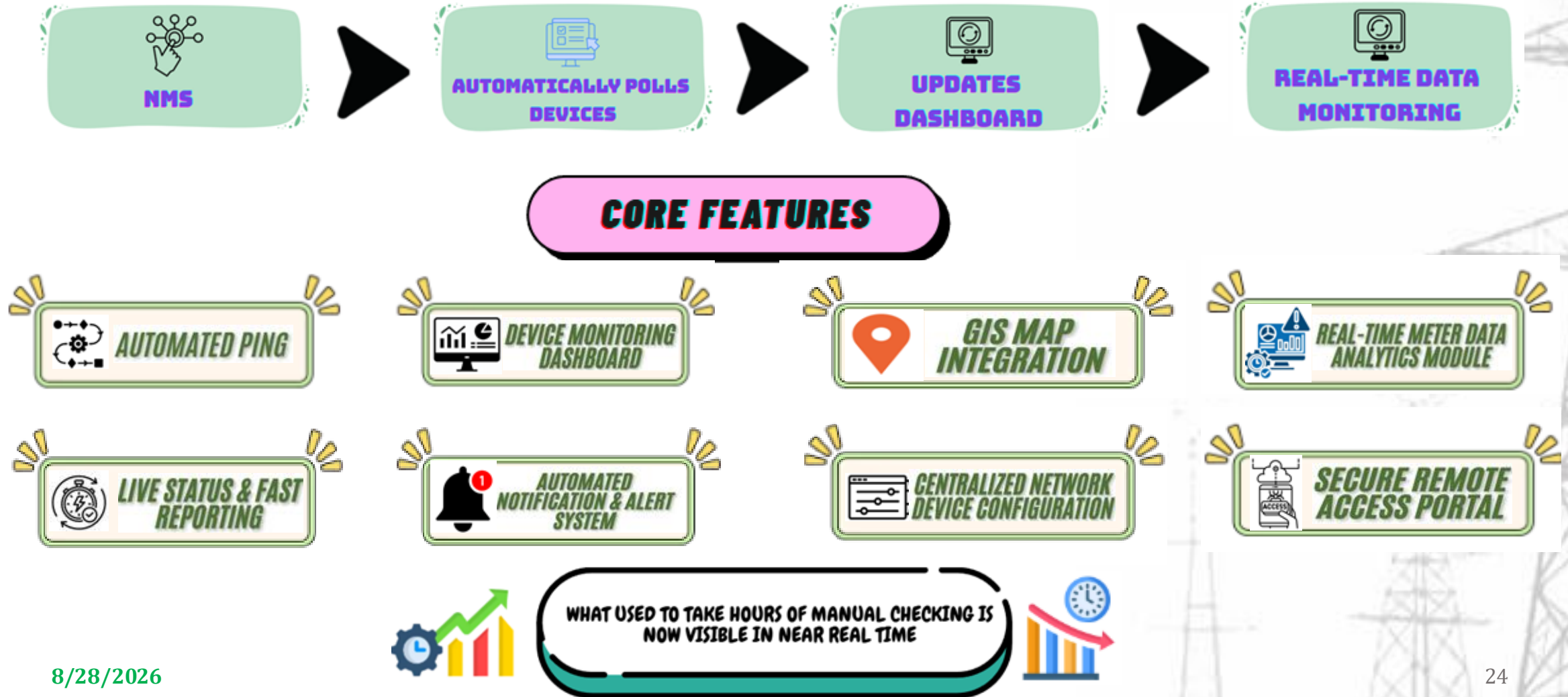


Automated	Still Manual
Ping execution	Switching between RF and Optical networks
Report generation	Waiting for one process before starting another
Basic connectivity checks	Device-by-device inspection
Reduced typing	Manual report consolidation
Faster than manual pinging	Spreadsheet updates and historical tracking

Limitations of Script-Based Monitoring

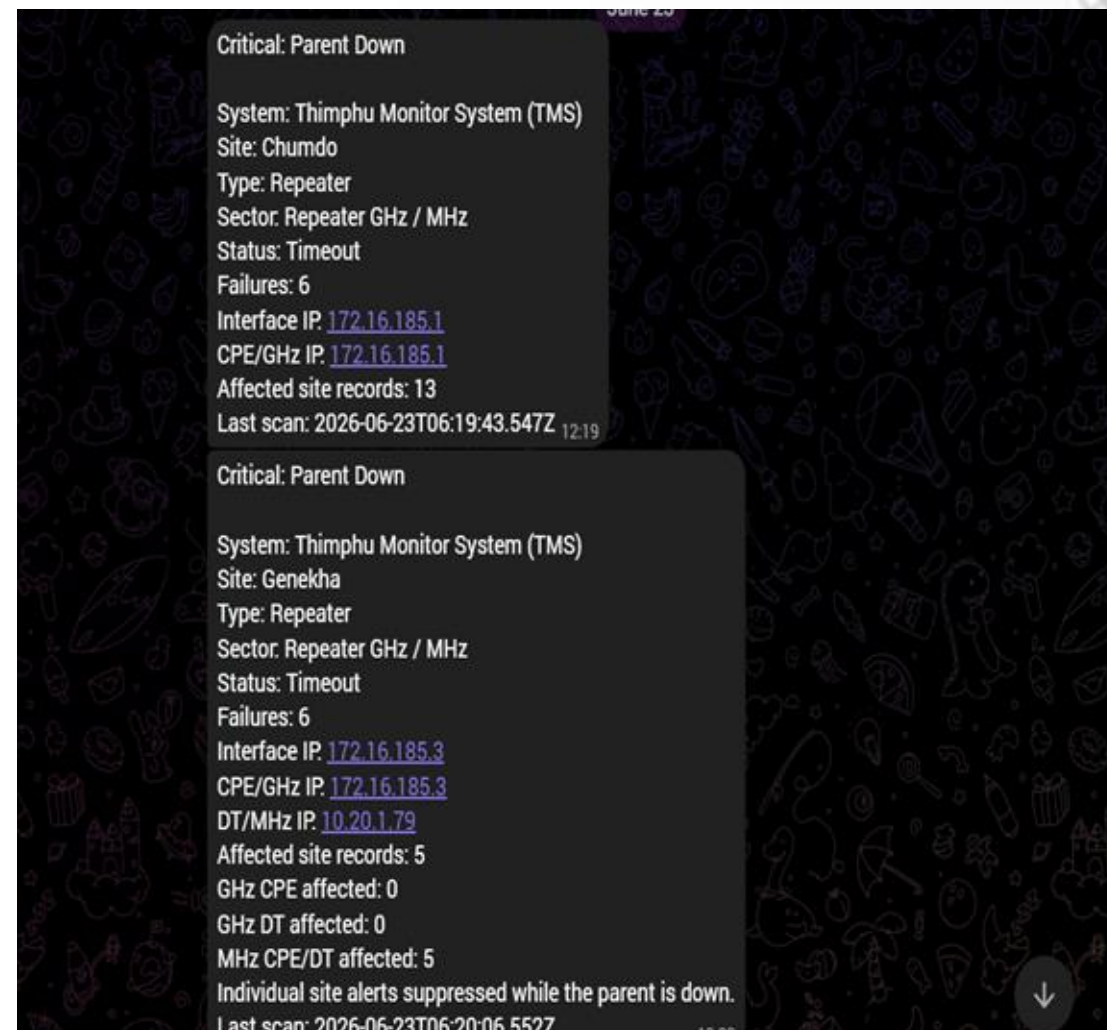
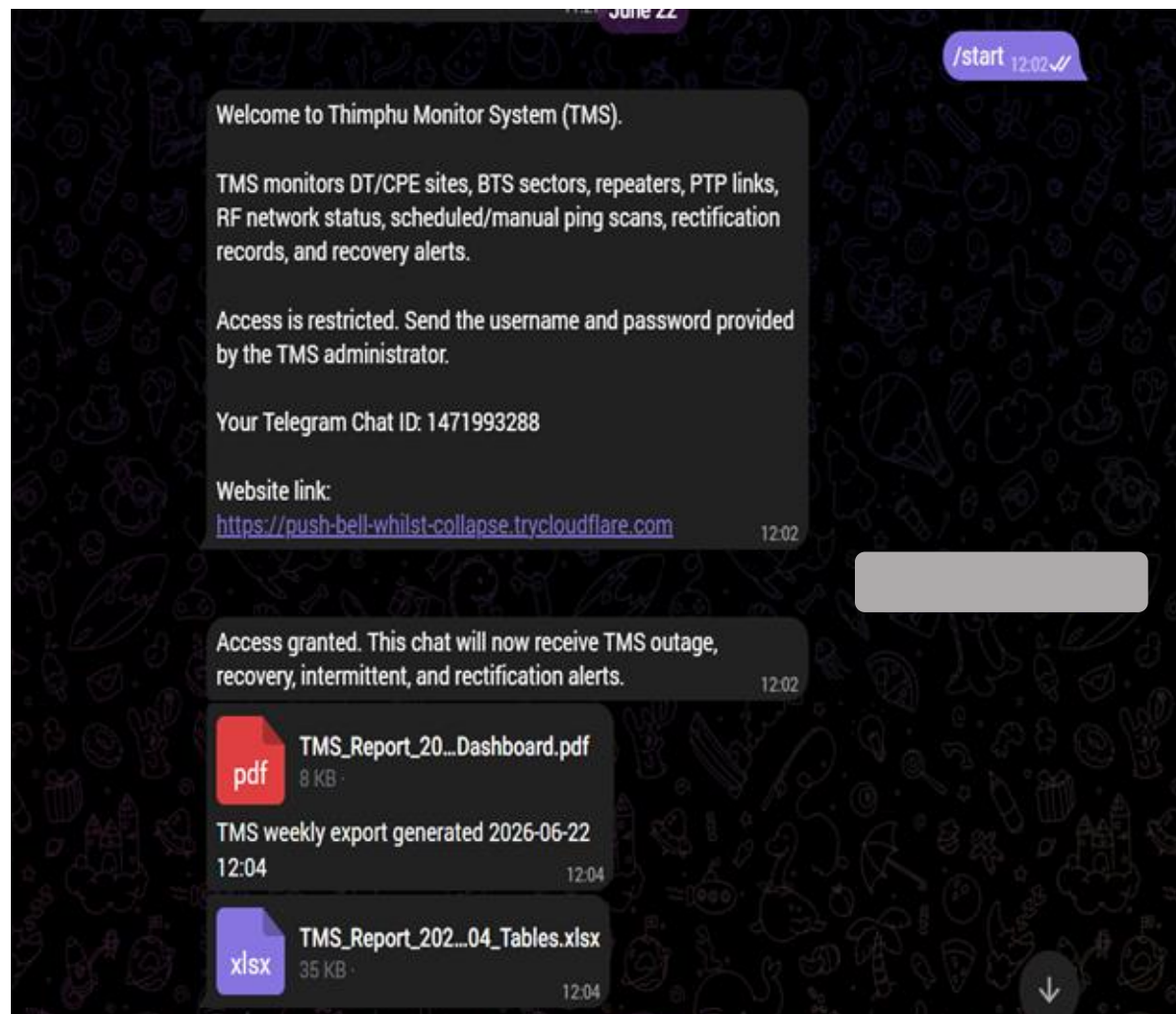
Solution – Network Automation via NMS App

- Created a Network Management System (NMS) App



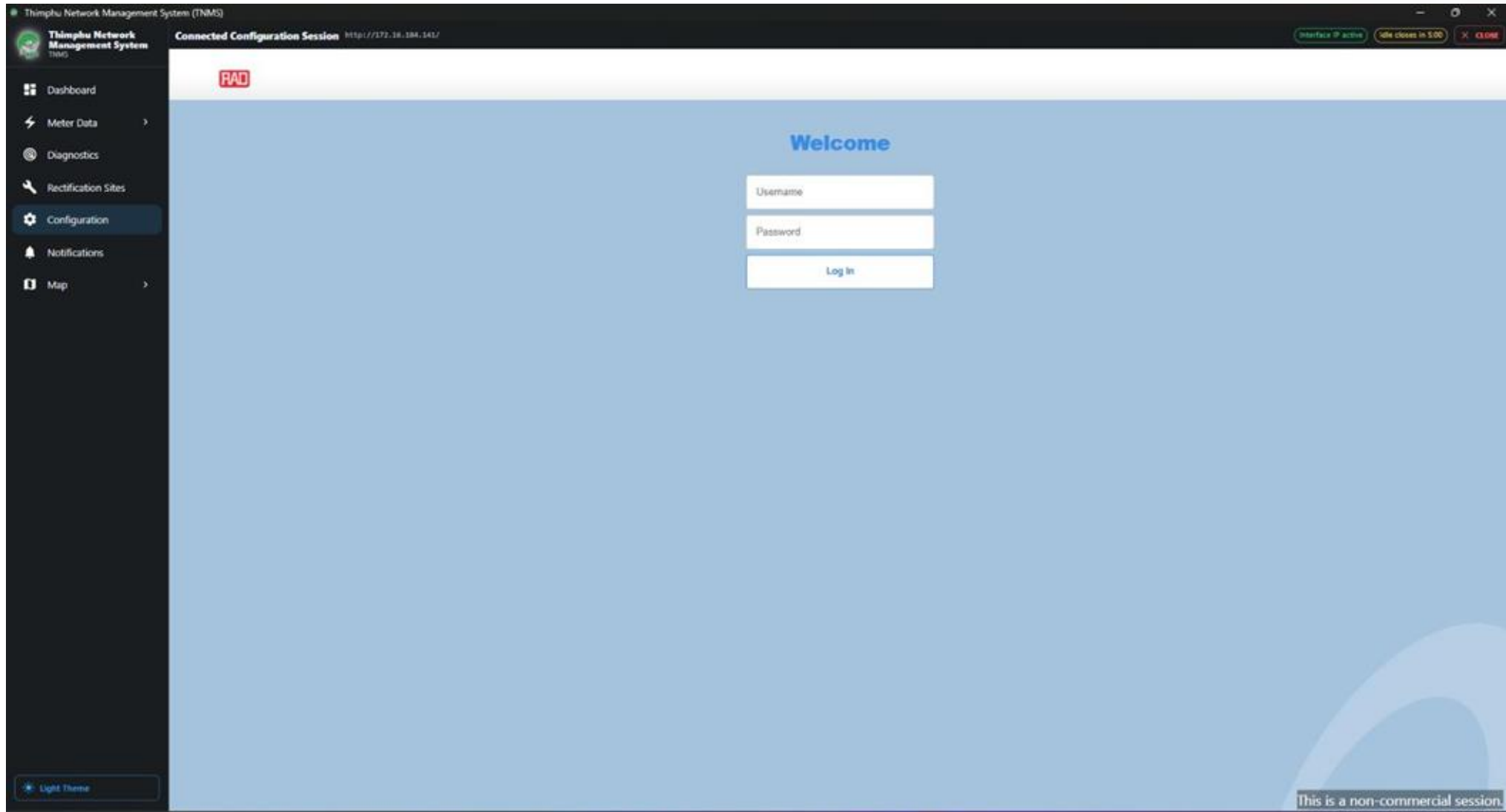
NMS APP LIVE DEMO

NMS App – Alert and Notification





NMS App – Configuration Page



Technical Challenges

- **Legacy & Multi-Vendor Integration:** Working across SDH, BTS, CPE, DT and FRTU equipment with different behaviors and platforms.
- **Multi-Layer Fault Isolation:** Identifying whether issues originated from the optical network, RF link, CPE or end device.
- **Network Segmentation & Policy Routing:** Implementing subnetting and traffic-control policies without disrupting existing communication.
- **Large-Scale Automation:** Integrating monitoring across **400+ sites** and reducing dependency on manual checks.
- **Validation & Reliability:** Verifying connectivity, packet loss and actual data reporting under live network conditions.
- **Network Interference:** Implementing changes across geographically dispersed sites was challenging due to **difficult terrain, long travel distances, and link instability.**

Conclusion & Summary

1

**Network Congestion
&
Segmentation**

2

**Multi-vendor
Network Monitoring**

3

**Network Automation
NMS App**



THANK YOU & ANY QUESTIONS?



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