Changing Technologies and Fault Location ISolation and Restoration (FLISR)

Opportunity for CIM and IEC 61850 Harmonization

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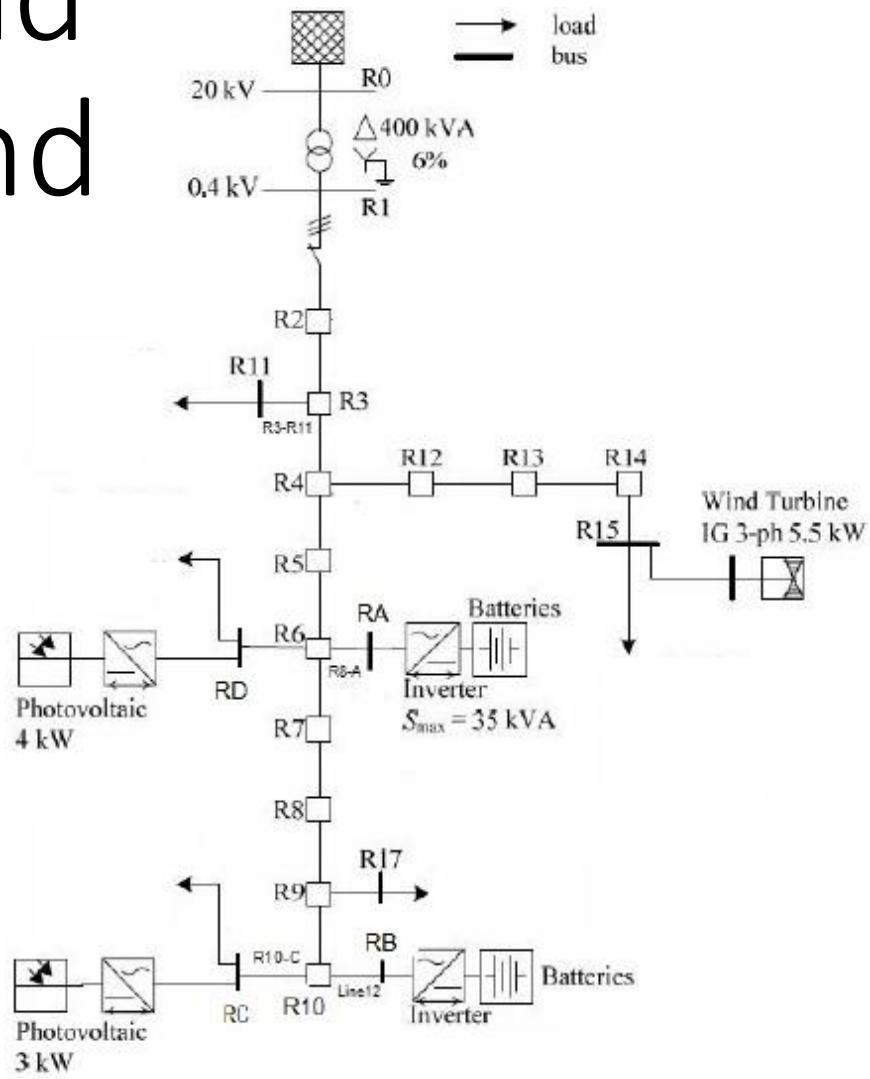
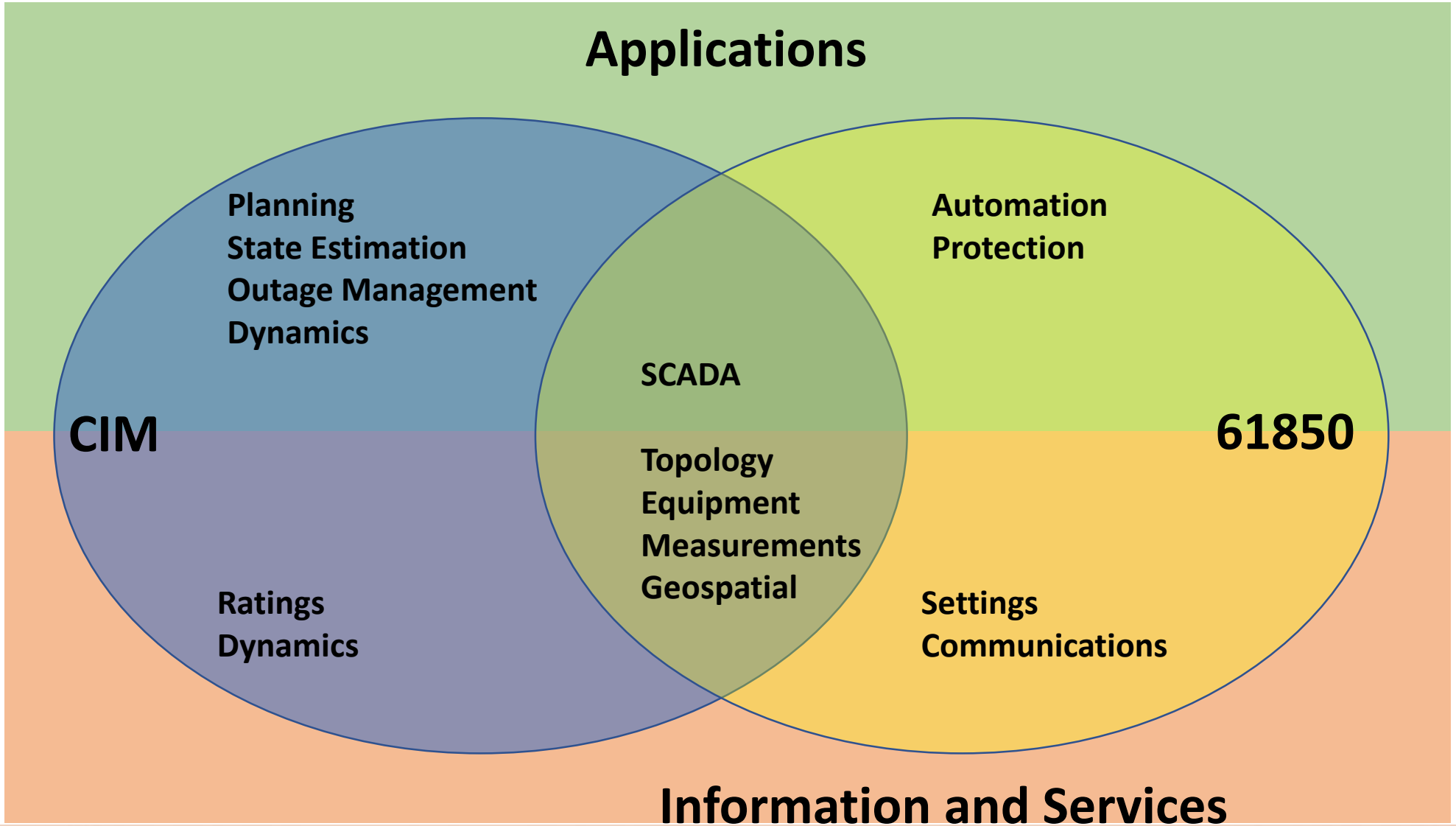
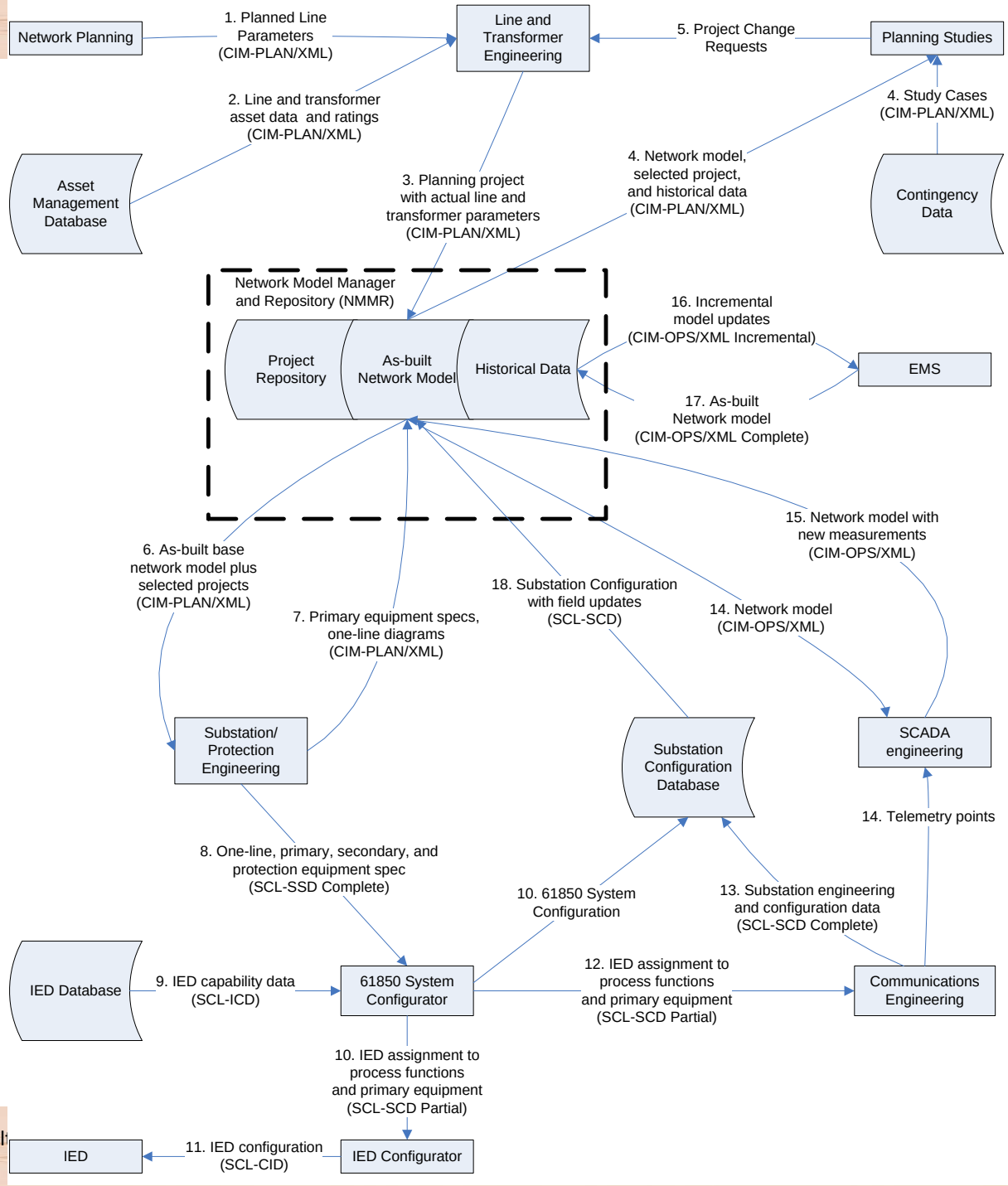
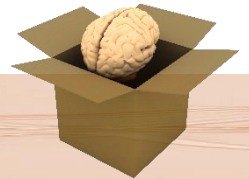


CIM and 61850 Harmonization

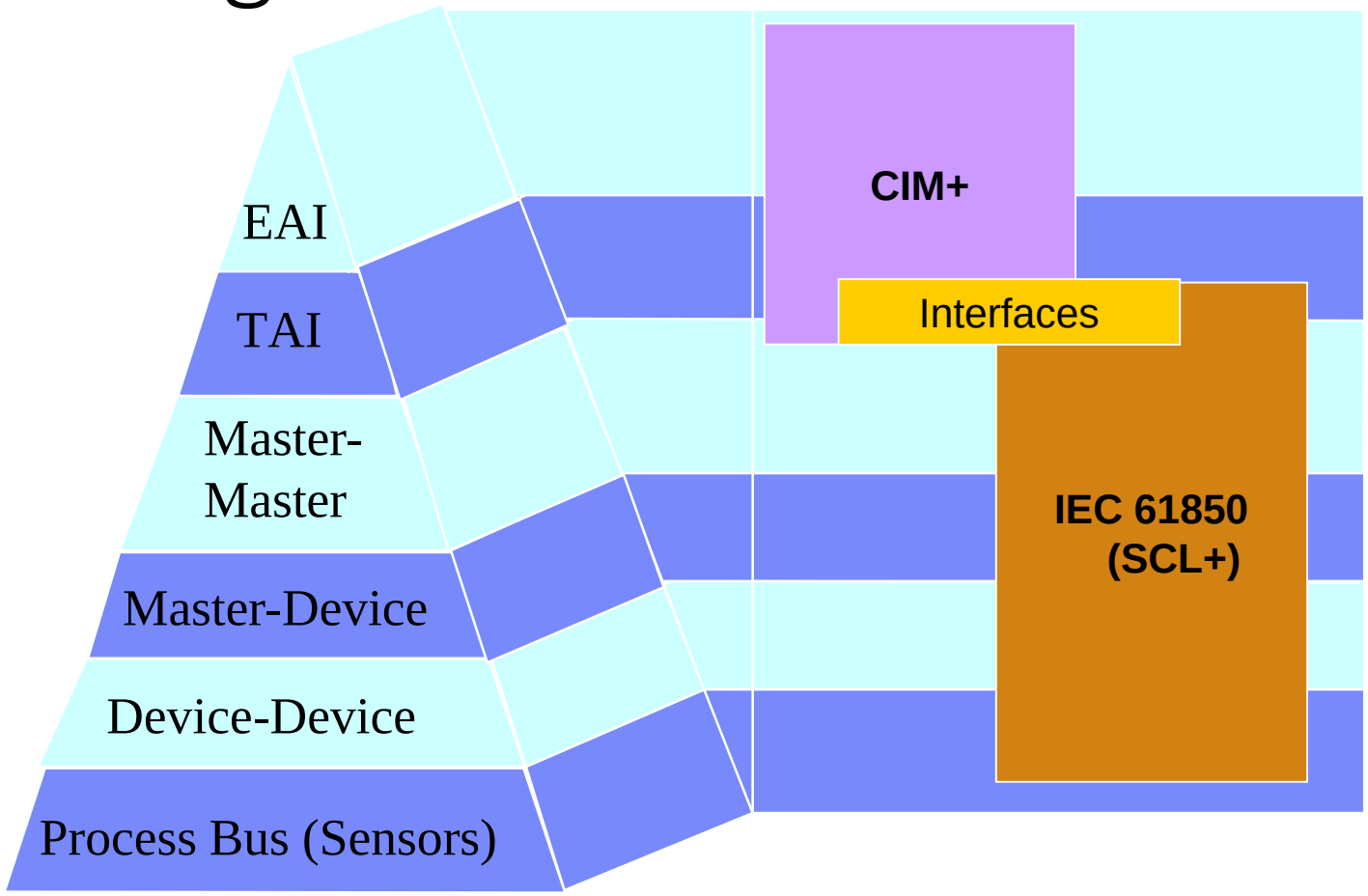


NMM and 61850

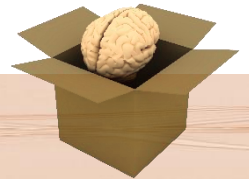




Connecting Different Areas



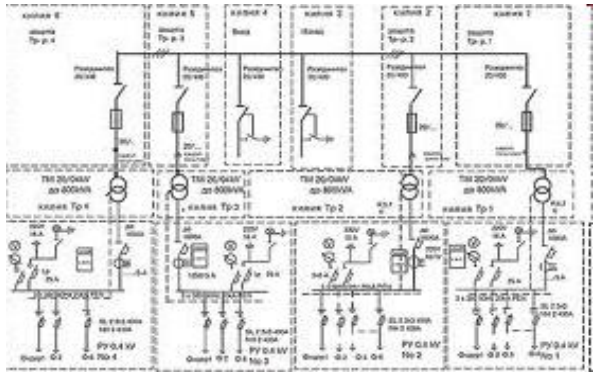
+ is what is required to exchange through interface in a lossless manner

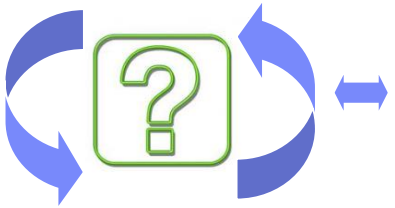


Process Issue: Who is Most Correct?

EMS

CIM



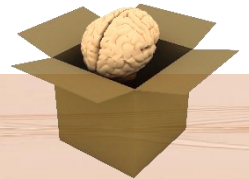


Substation

Substation Configuration Language (SCL)

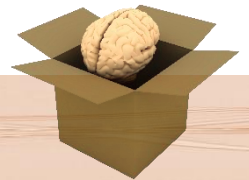
Some truisms:

- EMS one-lines do not accurately reflect the actual construction of a substation.
- Substation one-lines may have too much detail for the EMS.
- Neither top-down or bottom-up design methodologies work for an entire substation life-cycle.
- Harmonization of CIM and 61850 decided to address this issue through lossless conversion of 61850 Substation Configuration Language (SCL) to/from CIM.



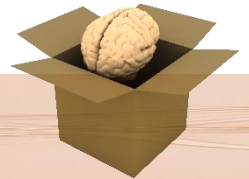
Technologies Driving Thought Changes

- Penetration of Distributed Energy Resources (DERs)
- Distribution Management System (DMS) and Advanced DMS monitoring of distribution networks
- 128Kbps to 10Mbps distribution communication availability
  - IP based Radio Networks are available



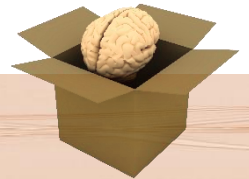
Thought Change

- Fault Location
  - Need to minimize the number of configuration changes for the intelligent devices
  - Shift from overcurrent coordination to directional overcurrent protection
- Isolation in 3-4 cycles
  - Isolate ONLY the faulted segment
  - Requires distributed intelligence that communicates
- Restoration
  - Manual
  - Automated: centralized or in the field
  - Hybrid

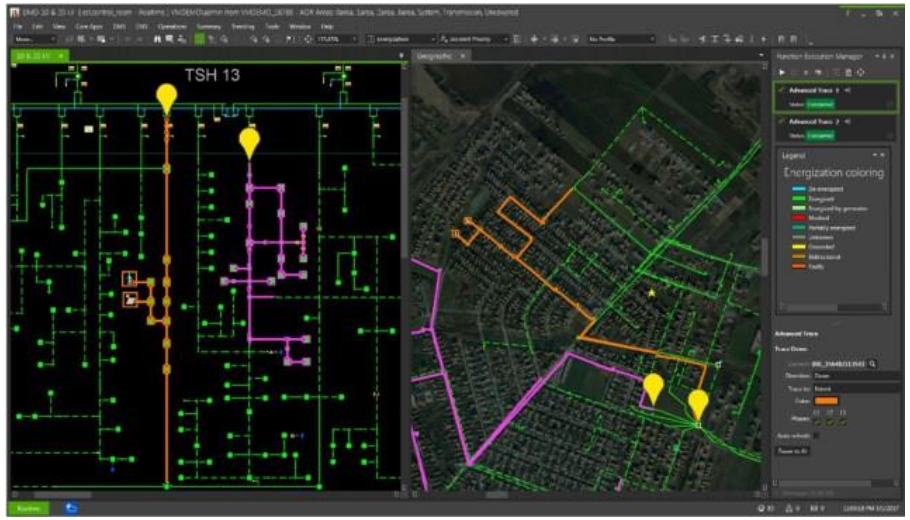


Current State Of the Art

- Proprietary “single vendor” solutions
- IEC 61850 systems
  - Utilities have used IEC 61850 GOOSE



Interaction of Network Model and Automation

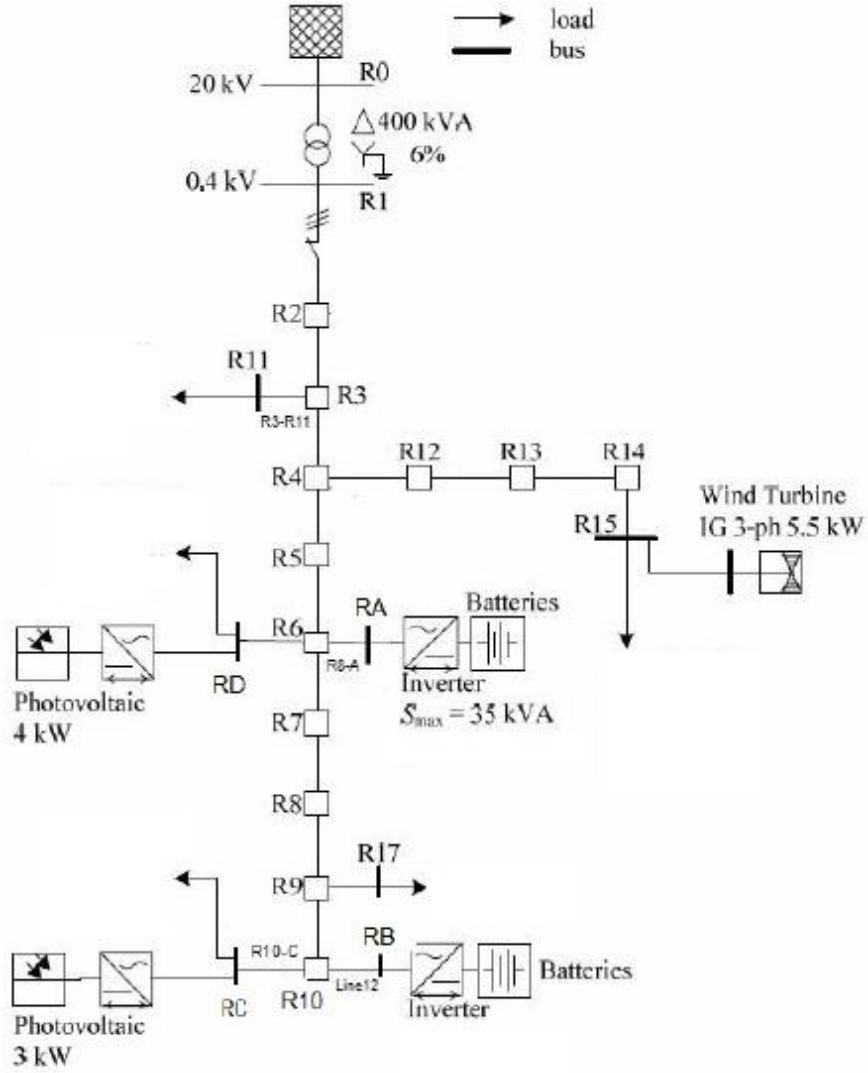


CIM Topology, Line Rating, and Geospatial Information

Protection Settings

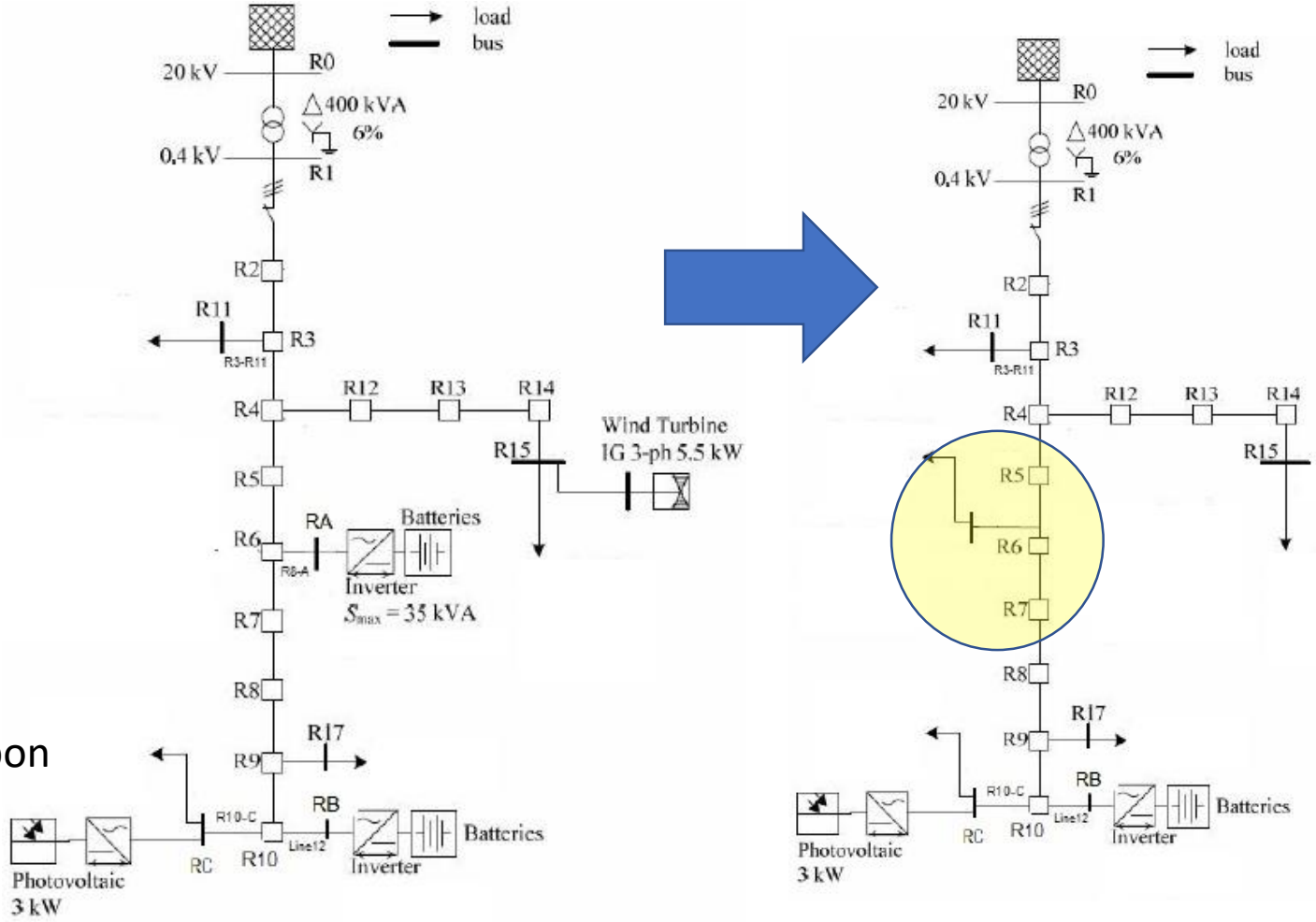
Communications

Communication Configuration



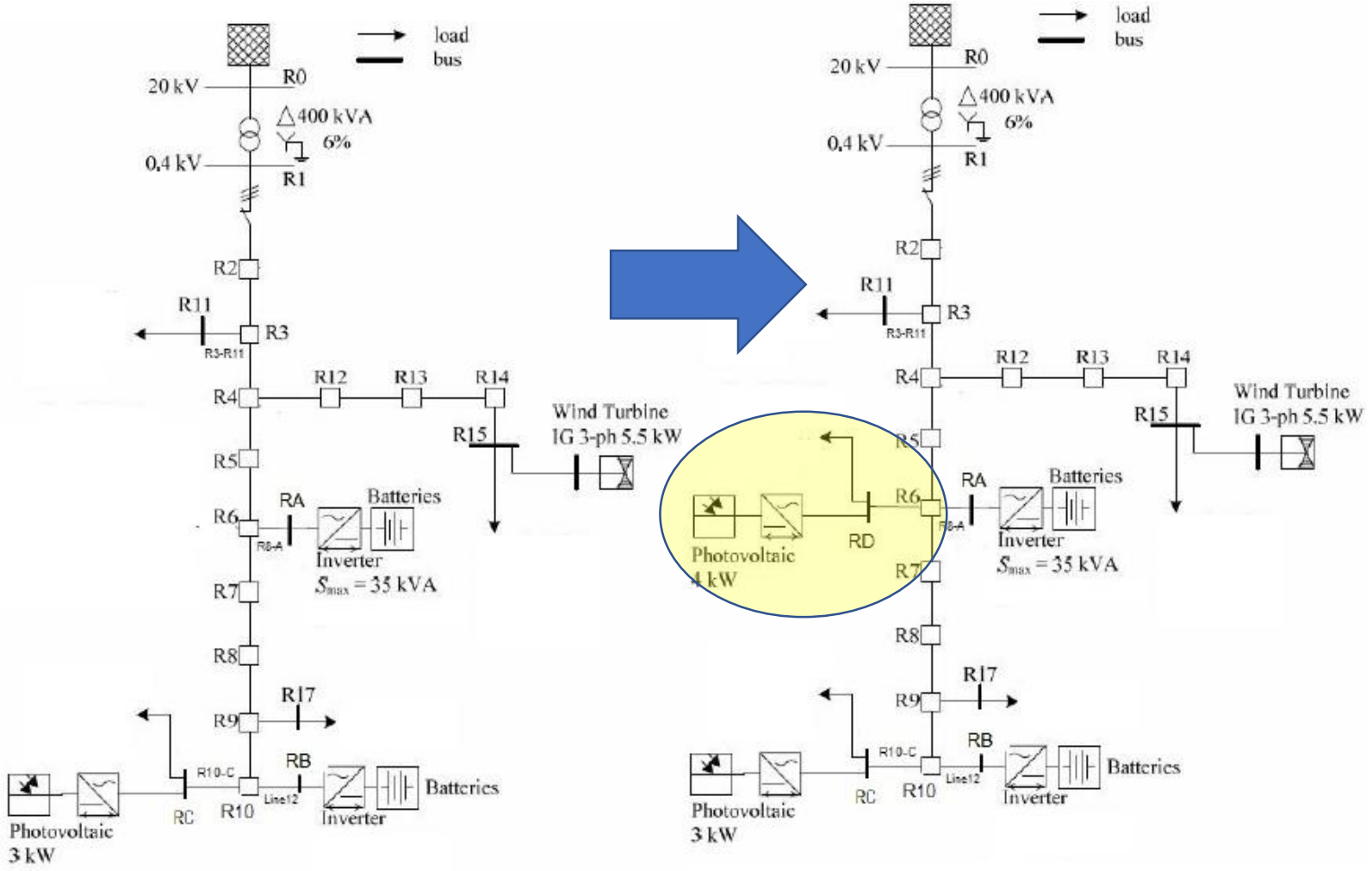
Use Case: Temporary Load Addition

- Does not impact Most Limiting Series Element (MLSE) analysis. Does not require protection setting changes.
- May impact impedance and therefore detail fault location for repair crew dispatch. Travelling Wave Fault Location will eliminate this issue in the future
- Additional load needs to be reflected in the ADMS system.
- Over-current ALARM level could be based upon CIM wire size and/or transformer loadability.



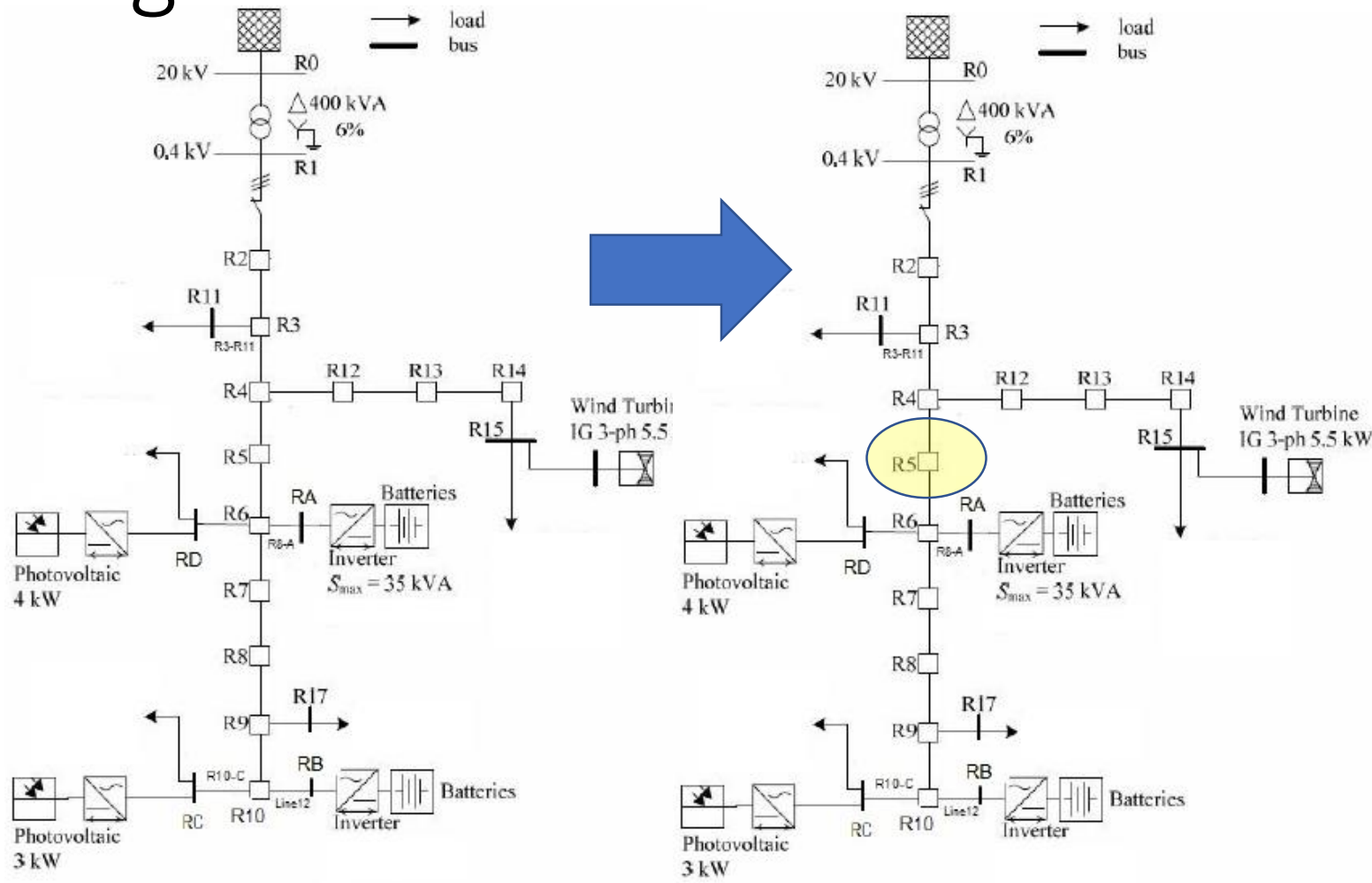
Use Case: Generation Addition

- Generator infeed can impact detection of fault mostly mitigated through the use of Directional Over-Current – but then requires Voltage
- Pre-planning and modeling can allow IEC 61850 devices to have infeed protection instantiated but not enabled.
- Allows ADMS or delegate to recalculate appropriate settings; sent via IEC 61850 Client/Server communications
- If pre-planned properly, no major configuration changes would be required.

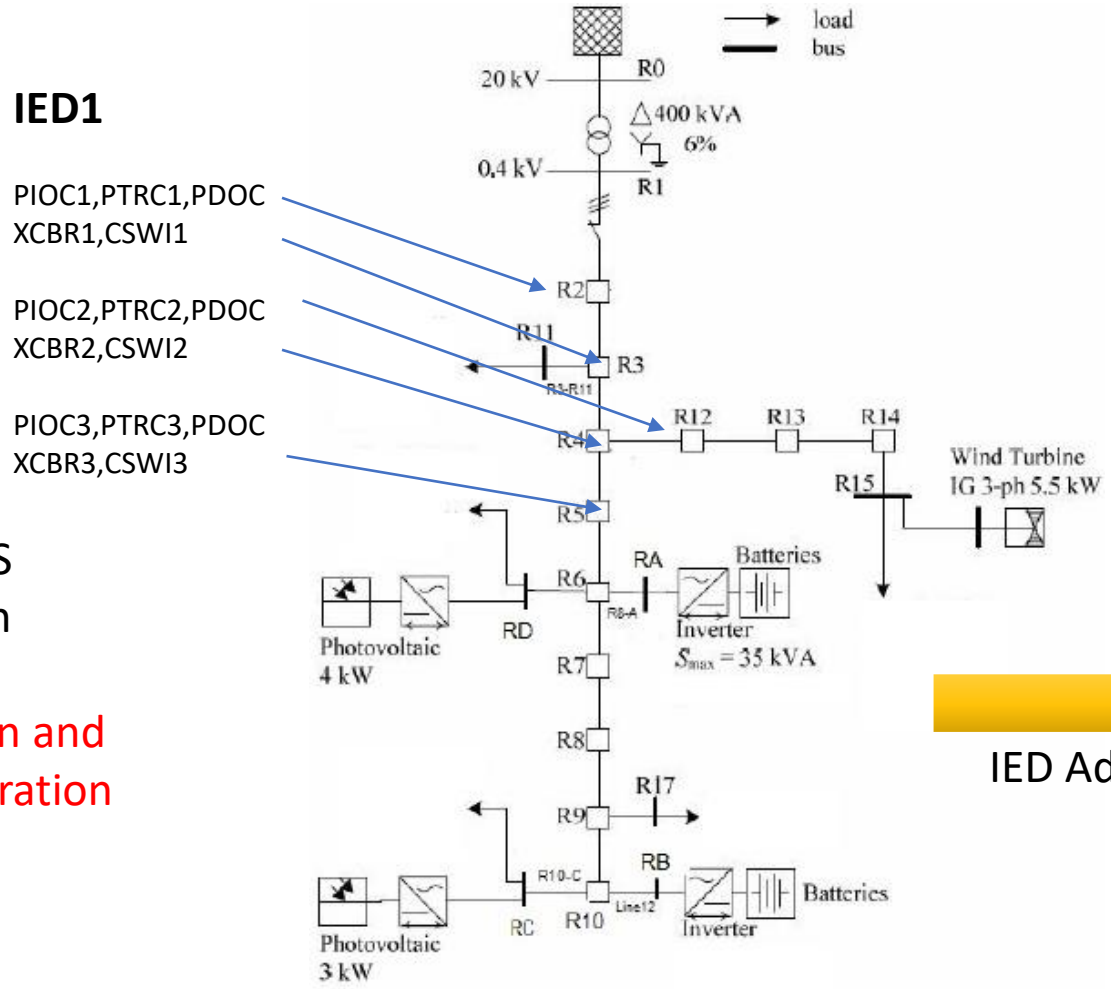


Use Case: Power System Resource (PSR) Change/Rating Change

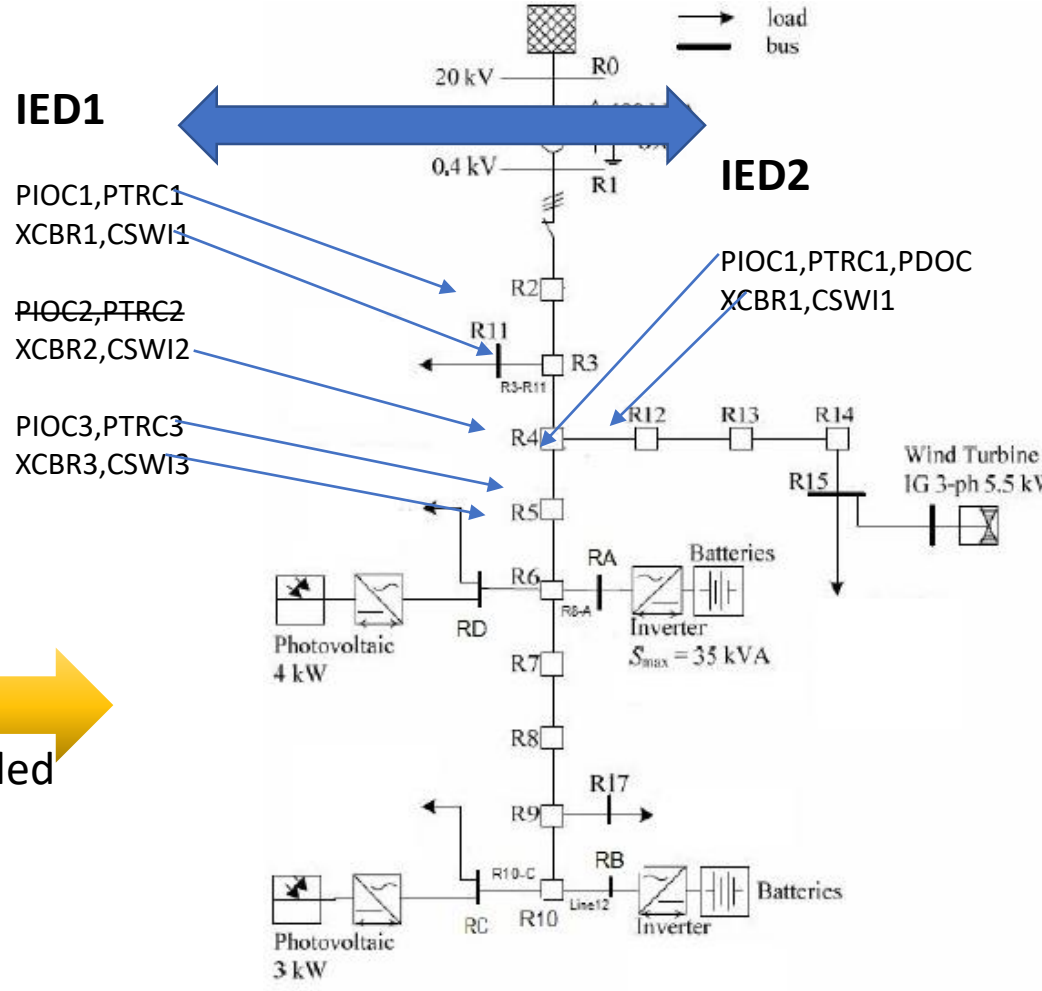
- Will need protection setting changes if:
  - PSR was MLSE and new PSR has lower ratings
  - PSR is the new MLSE
- MLSE needs to be calculated by ADMS and revised settings need to go to the field.



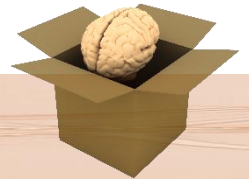
Use Case: IED Addition/Redistribution of Functions



IED Added

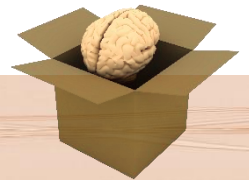


- Requires ADMS reconfiguration
- Communication and logic reconfiguration in the field*.



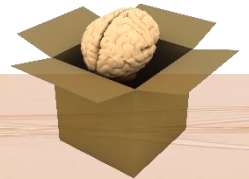
Field Communication Reconfiguration

- Minimized by pre-planning and configuration
- Viewing FLISR zones based upon topology and geospatial reach
  - Driven from ADMS/CIM
- Communication changes conveyed by IEC 61850 (e.g. IEC 61850 to CIM)
- Pre-planning and layout of IEC GOOSE/Routable GOOSE information can allow auto-adaption in the field.



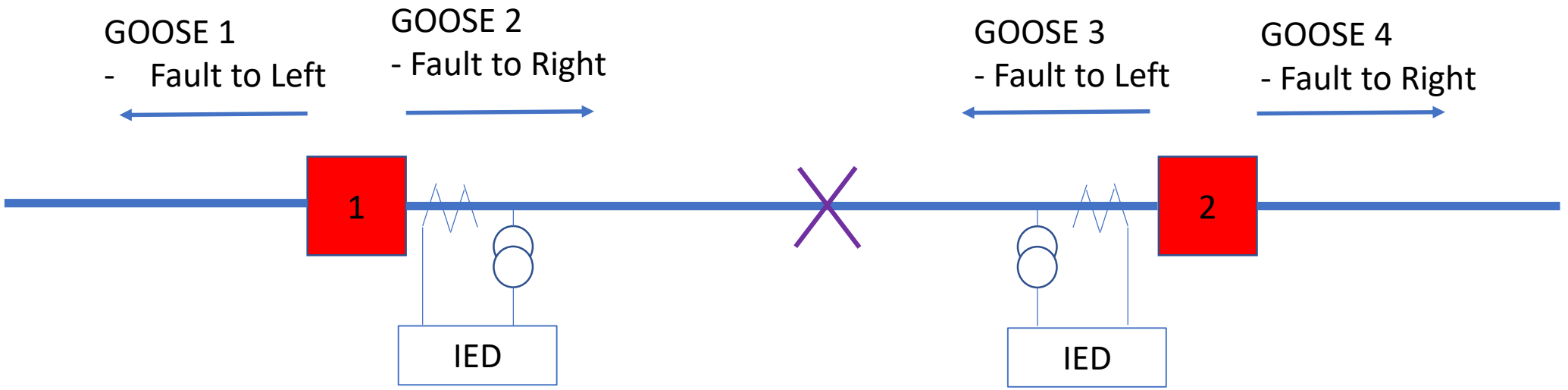
Faulted Segment Isolation

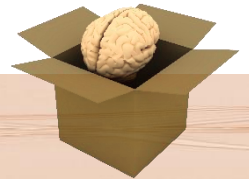
- Identification of Switchable Segment through CIM connectivity



Faulted Segment Isolation

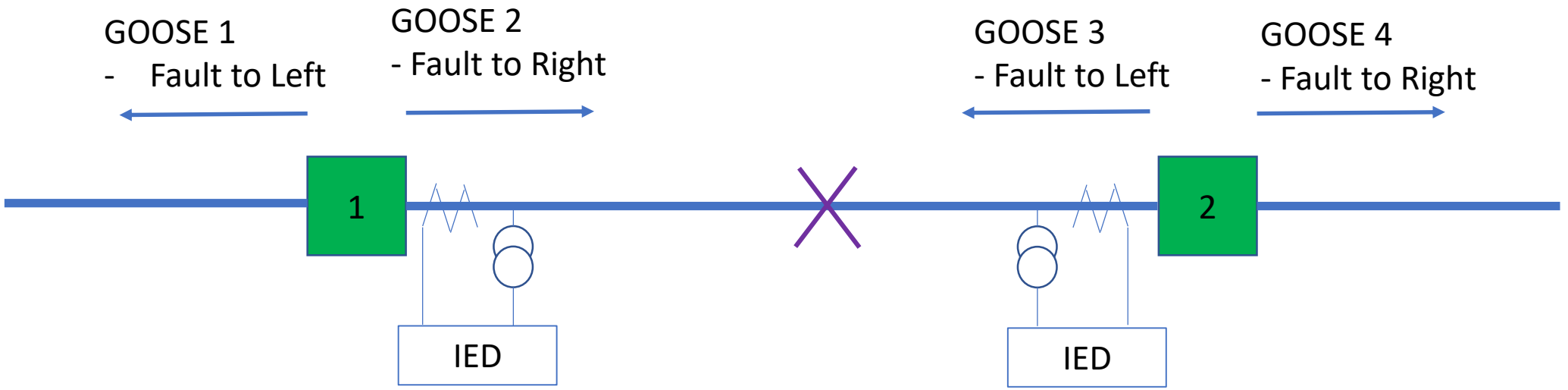
- Directional Over-Current used to detect fault and fault direction
- On Fault Occurrence, R-GOOSE messages sent in ALL directions
  - Message contains Direction of Fault

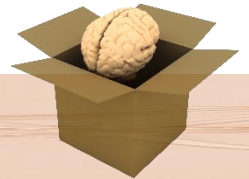




Faulted Segment Isolation

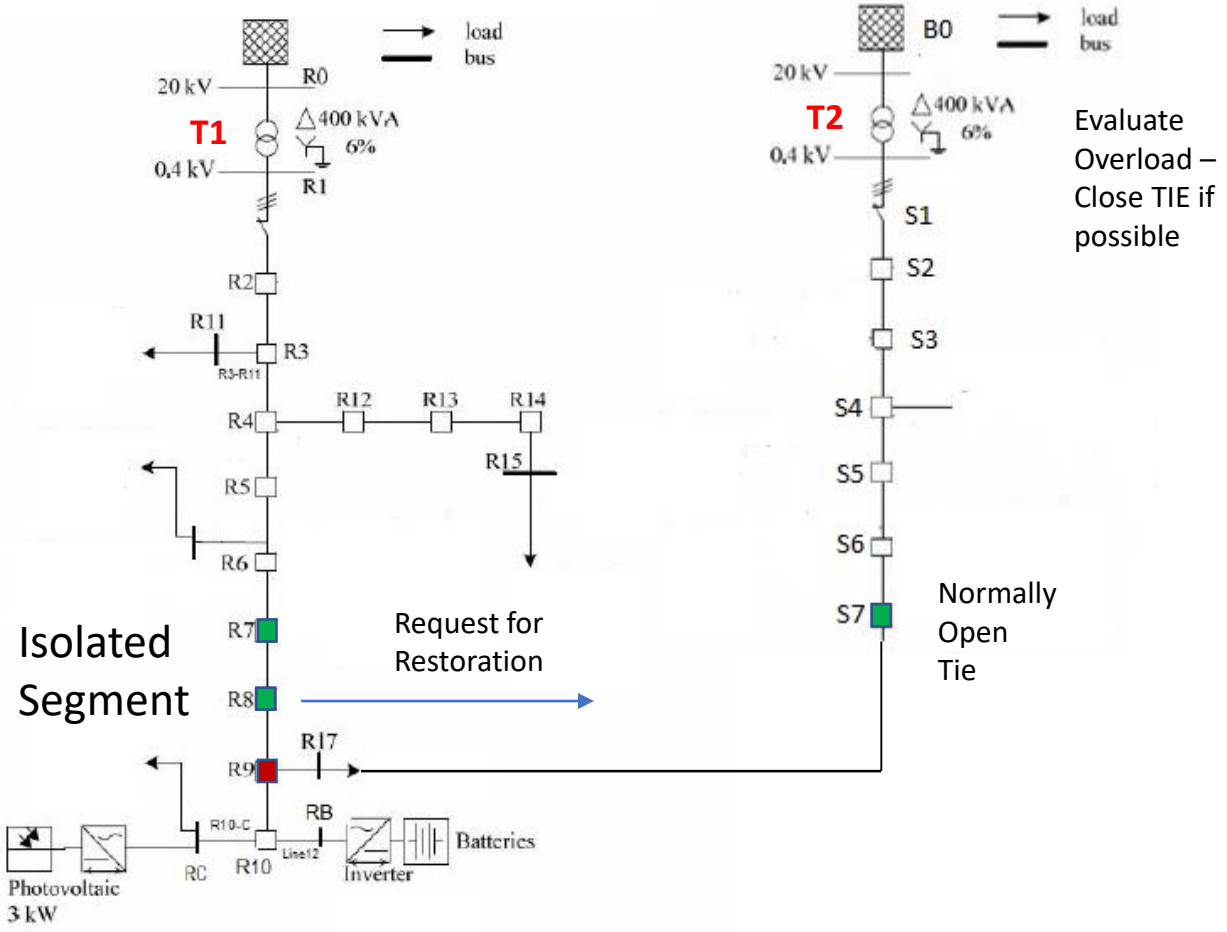
- Logic: Fault internal on a segment, OPERATE (trip) relevant XCBRs
- ONLY the faulted segment is isolated – the rest of the feeder remains energized

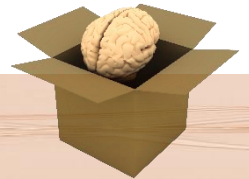




Partial Restoration

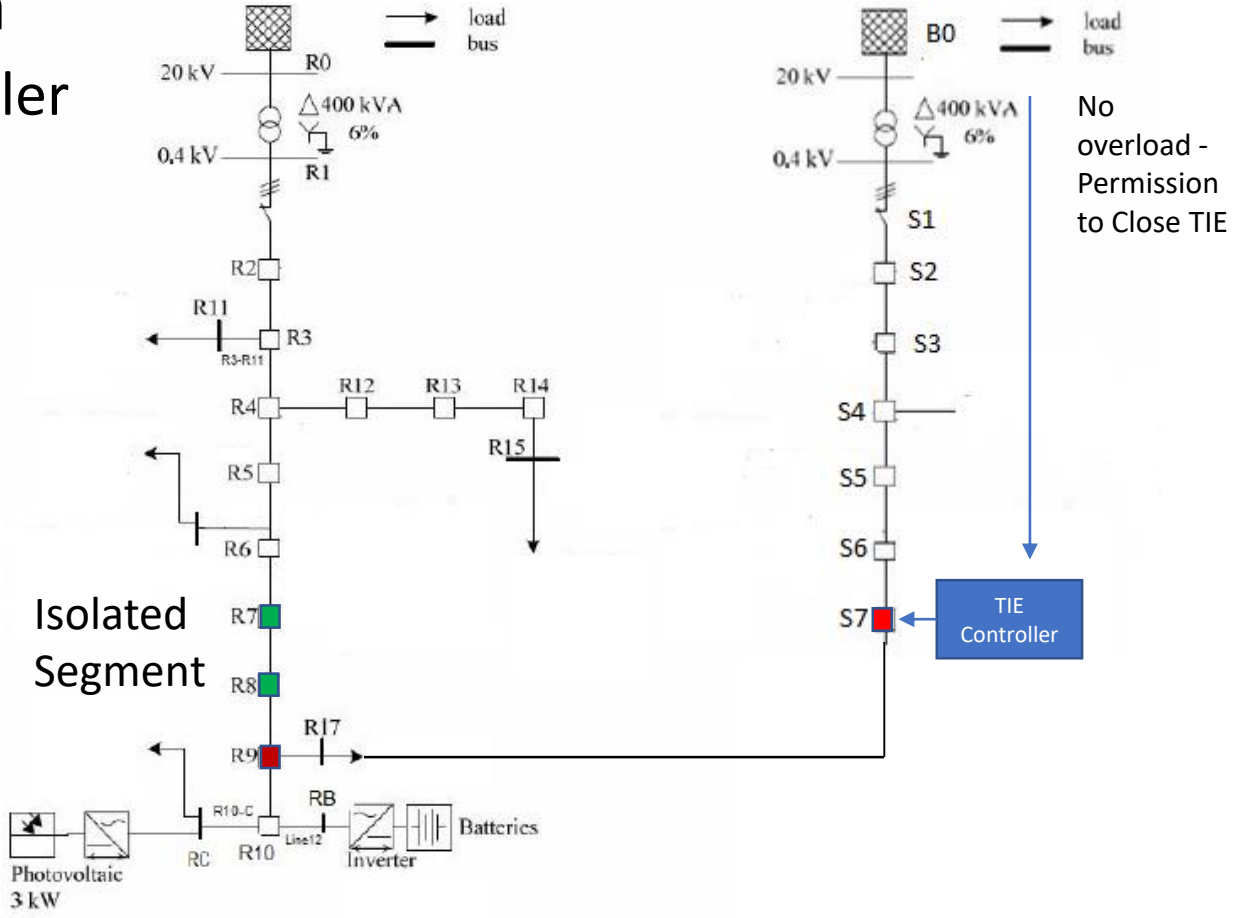
- Need to identify “restoration” options (CIM search??)
  - Identify “TIES” (S7 in this diagram) that can be closed to partially restore customers
  - Evaluate the ability of transformer (T2 in this example) and feeder capacity to support additional load

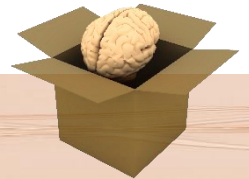




Partial Restoration

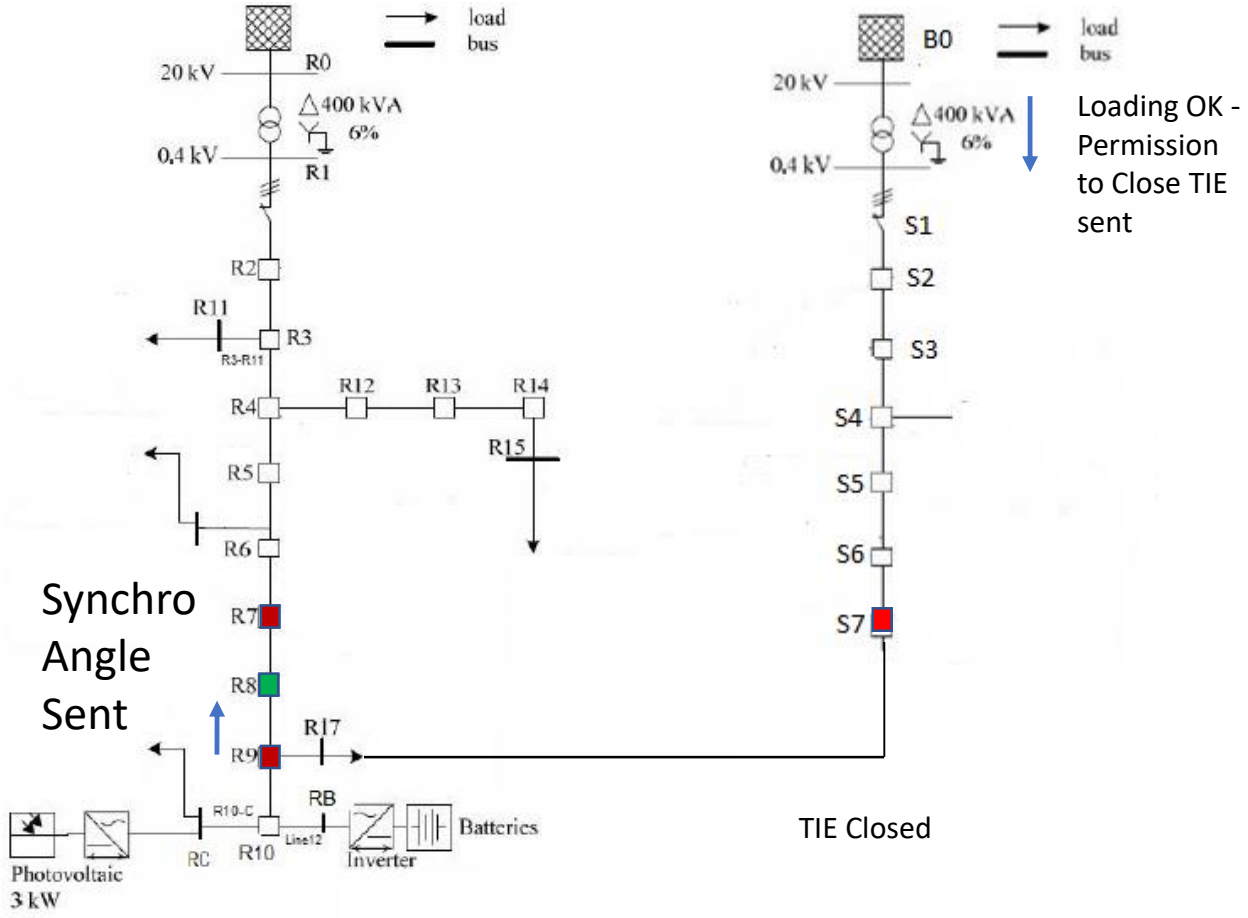
- Permission to CLOSE the TIE given
  - Sent via R-GOOSE to the TIE controller
- TIE breaker closed





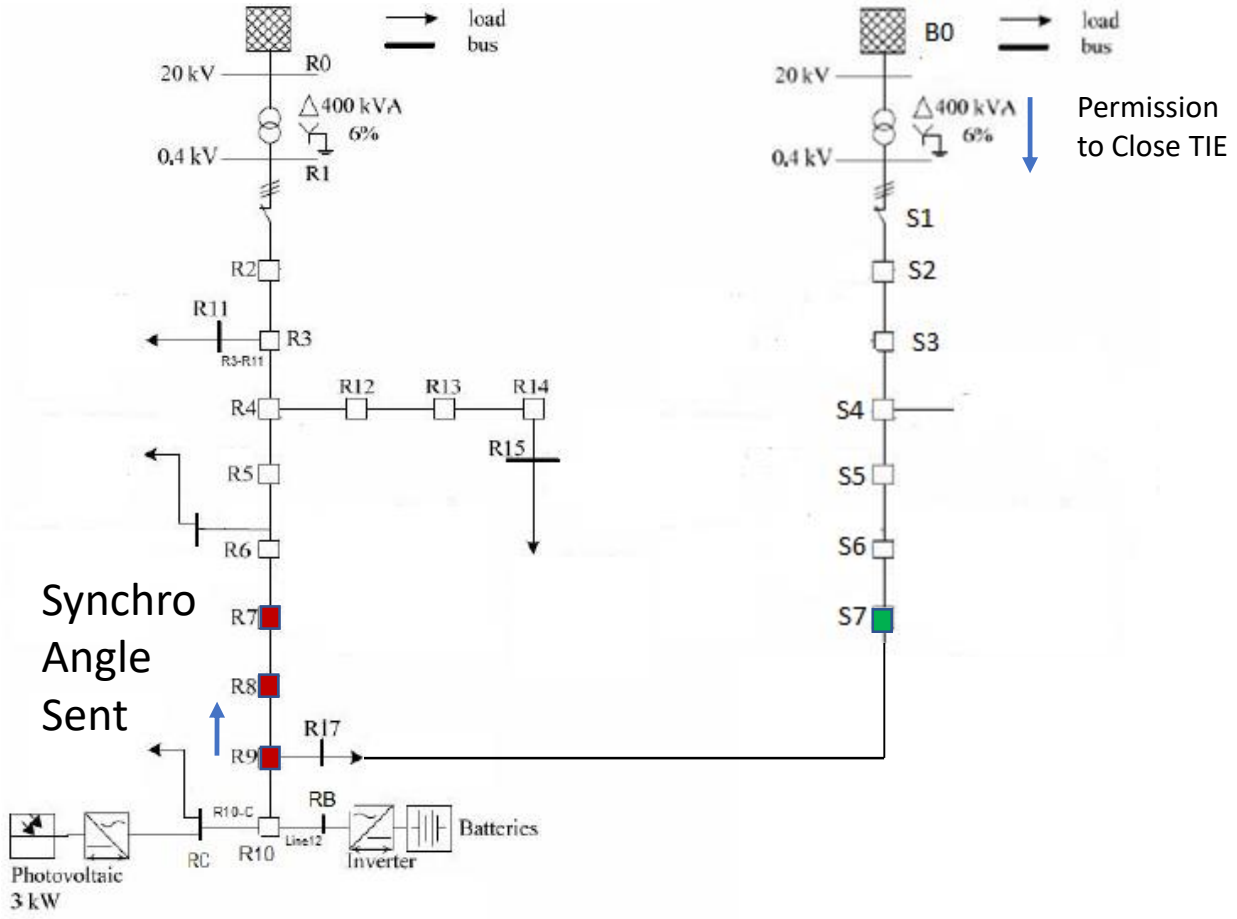
Enhanced Restoration

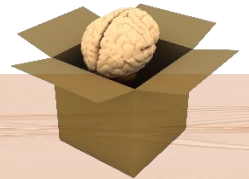
- Fault condition cleared
  - Restoration begun (R7 closed)
- Check-Sync between segments may be required
  - Dynamic Subscription of R8 controller to R9 R-GOOSE
- Synchro-Angle sent between lines via R-GOOSE
  - Sent on Change in Angle
  - RSYN LN used with Synchrophasors
  - “Relative” time good enough
- If re-connecting a MicroGrid, INCREASE or DECREASE frequency messages can be sent to the MicroGrid Controller



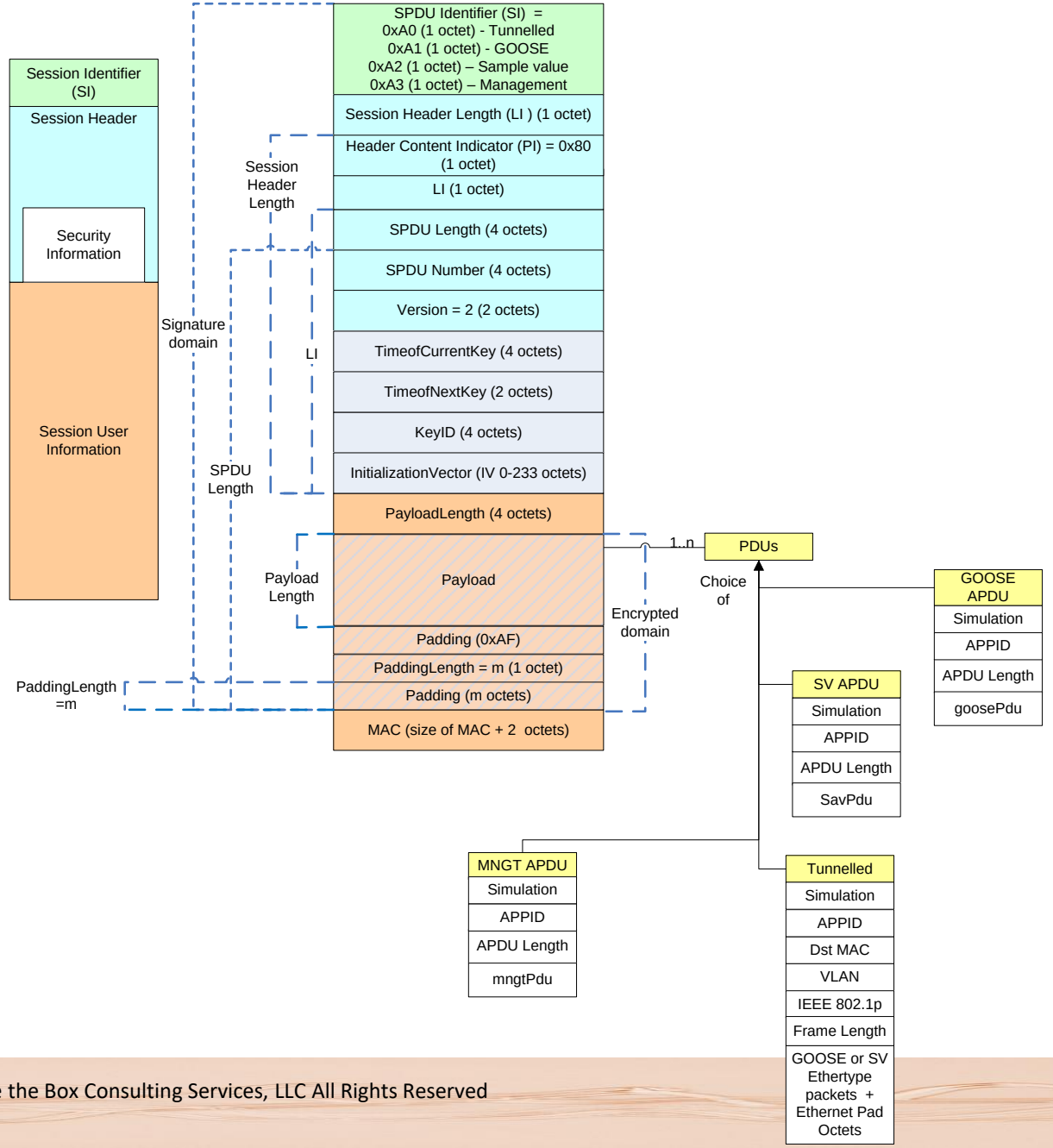
Enhanced Restoration

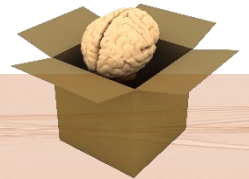
- Angles within range
  - R8 Closed
  - TIE breaker (R7) closed
  - Subscription released





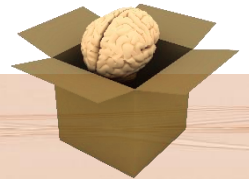
Security and R-GOOSE





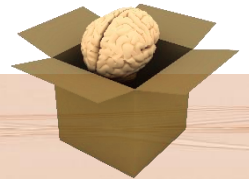
Security Characteristics

- Policy driven from Key Distribution Center
- Provides protection for:
  - Tamper
  - Spoof and Replay
  - Privacy (optional)
- Key distribution is secure (based upon Internet Standard GDOI)
  - Delivers 2 keys
  - Keys rotate every 48 hours typically
  - Requesting of keys typically from devices to KDC
  - Keys are per GOOSE Control Block which defines a group of interest



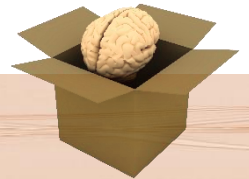
Settings are the key to protection

- IEEE PSRC H27 working on a format for settings information
- IEEE PSRC H31 working on standardized names

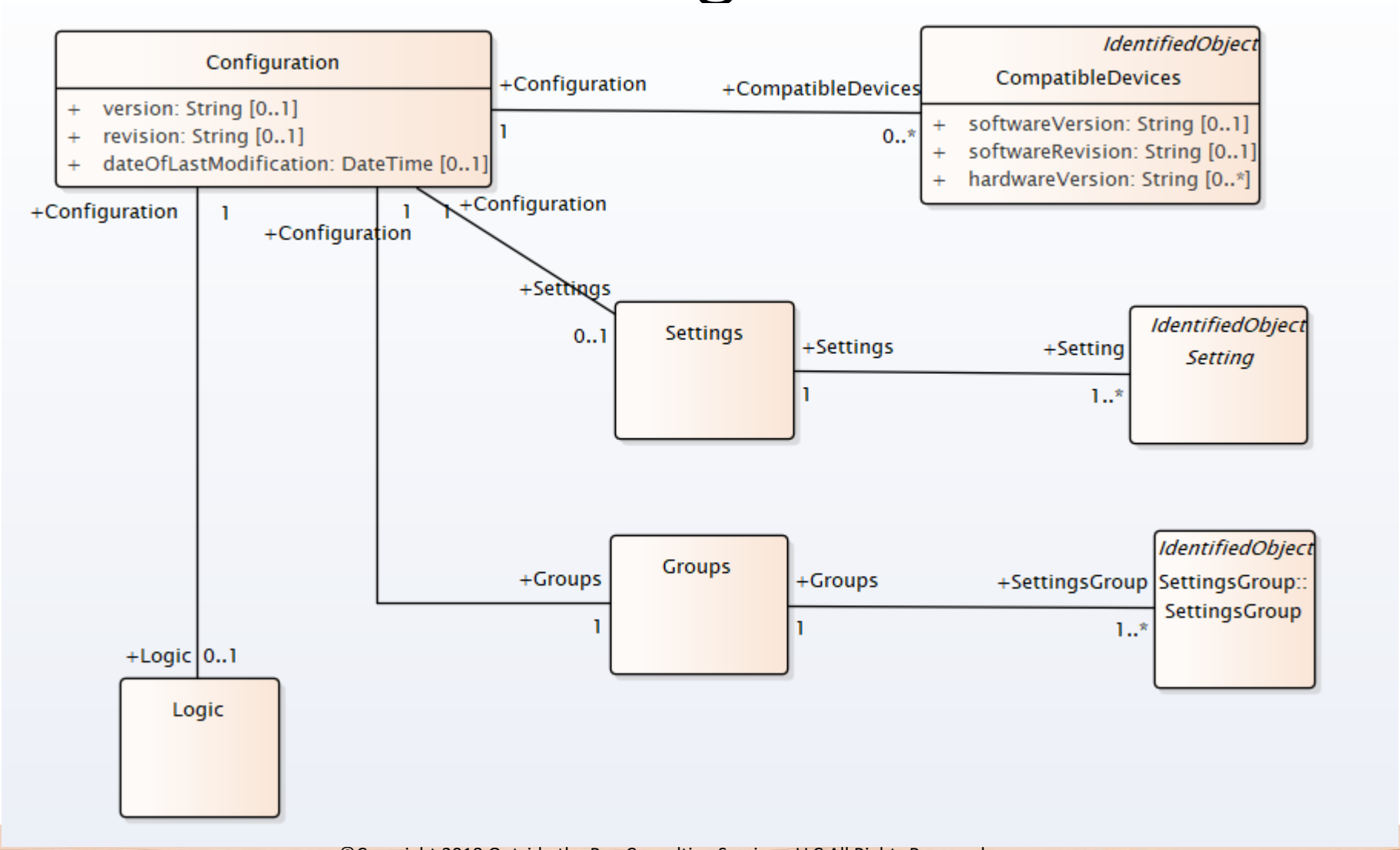


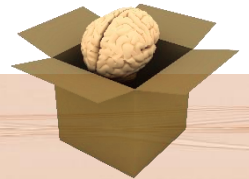
Current State of H27 work (preliminary)

- Modeled in UML
- Following CIM Modeling Constructs
- Includes
  - Settings Groups
  - Settings
  - Logic Connectivity (required to understand how settings interact/behave)

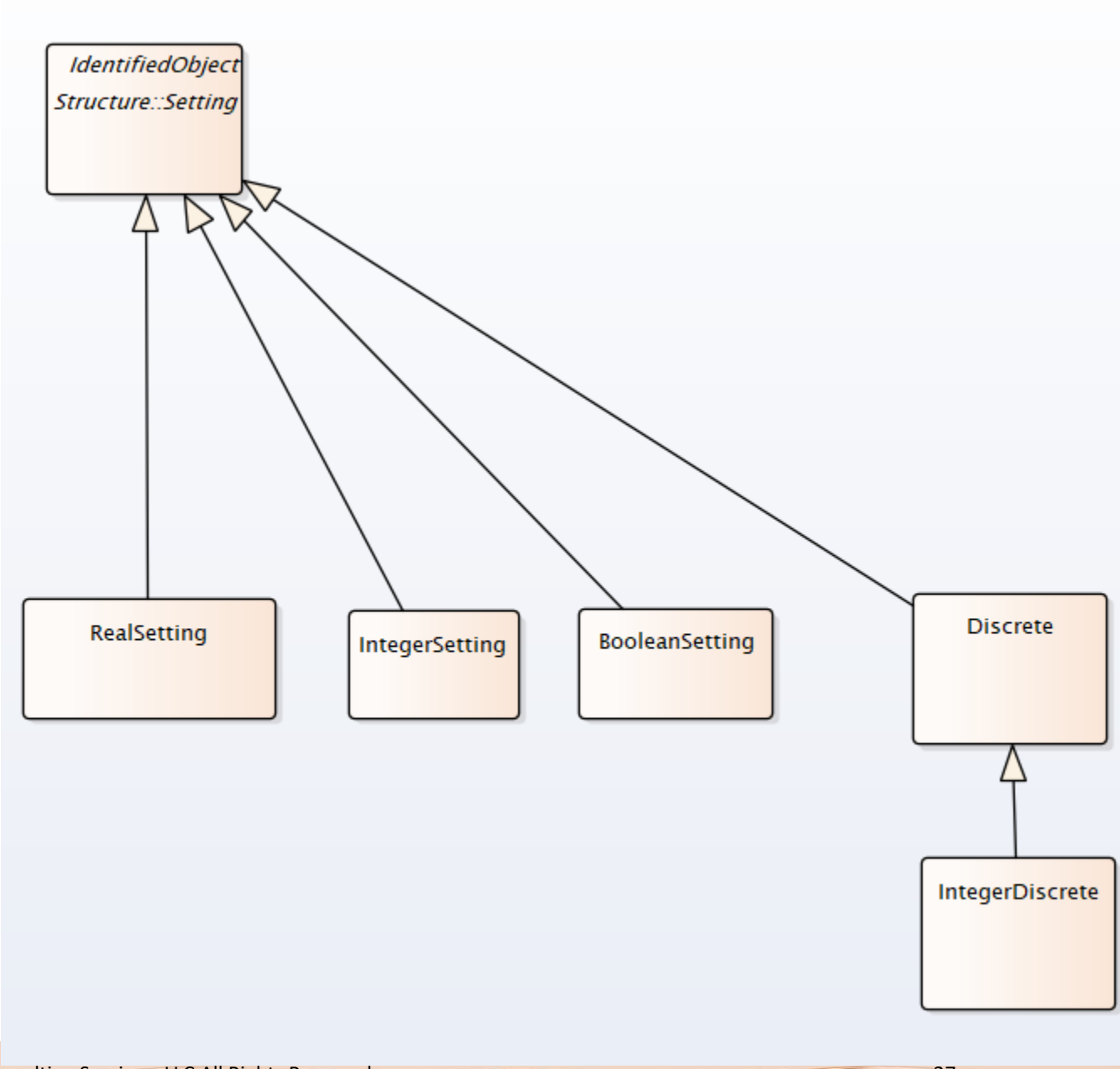


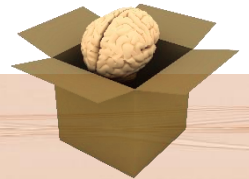
The Collection of Setting Information





Settings

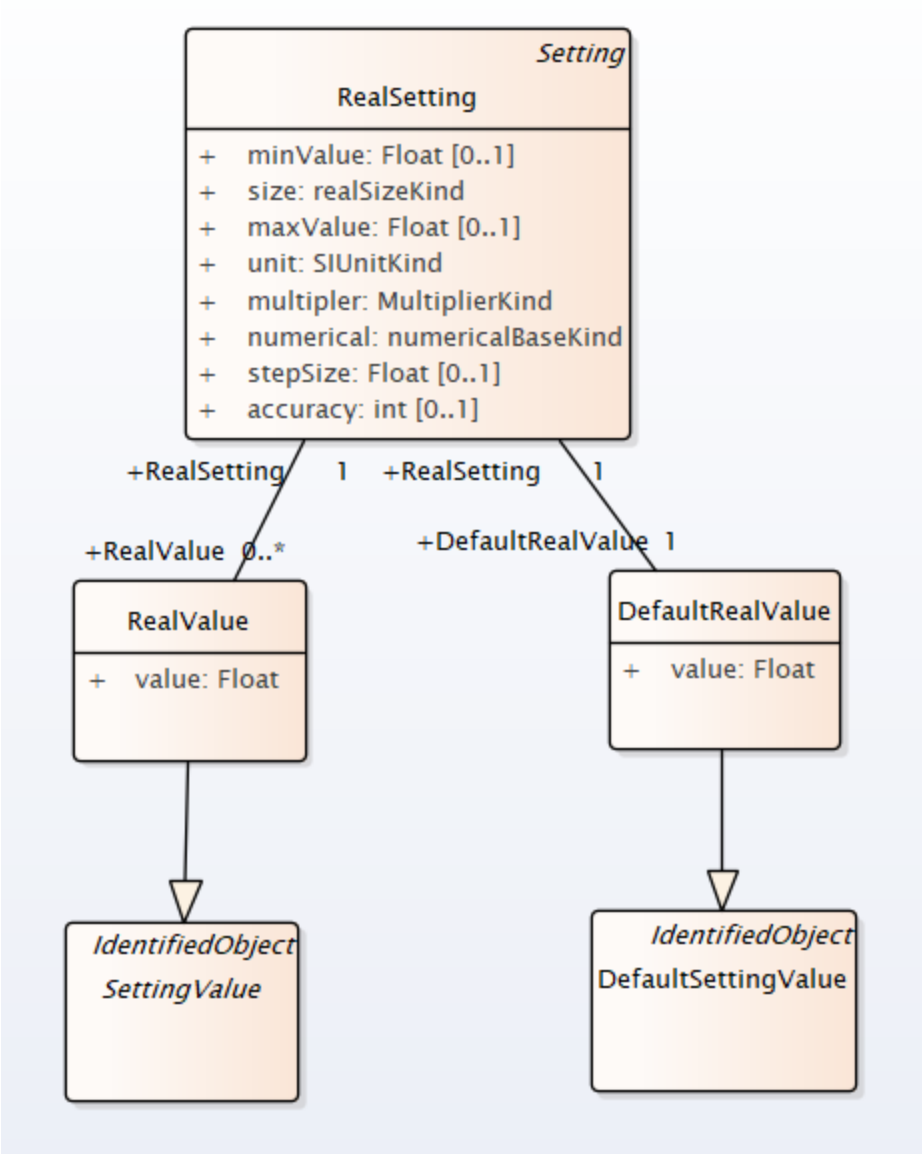


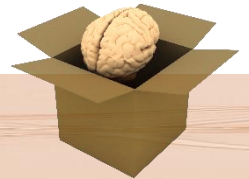


RealSetting

Allows intelligence to understand if there has been user configuration or only default values.

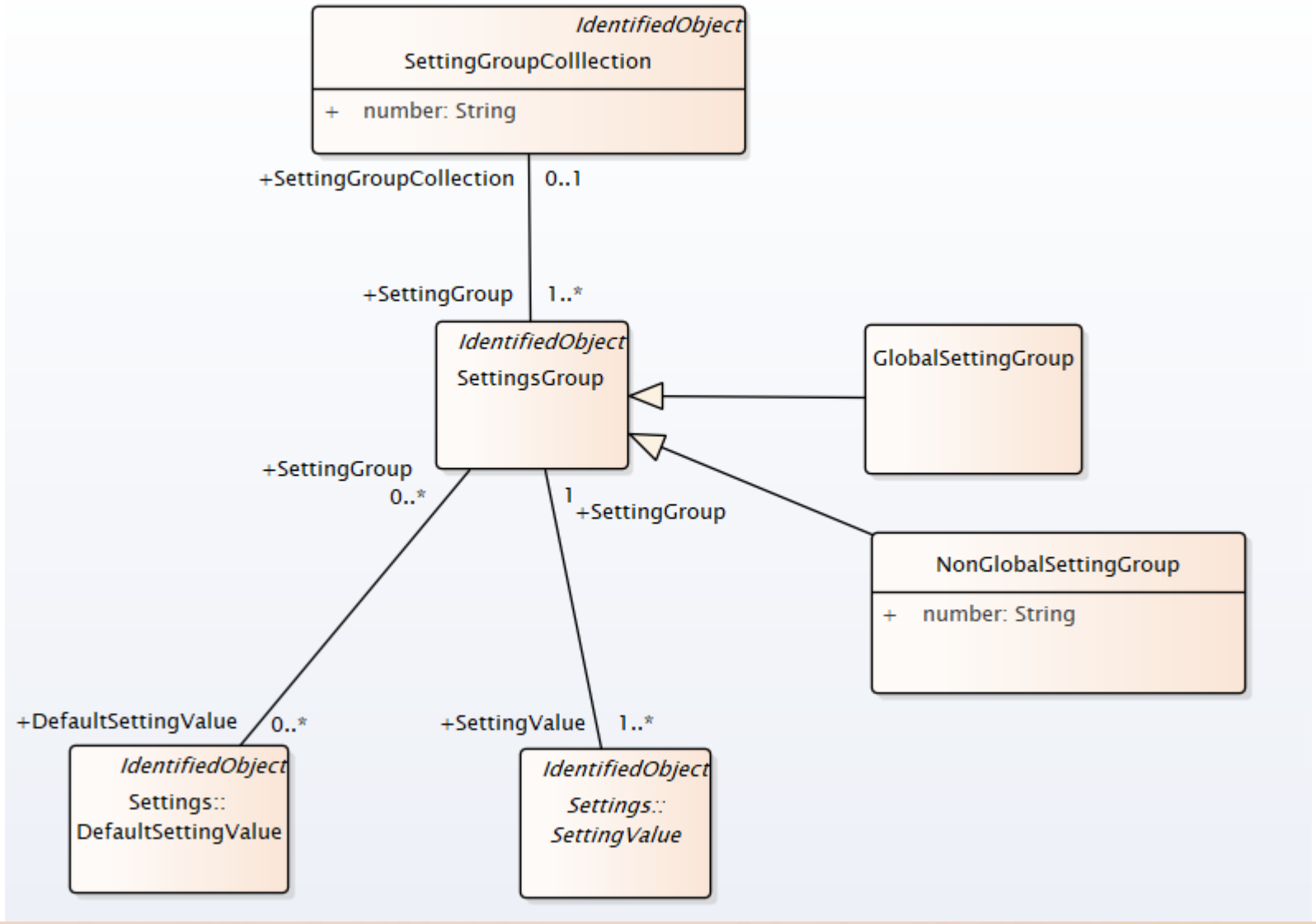
SettingValue and DefaultSettingValue are used as part of SettingsGroup

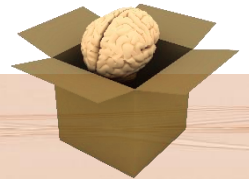




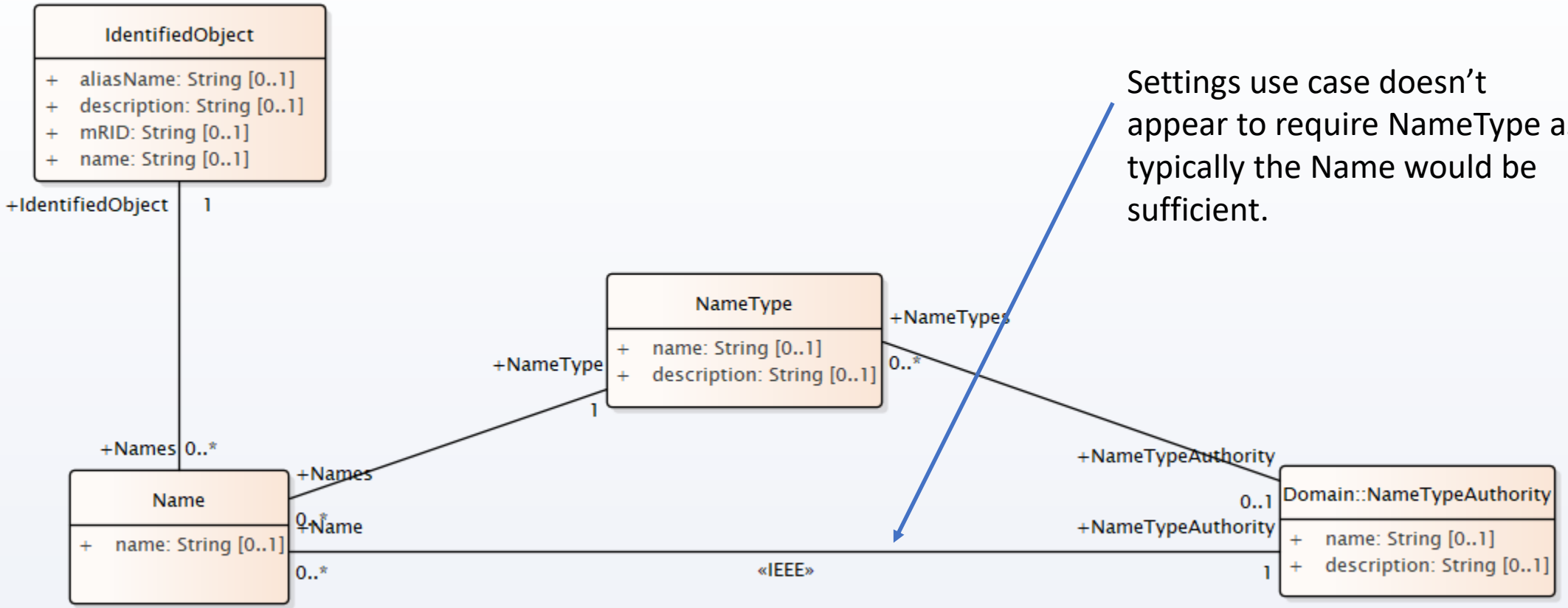
SettingsGroup

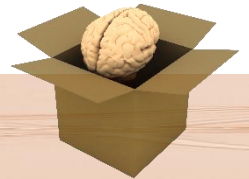
Allows determination if default values are still in use.





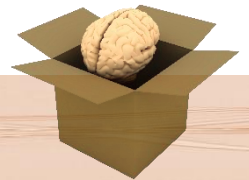
Naming (same as CIM*)





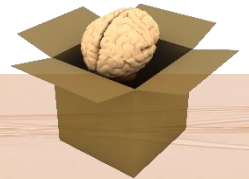
Next Steps

- H30 Linkage to IEC 61850 Logical Nodes
- Standardizing standardized setting names and the Authority.
- CIM Protection model embracing IEC 61850 Protective Functions
  - Note: All Protection Functions are not always related to RegulatinEquipment.



Conclusion

- The combination of CIM and IEC 61850 provides a foundation for enhanced FLISR
  - Enhanced FLISR requires more information exchange between field IEDs.
- Minimizes the need for
  - Field reconfiguration
  - Control center to IED communications for protection



Questions