



PNNL-SA-141891

Software Defined Networks for Energy Delivery Systems

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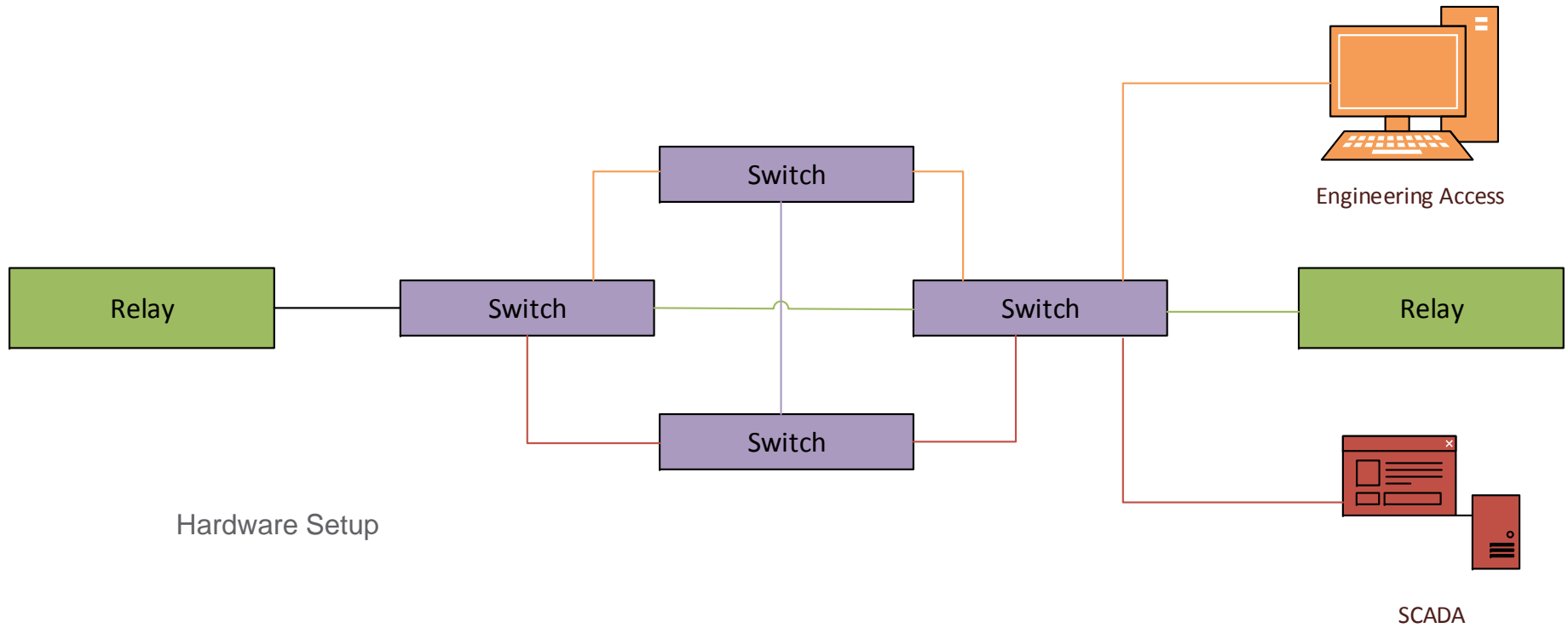


What is SDN?

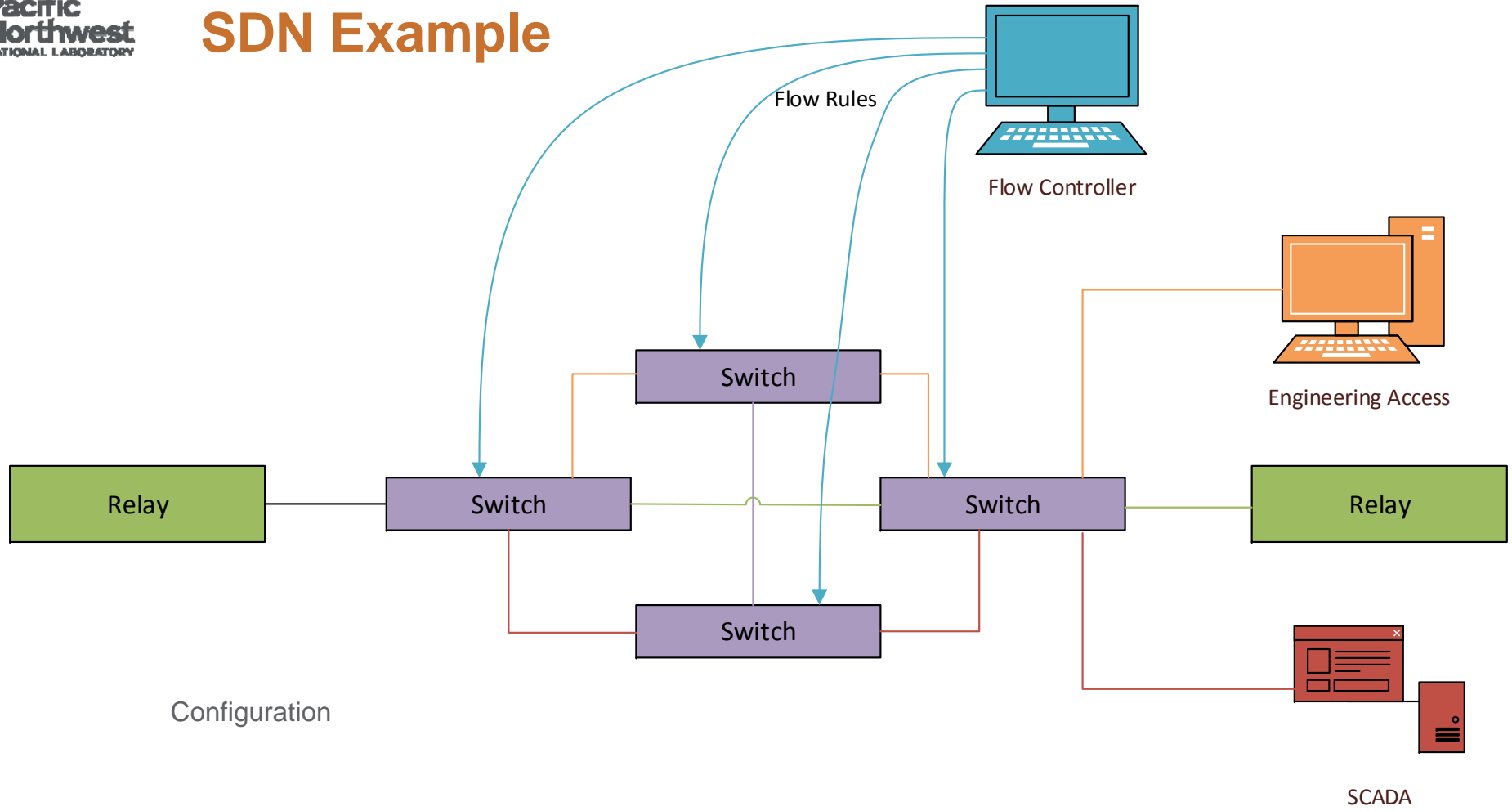
- Think of a combined FACTS device and a Remedial Action Scheme (RAS) for communication networks
 - Engineered network traffic flows
 - Path routing decisions made on a per-frame basis, in real-time, with more granularity than in a traditional router or VLAN switch environment
 - Recover from link failures in less than 1ms
- Whitelist network environment
 - No devices communicate unless specifically configured
 - No packets flow unless specifically configured
- Separate “data plane” from “management plane”
- Widely deployed in traditional IT (data center) environments
- Commercial products available for substation LAN
- OT-SDN – SDN designed for a high availability real-time environment



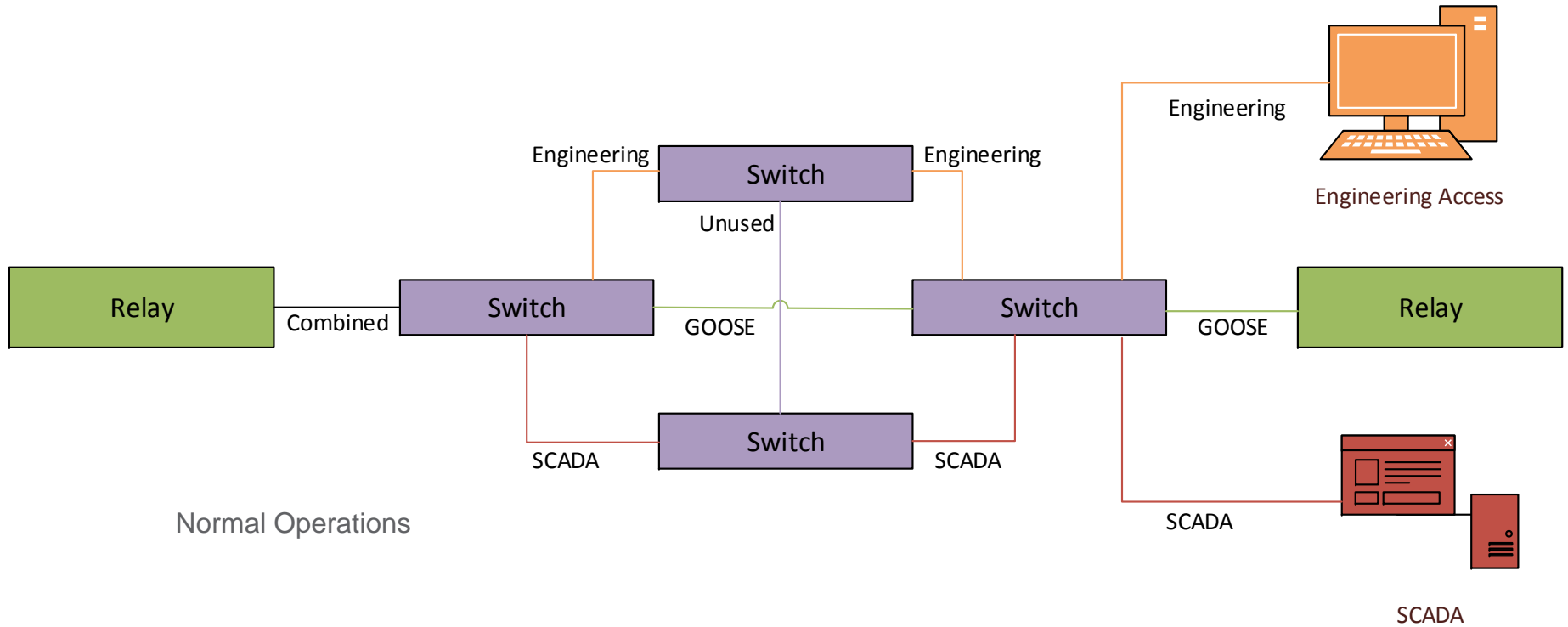
SDN Example



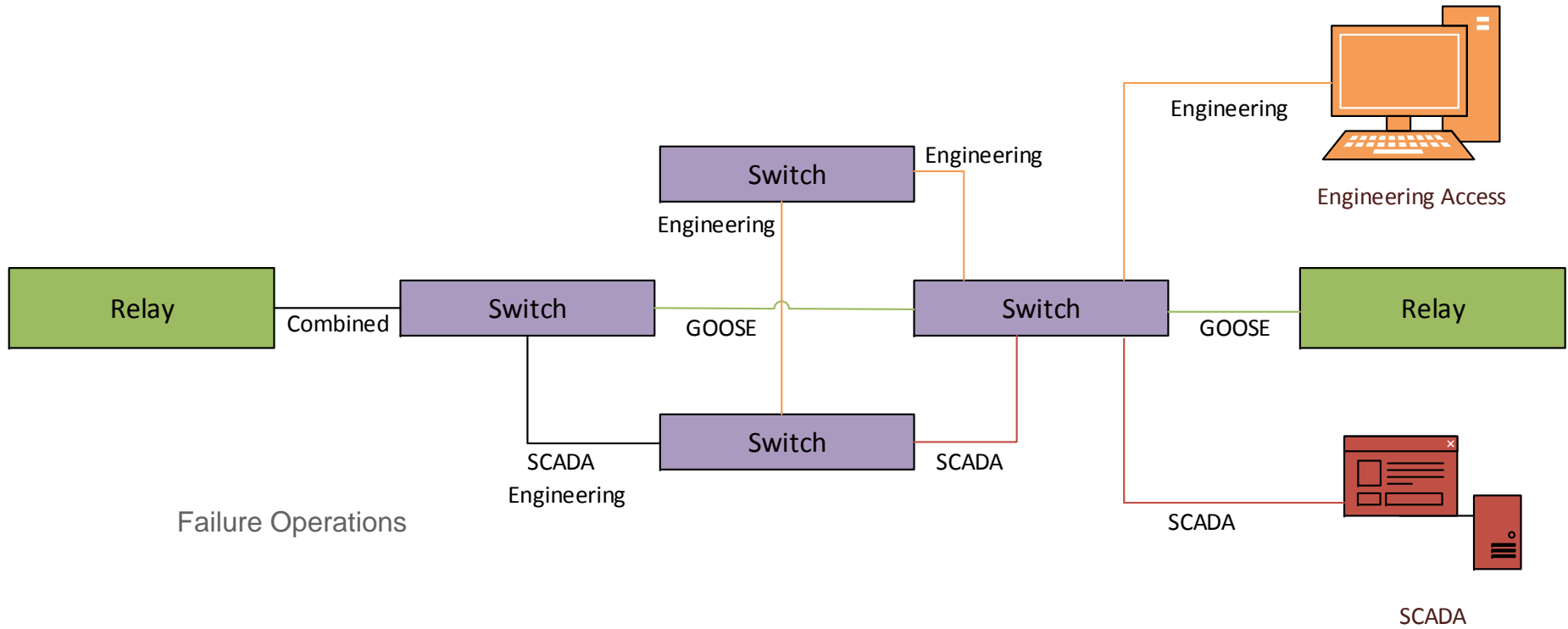
SDN Example



SDN Example

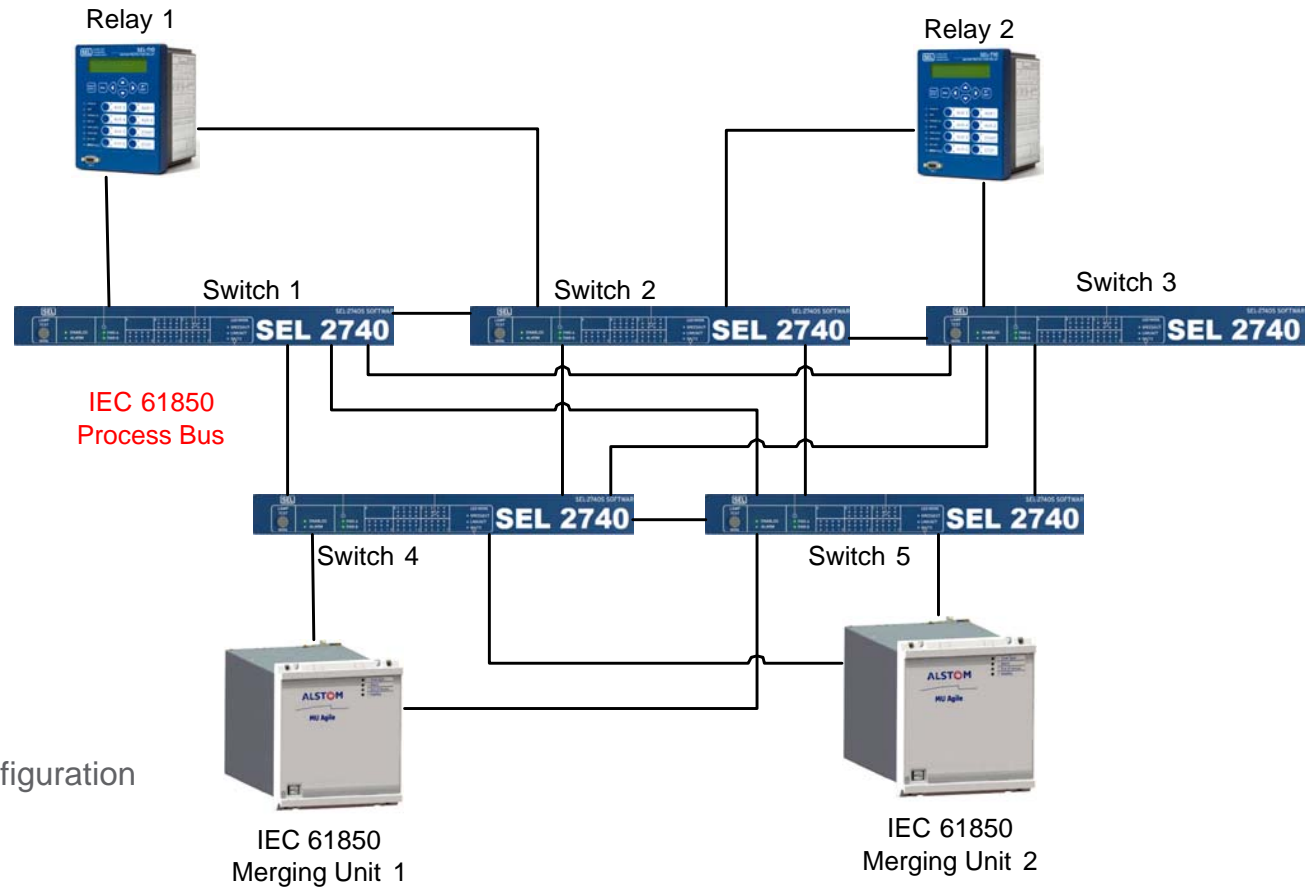


SDN Example



Failure Operations

SDN Example



Resilient Configuration



SDN4EDS Project Goals

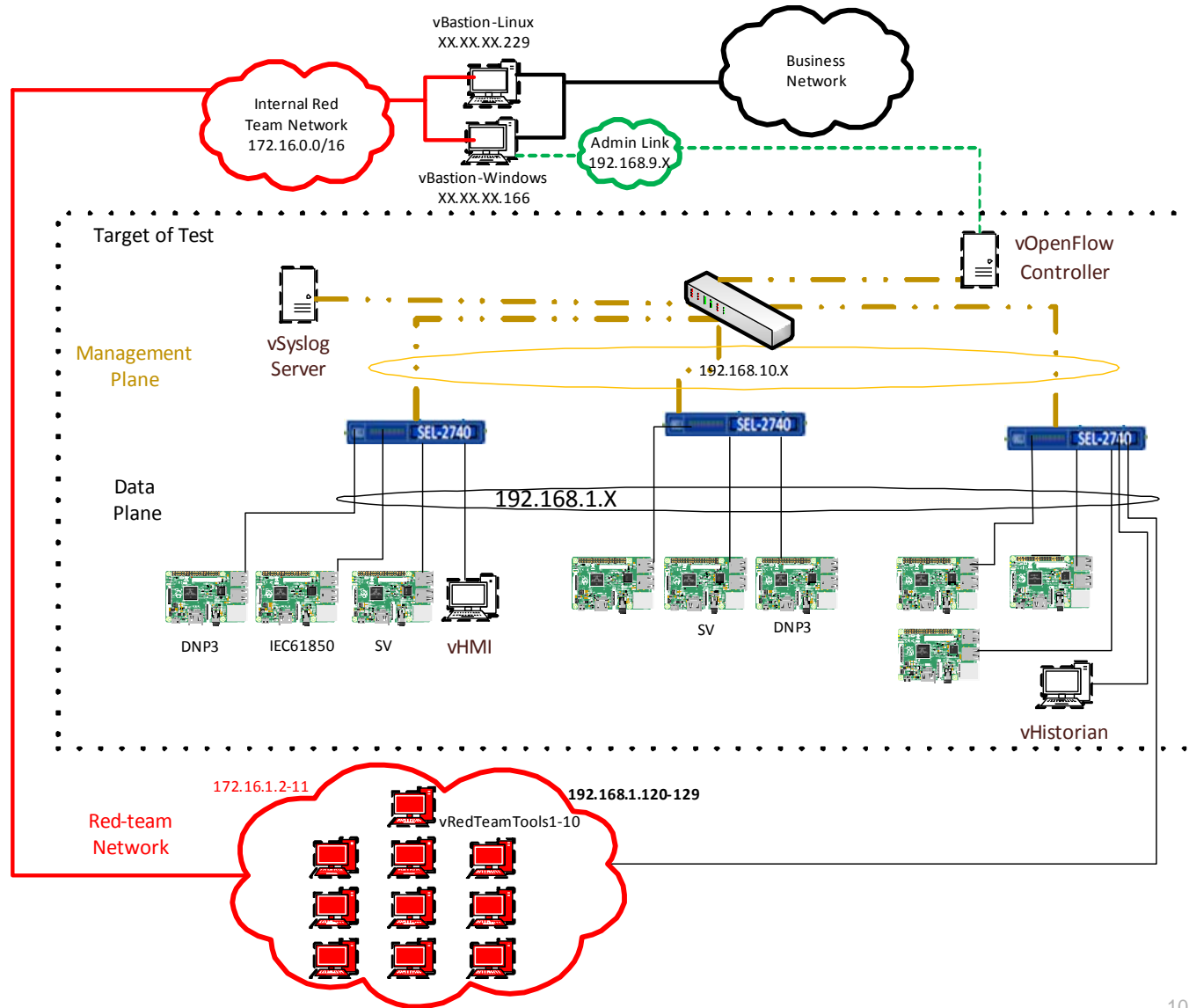
- Develop a “blueprint architecture” for continuing adoption of SDN technology in OT environments
 - A description of how to best deploy a set of techniques to accomplish a business function
 - Document recommendations on how and where SDN technology can be deployed in energy delivery systems (and possibly expand to others)
 - Provide working example implementation
- Develop decision process for industry
 - When to use, where to use, how to decide, etc.
- Build on existing implementations and products
 - Document existing requirements
- Assess Scalability
- Document use cases



SDN4EDS Project Goals

- Develop set of extended requirements:
 - General
 - Performance
 - Operational
 - Security
- Define metrics and situation awareness procedures
- Create a reference architecture deployment
 - For testing:
 - ✓ Red team
 - ✓ Performance
 - ✓ Metrics
 - ✓ Functionality
 - ✓ Use case validation
 - Documented in final report for repeatability by industry

Laboratory Test Environment





Project Future Directions

- Add actual protection devices into network
 - Relays, Merging Unit, PTP Clock
- Add WAN component
- Develop performance metrics and analytics
- Develop protocol-aware flow rules
 - Implement intrusion prevention at entry into switch backbone
- Develop trust models
- Investigate large scale (wide area) deployment practices
- Ongoing red-team testing
- Multi-vendor testing (if products become available)



Thank you

