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Active Management of Communication Resources in a Modern Power System

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Overview

- Communication for Substation Network
- Challenges of the modern packet network
- Addressing challenges with Bandwidth Management
- Case Study
- Continuous Improvement

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Communication for Substation Networks

- Initial Communication was largely analog
- SCADA systems get more complicated
- The utility industry adopted Telecommunication standards leading to Time Division Multiplexing (TDM)
- Utility industry moved to packet based networks
  - Eliminates the need for multiple circuits as applications increase (separate circuit with unique provisioning)
  - More efficient use of the Bandwidth
  - Intelligence was pushed to the endpoint

Mature Packet Based Network

- The network was mostly used for SCADA traffic at first
- Substation technology become packet aware, more applications are added to the network
  - Intelligent Electronic Devices (IED)
    - Engineering access
    - Distributed Digital Fault Recording (DDFR)
  - Voice Over IP (VOIP)
  - Video Surveillance
  - Mobile work forces

Packet Network Challenges

- Few initial challenges because the applications had low throughput
- New packet aware applications were added without analyzing the station requirements
- Just Increasing backhaul capacity alone could be the initial step
- Core packet switching infrastructure struggled to keep pace with backhaul connectivity

Solutions for Modern Power System Communication

- While better then previous options, the packet network still needed to be managed
- Plan for application that will be installed on the network
  - AEP's solution was to build a simplified network model
  - Use the network model to size wan connections

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Network Throughput Traffic Model

Technology	Quantity	Constant Bandwidth Per Device (Kbps)	Constant Bandwidth Required (Kbps)	On Demand Bandwidth Per Device (Kbps)	On Demand Multiplier	On Demand Bandwidth Per Technology (Kbps)	Demand Factor	On Demand Bandwidth Required (Kbps)
VOIP	1			33	1	33	0.5	16.5
METERS	2			10	2	20	0.05	1
CORP LAN	1			100	1	100	0.2	20
CAMERAS	3			512	3	1536	0.2	1536
SDR	1			100	1	100	0.4	40
AH DR-E3	3	2	6	100	1	100	0.2	20
AH OCU	3	10	30	100	1	100	0.2	20
RTU	1	16	16					
PMU	3	58	174					
TOTAL CONSTANT BANDWIDTH			226		TOTAL ON DEMAND BANDWIDTH			1653.5
					TOTAL STATION BANDWIDTH			1879.5

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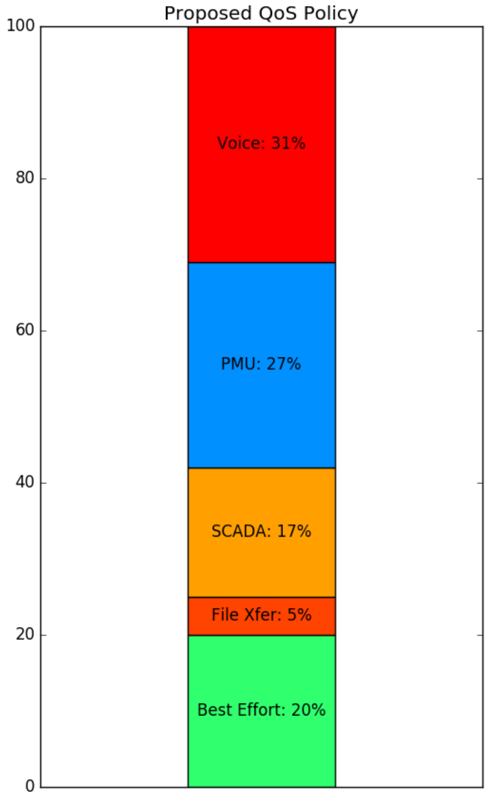
Network Modeling Reality

- Traffic model will not prevent temporary oversubscription
- The static allocations and use of the demand factor allows for some chance of oversubscription
- Combine the traffic model with Quality of Service (QoS) mechanisms to prevent any undesired performance

Quality of Service



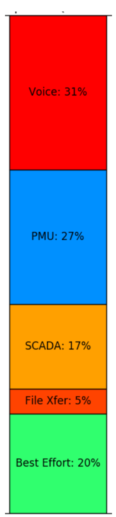
* This representation is use for illustrative purposes only.

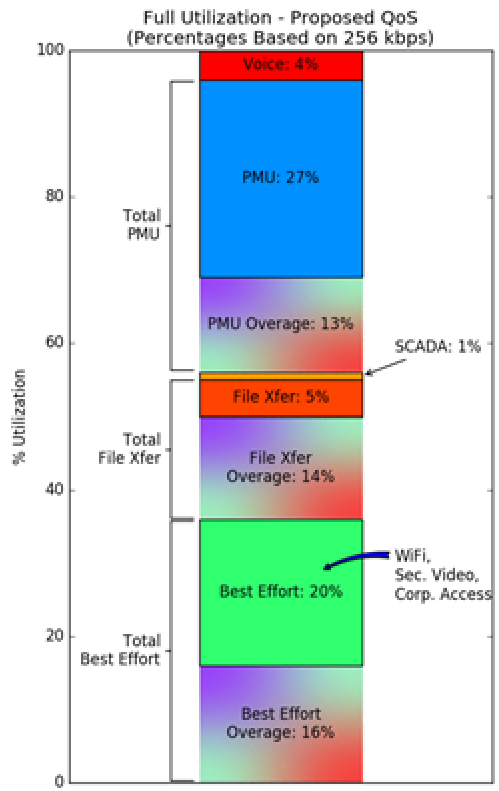
– Mark the Traffic
  - Categories are defined and criteria is set up to classify traffic into the categories
  - Each category is assigned a priority to be used in the queuing mechanism

– Determine Congestion and Queue traffic
  - Use Low Latency Queuing and Class-Based Weighted Fair Queuing

Quality of Service

Sample QoS Policy

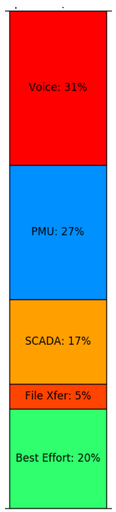


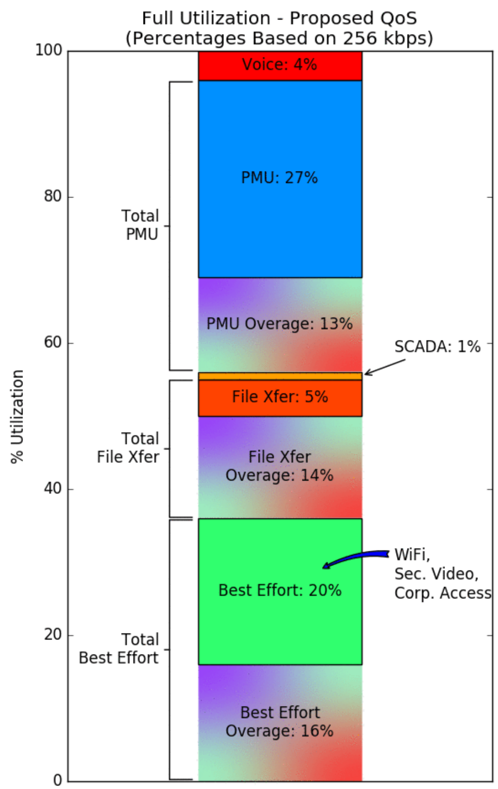


- Unused bandwidth can be given to categories using more than the allocated share
- Traffic will fall into one of 2 zones
  - Under the allocated throughput
  - Over the allocated throughput
- Traffic that is over the set throughput will not benefit as much as traffic below the set throughput

Quality of Service

Sample QoS Policy





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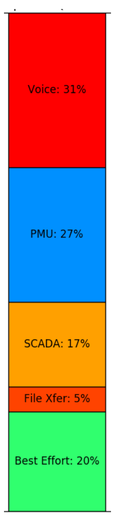
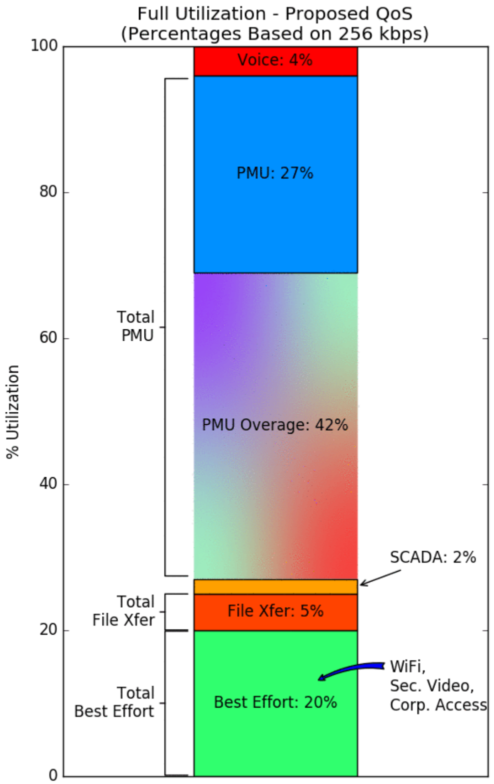
Quality of Service

QoS policy





- Lower priority throughput increases, the allocated capacity is supplied

Case Study

- Security cameras and Phasor Measurement Unit (PMU)
- Synchrophasor is a time synchronized power system phasor measurement.
  - Continuously streamed and requiring low latency
  - High latency will limit the abilities of Wide Area Monitoring Systems (WAMS) and degrade solutions for Linear State Estimators(LSE).
  - Late data will be considered missing

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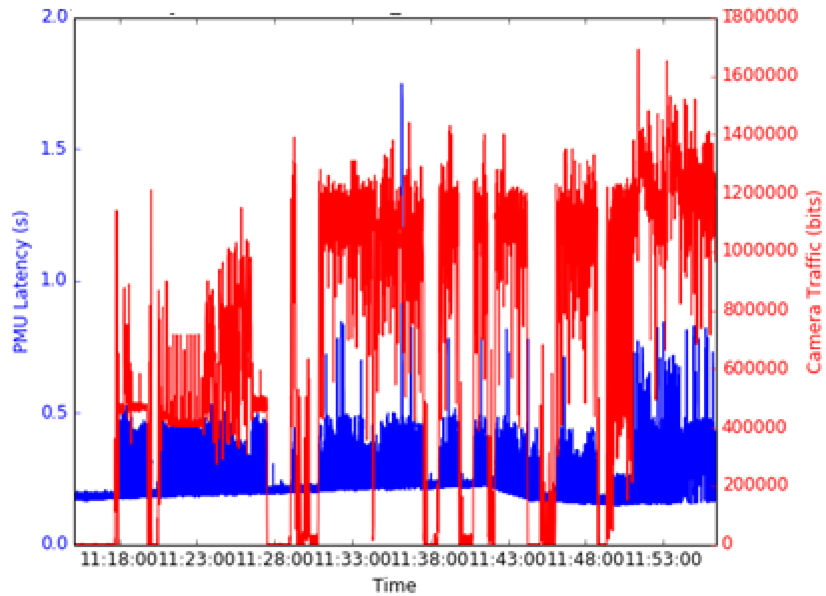
PMU and Security Camera Separation

- Security Camera and PMU traffic was in the same category
- PMU traffic was being delayed when security cameras were streamed
- Separating security camera data and PMU data removed queuing related delays

PMU and Security Camera



- RED – Security Camera Throughput
- Blue – PMU latency

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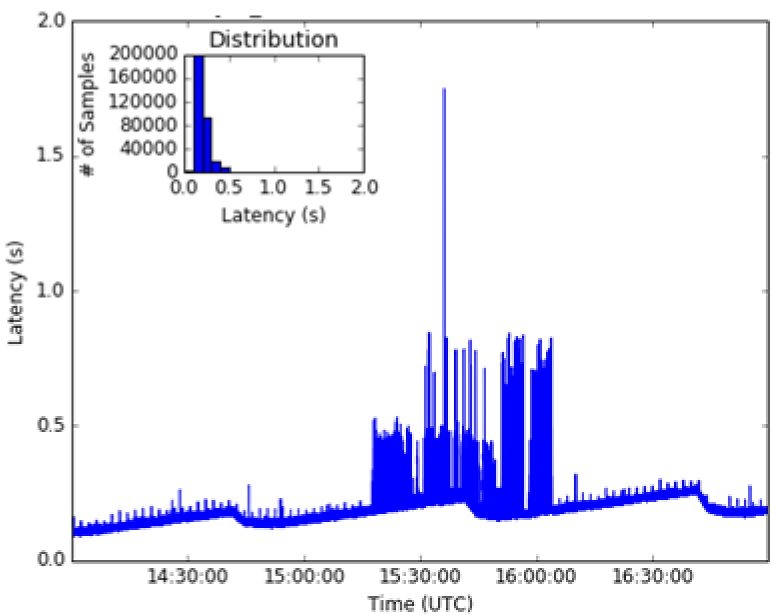
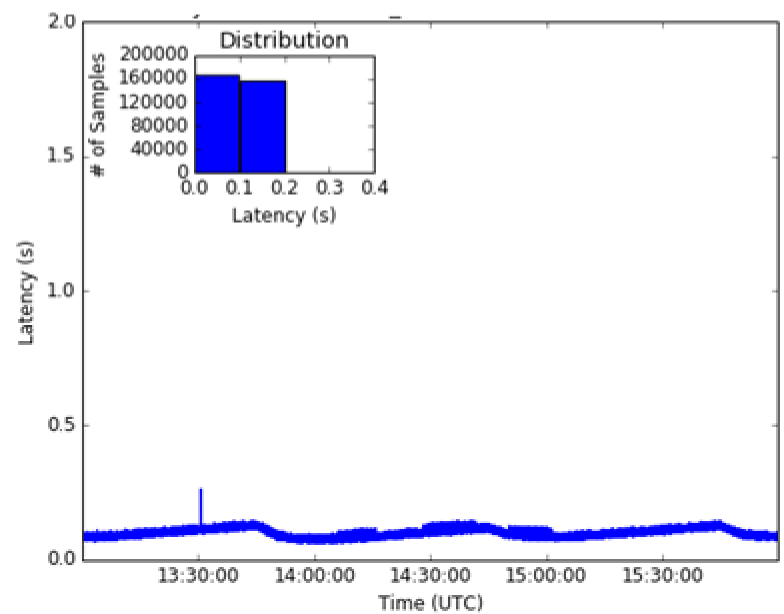
Results after QoS update

- PMU latency before QoS Update

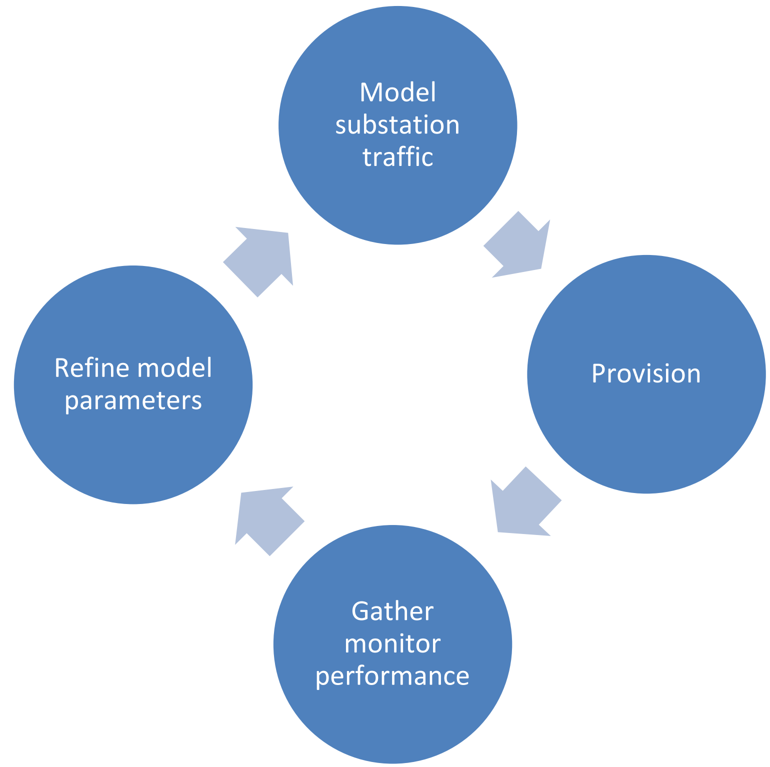


- PMU latency after QoS update



Continuous Improvement

- Continuous Improvement
  - Model and record substation traffic
  - Provisions circuits based on the model
  - Build a system to gather usage data
  - Refine the model and continue model traffic



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What questions do you have?