Network Function Insertion for Reliable and Secure Control Messaging Over Commodity Transport

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CYBER RESILIENT ENERGY DELIVERY CONSORTIUM

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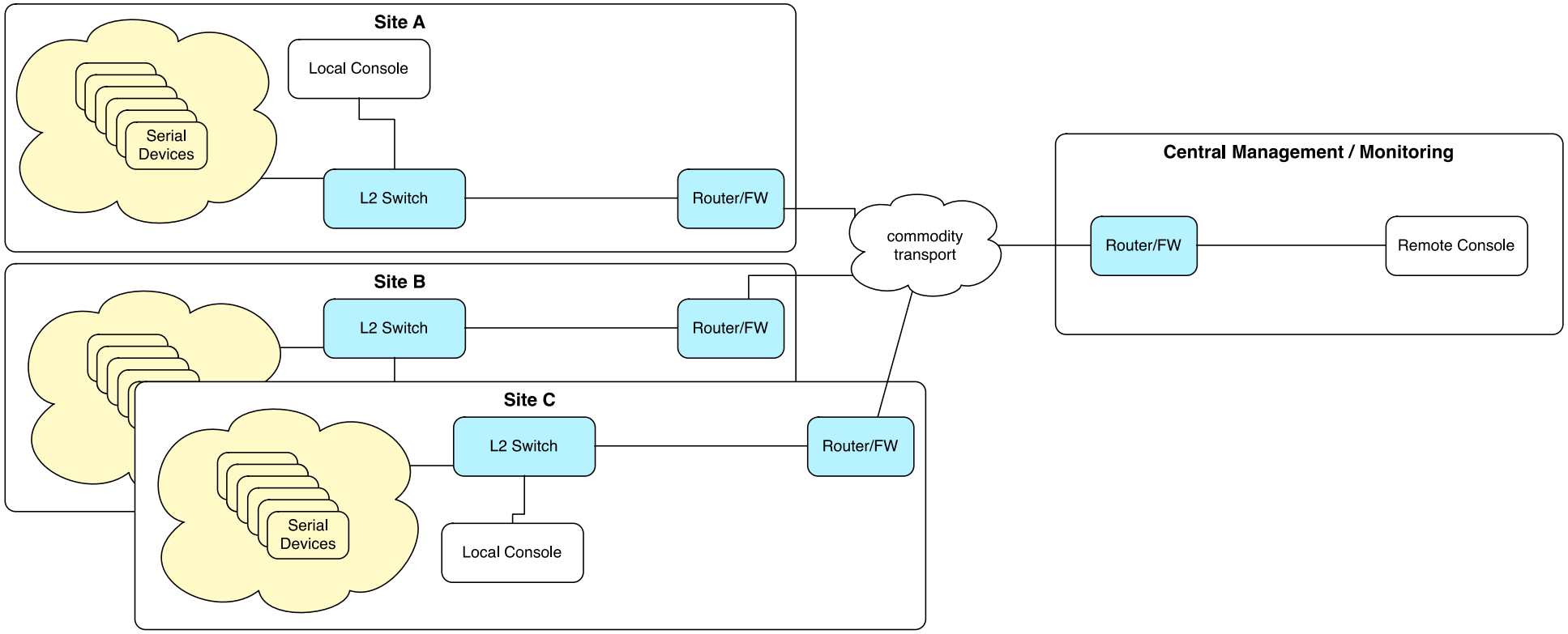
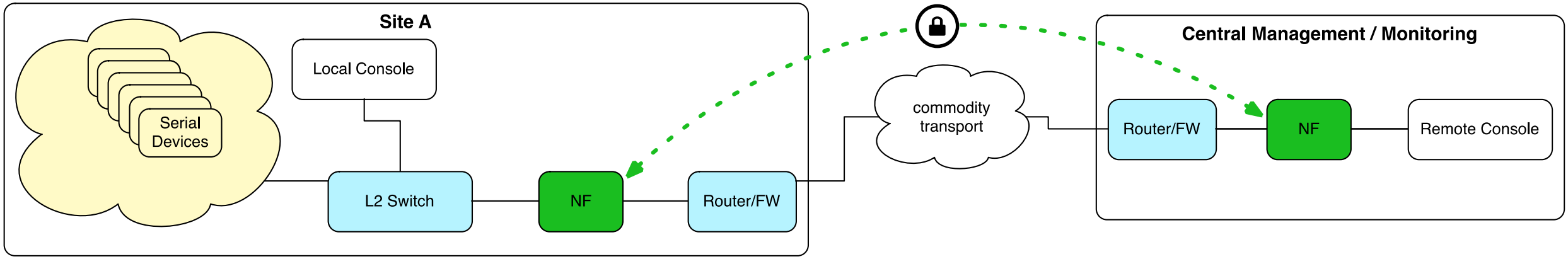
Resiliency against Threat Vectors in Commodity Transport

- Sensor data and control directives from oil/gas production facilities are transmitted unencrypted using unreliable transport protocols over lossy network infrastructures
- Network threats evolve on a time scale significantly faster than the upgrade schedules of industrial equipment



Resiliency Solution: Network Function Insertion

- Decouple the implementation of secure, reliable transport from the actual industrial hardware
- Provide agility in responding to new threats without downtime or vendor upgrades
- Design and implement a network function which can be deployed without infrastructure disruption into existing ICS

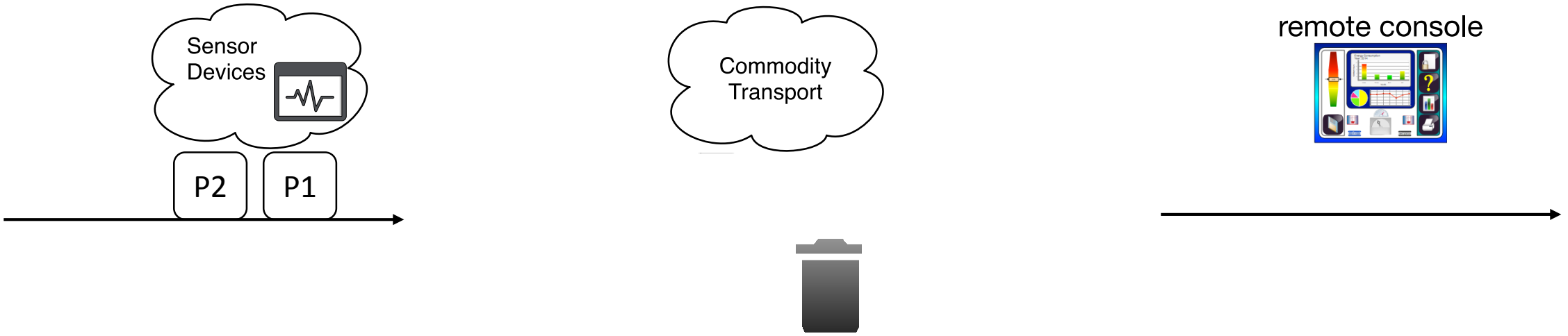


Resiliency through Policy Enforcement

- Network transport quality
  - Loss
  - Delay
  - Re-ordering
- Threat vectors: injection attacks
  - Signed packets: Integrity of the system – system control data:
    - Injection by an external third party
    - Injection by an internal third party
  - Encryption: Privacy – system sensor data:
    - Listening by a third party

POLICY: control knobs with trade-off

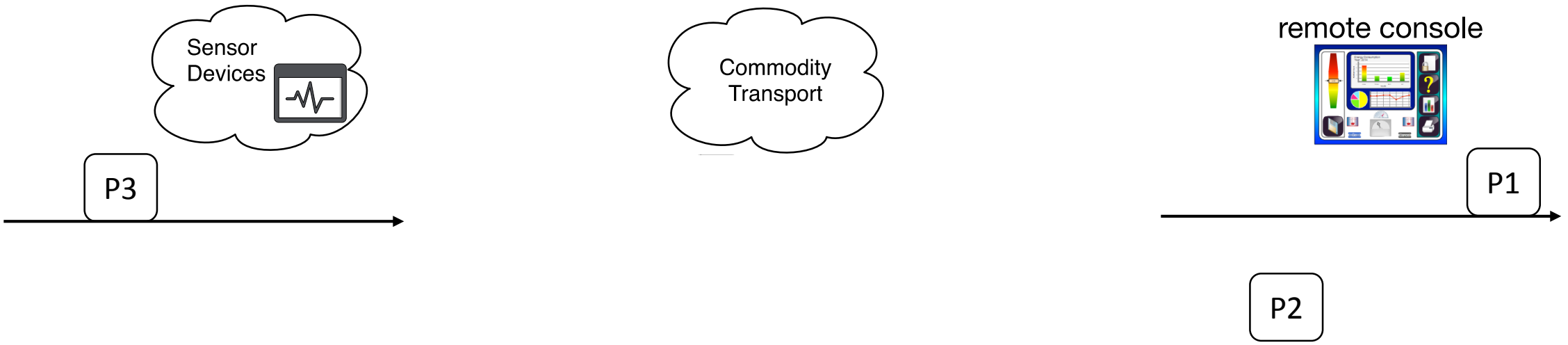
- A lossy network:



POLICY: control knobs with trade-off

- A lossy network:

Existing protocols: retransmissions, lost connections, end point (*not flow-specific*) tuning

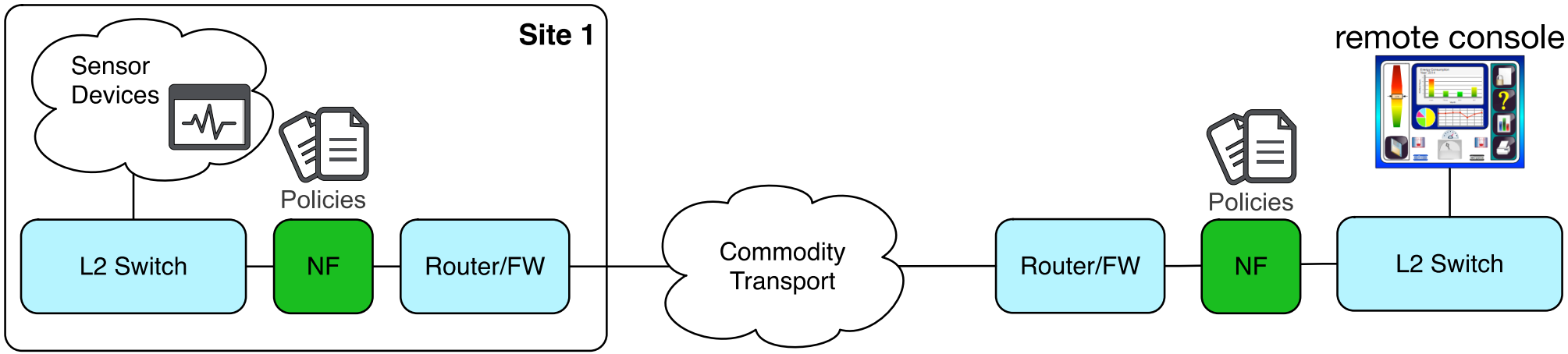


Custom POLICY: delayed but GUARANTEED delivery

Custom POLICY: NO delivery unless IN-ORDER

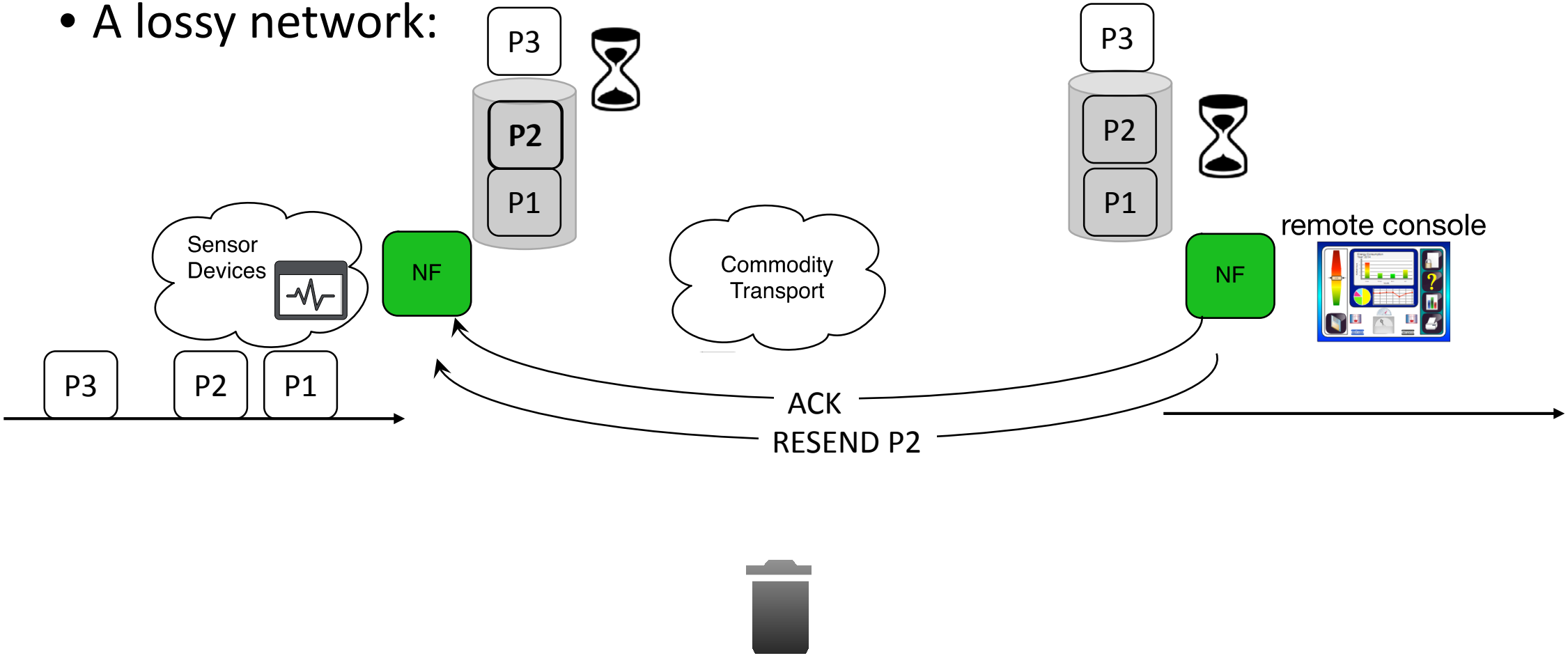
Resiliency – Network Transport Quality

- Loss, delay, re-ordering



POLICY: control knobs with trade-off

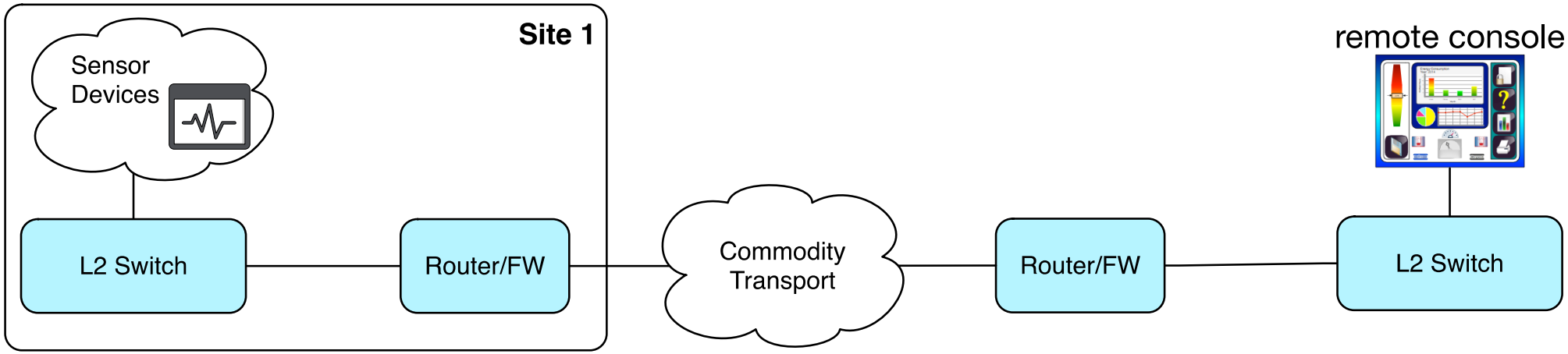
- A lossy network:



Custom POLICY: GUARANTEED delivery – *delayed on lost packets*

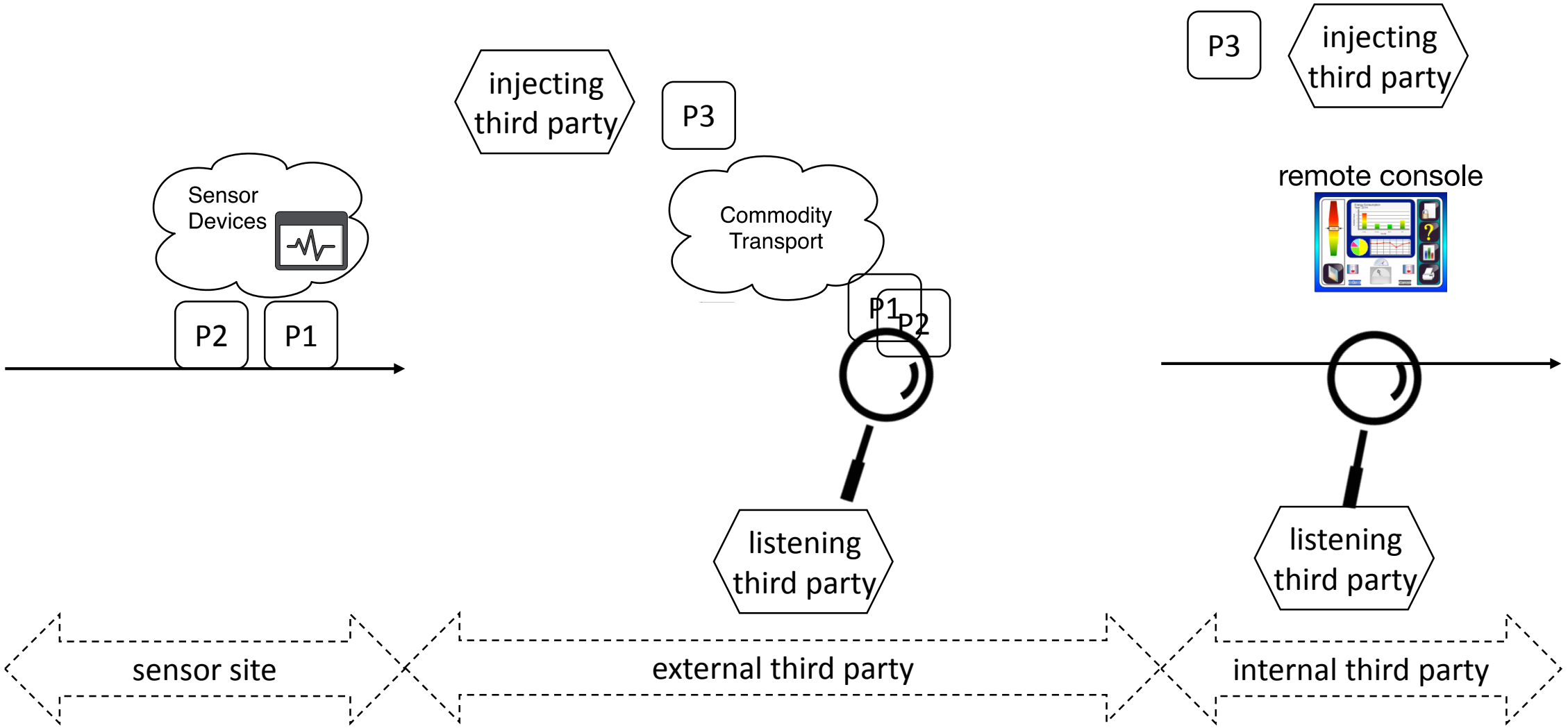
Resiliency – Attack Vectors: injections

- Integrity of the system (system control/sensor data), privacy (sensor data)



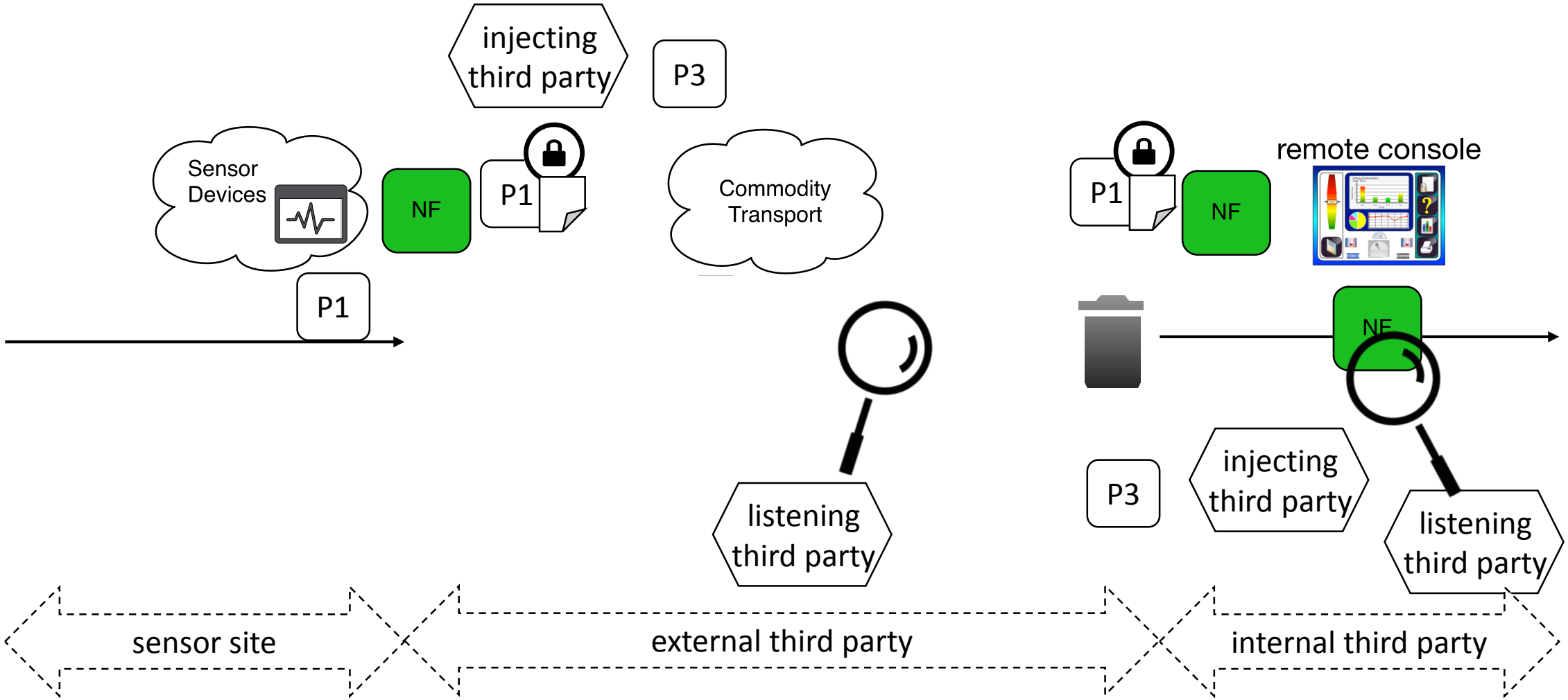
Resiliency against attacks

Existing protocols: end to end protection with firewalls, without signed packets *per flow*



POLICY: guarantee access by authorized personnel and keep sensor/control data private

Custom POLICY: signed and encrypted packets of the *flow*



Reconfigurable ICS Scenario on UH Testbed

- Support ***multiple concurrent arbitrary isolated*** topologies, with MTS (Managed Topology Services) orchestration system:
  - Software-defined networking scenarios
  - Critical infrastructure security
  - Internet of things
  - Computer networking education
- UH Testbed Resources:
  - Over 1000 1Gb and 10Gb switch ports from Brocade, Cisco, Dell/Force10, HP, Intel, and Pica8
  - Over a dozen SDN switches
  - A variety of specialized forwarding devices (NPUs, hybrid server-switches, etc.) from Caros, Cavium, Freescale, Intel, and Znyx
  - Over 250 general purpose CPU cores and 1.5TB of ram across two dozen servers
  - Over 100TB of raw storage capacity and 24 line-rate taps

Network Function Insertion: Testbed Setup

- Number of sites
- Sensors per site
- Sensor emulation software at sensor nodes
- Management emulation software at remote console

- Loss
- Delay
- Reorder

- Without a NF - baseline behavior of the network
- With NF - network function software at NF nodes

Project Next Steps

- Reference implementation that achieves representative ICS scenarios with configurable loss and delay.
- A test suite for the reference implementation using the UH Testbed.
- A specification document for the network function deployment and logical functionality.
- Analysis to show the level of resiliency achieved through the network function deployment.
- Validation and verification results of our implementation and testbed setup in collaboration with PNNL.

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