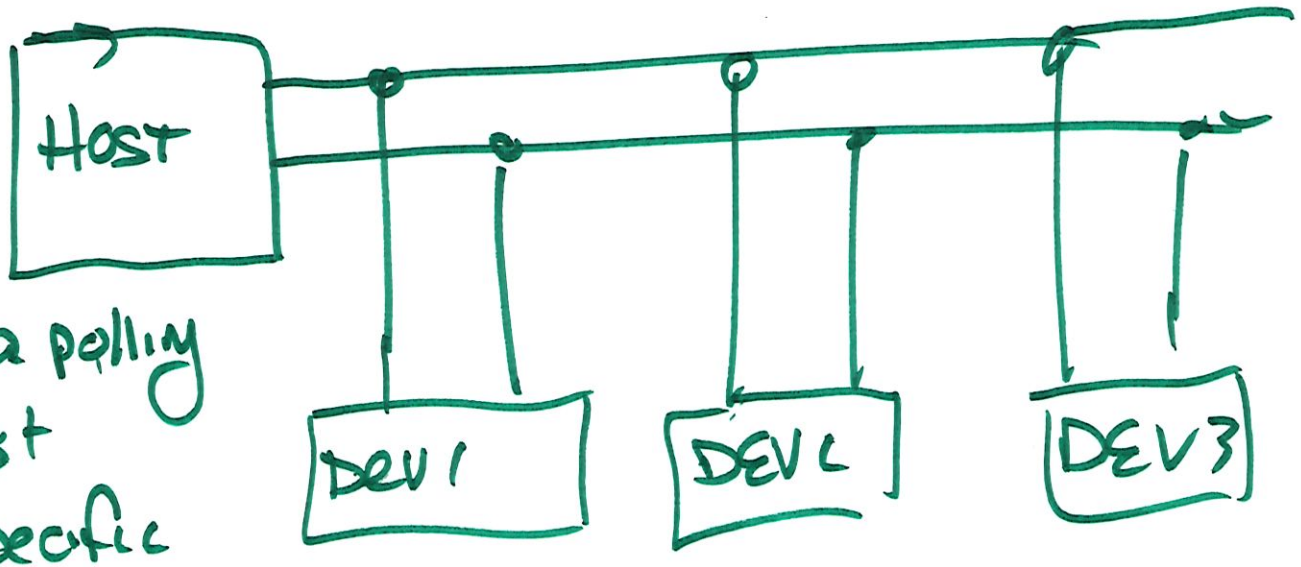
University of Idaho

ECE 444 / ECE 544 / CS 444 / CS 544 Supervisory Control and Critical Infrastructure Systems

Session 14

Polling

→ Generally for measurements



Send a polling request to specific dev or set of devices with ID → Round robin poll → poll each device one at a time

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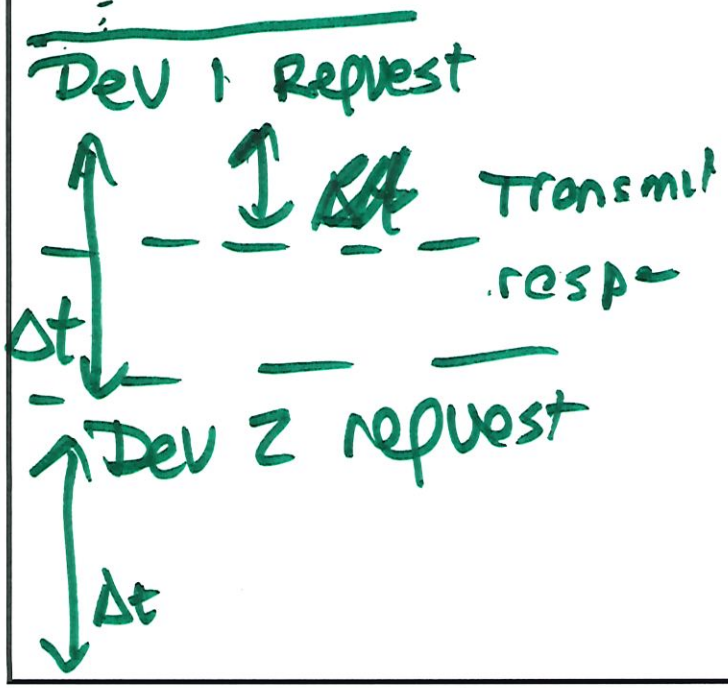
Host will send message

→ allow Δt for message to be received and responded to

→ each device has to respond to request within a time limit



→ cycle through all devices & repeat

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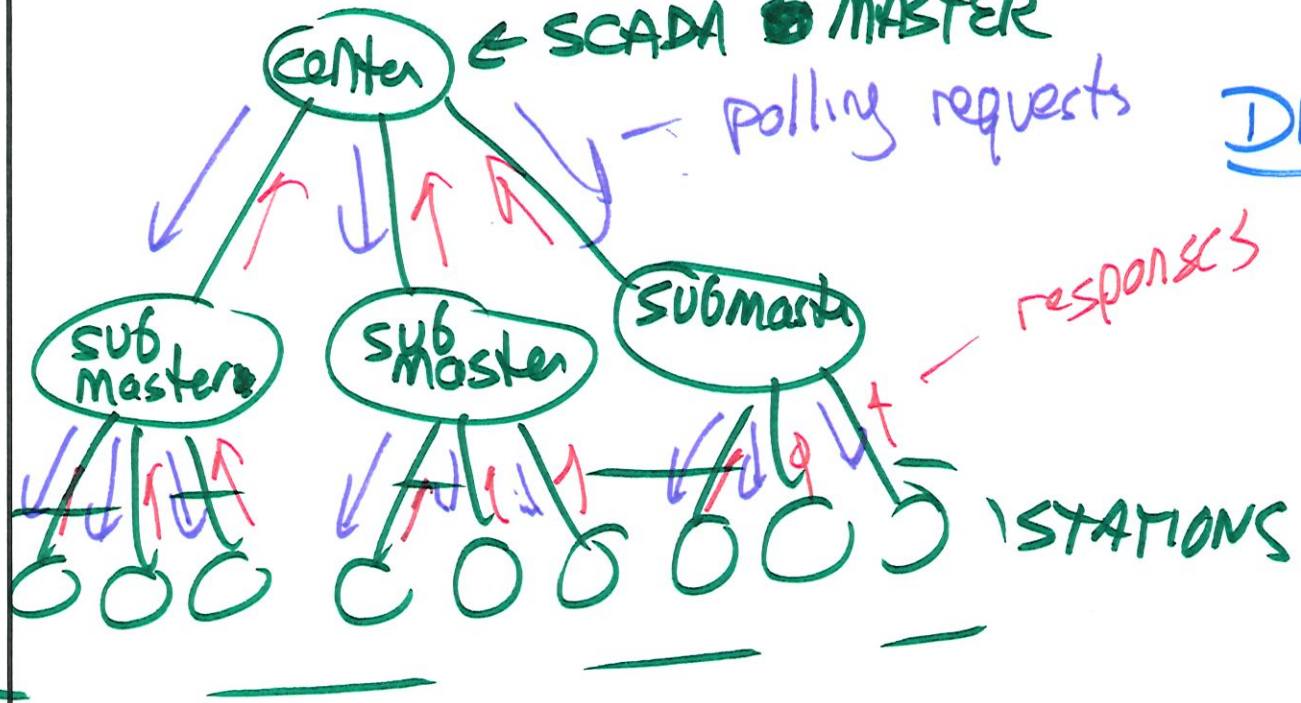
- Inside a station
  RTU or Automation control
  initiates
- control center to RTUs in substations } classical power system SCADA



DNP3 - in addition to polling requests MASTER can send commands

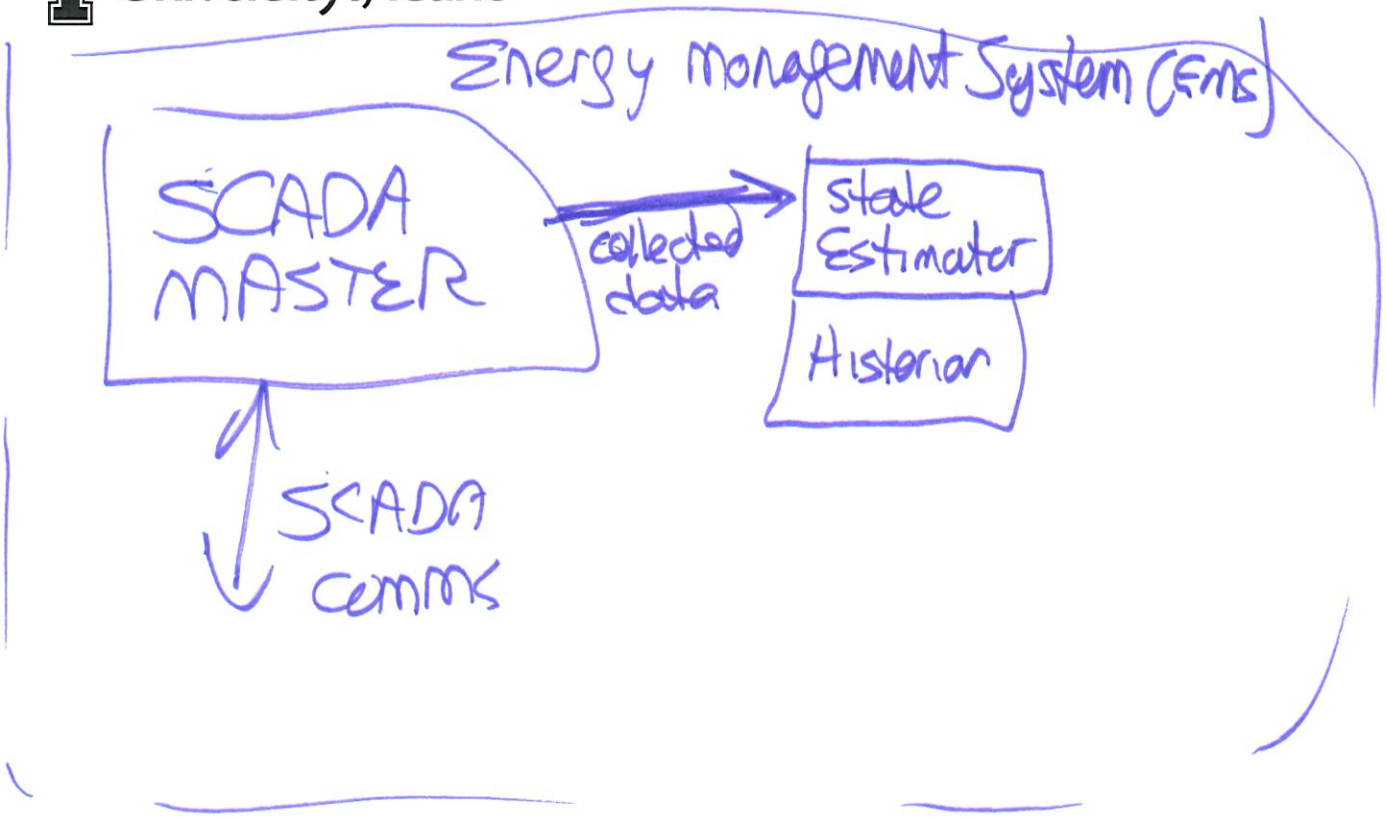
If response doesn't meet time window?

→ SCADA master response

- [redacted] → use the most recent data from that station (assume no change)

Polling requests

→ Dev - response → one config option is to set it to respond only if changes in measurements exceed a threshold.

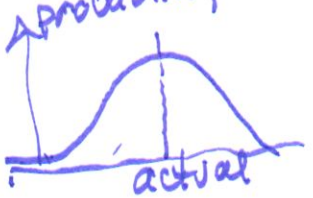


STATE ESTIMATOR

→ measured |V|, P, Q (branches - lines, transformers)

Breaker status (open/closed)

→ optimization calculation to determine |V|, θ at every bus



- Error in measurements → |V|, P, Q → Gaussian noise distribution

over measure (more measurements than states)

↑

a state is $|V|, \theta$ ($|V|$: state variable)

↑

every node (BUS) in the system

$v(t) = V_m \cos(\omega t + \theta)$

$|V| = \frac{V_m}{\sqrt{2}}$ (assuming nice sinusoidal waveform)

Two difficulties

(1) Don't have the best measurements for a linear solution → non-linear solution

(2) Errors & missing measurements

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- more measurements that state variables

Results of state estimation

(1) -|V|, θ at each bus
- verify topology (breaker/switch status)

→ software ~~calculated~~ calculated
I, P, Q on each line, generator, load bus
etc... ⇐ BASE CASE

(2) Alarm states if any lines overloaded,
|V| too high or too low...
in the current operating point
⇒ operator will check these to see if correct...

first level of response by operator

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(3) software will perform contingency analysis } uses base case as initial condition

→ what if scenarios

→ at a minimum do

n-1 (any one line, transformer, etc out of service)

→ loss of any one these components shouldn't jeapordize operation

2nd priority for operation

→ most utilities required to do n-2 and/or (n-1-1)

next priority

→ measurements come from a subset of system buses → not as much visibility at low voltage buses (sub transmission or distribution)

→ Transmission EMS concentrates on the +1V transmission system

→ observable from the available measurements (can you infer/calculate |V|, θ at buses without measurements from available measurements)

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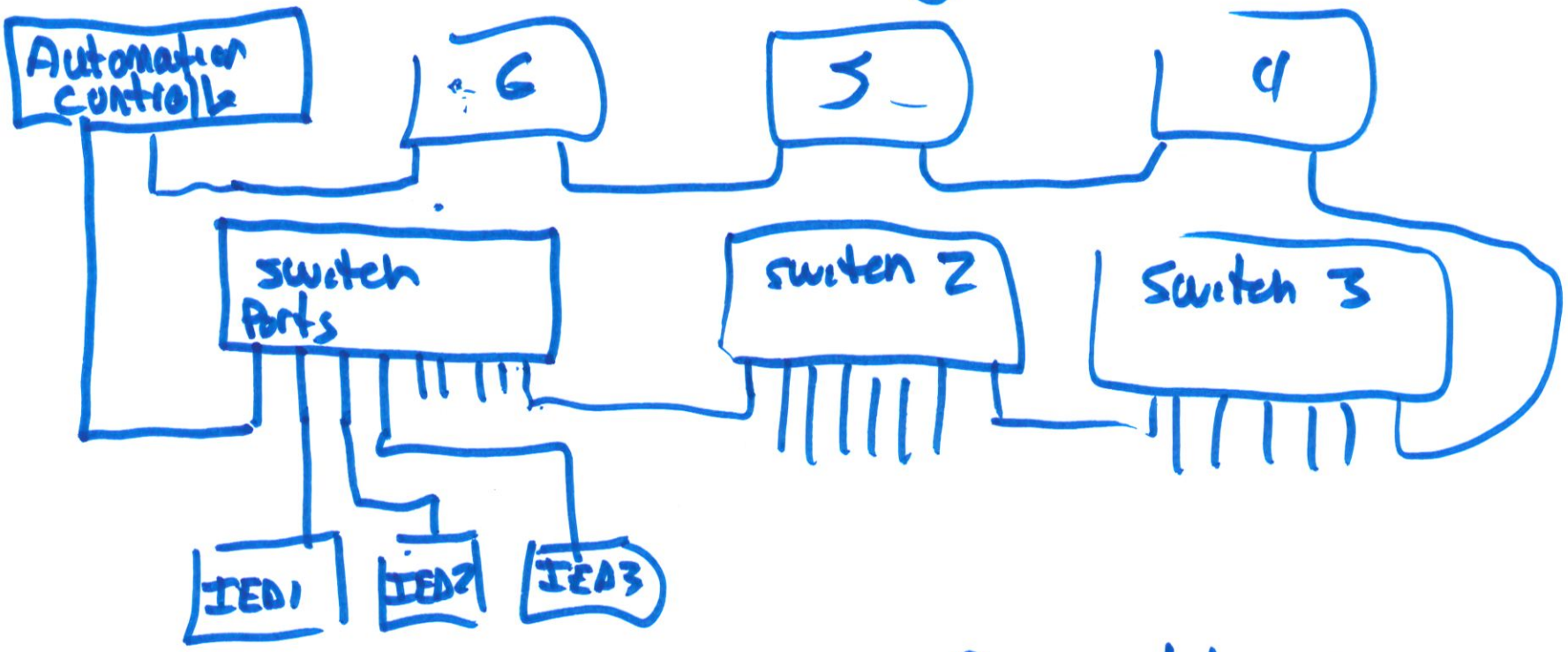
Next lecture - Guest speaker who will talk about IEC 61850 and the related protocols

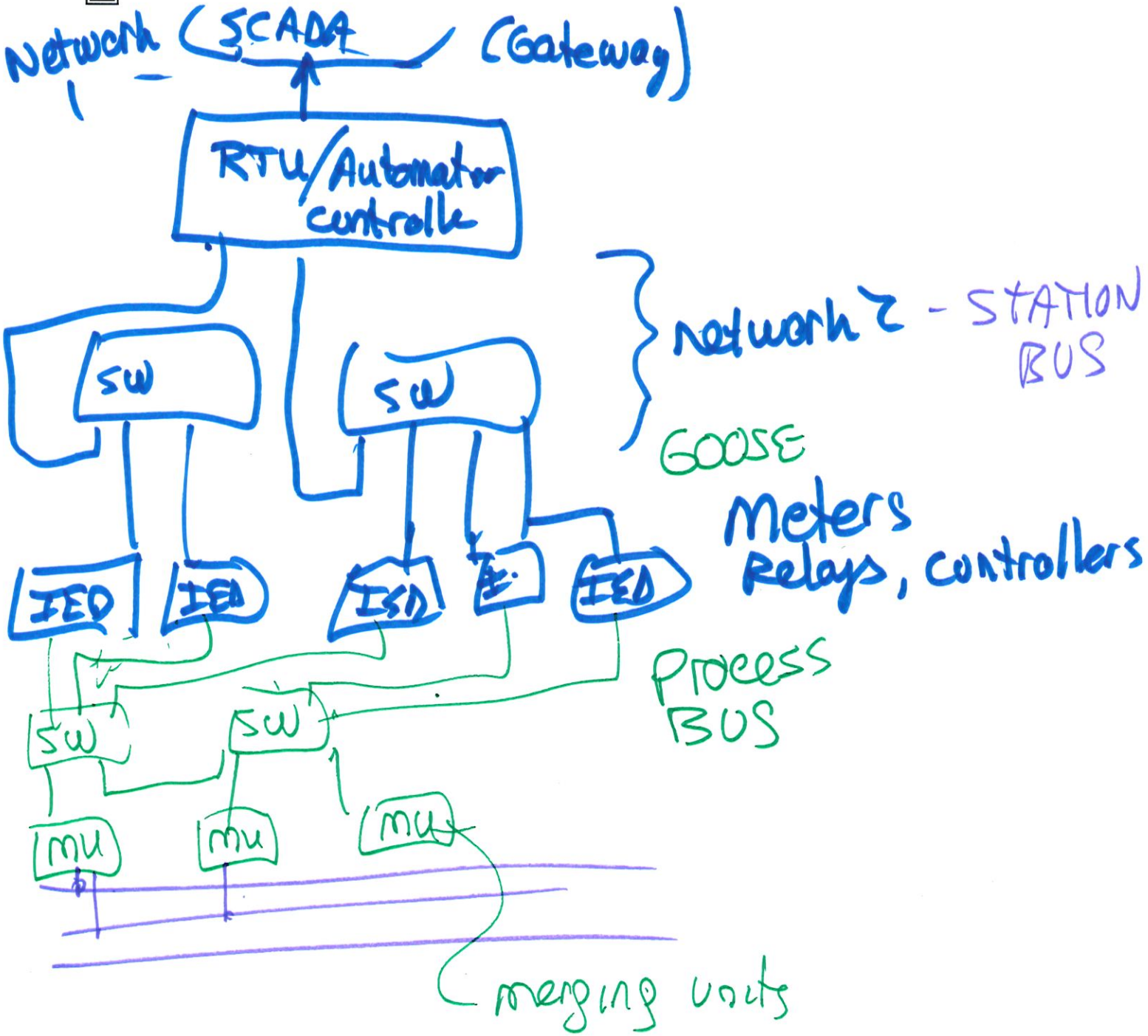
→ MODBUS, DNP3 ⇒ were developed with serial communication channel of choice RS-232, RS-485

- can support Ethernet - now often implemented over Ethernet in new construction

The IEC-61850 family of protocols were developed assuming Ethernet



- Reliable topologies for switches to handle failures
- failover mechanism


Network (SCADA (Gateway)
RTU/Automation controller
network 2 - STATION BUS
SW
SW
GOOSE
Meters
Relays, controllers
IED
IED
IED
IED
IED
Process BUS
SW
SW
MU
MU
MU
merging units