IEC TC 57 WG 10

Enhanced Engineering Process SCL Files

Proposal for SFD File and Hierarchical Logical Nodes

White Paper

Rod Hughes Consulting Pty Ltd
A.B.N. 64 137 442 089
PO Box 757
Blackwood
SA 5051
Australia
www.rodhughesconsulting.com

This document has been prepared by:

Rod Hughes Consulting Pty Ltd
PO Box 757
Blackwood
SA 5051
Australia

Issue	Date	Filename	Comment
1-0	10 Jul 2012 2:11 PM	SFD and Abstract Nodes.docx	

Contents

1. SUMMARY

This proposal is for an enhancement to the SCL engineering process described in IEC 61850 Part 6 and additions to the Common LN class in Part 7-4.

This proposal identifies

1. An additional file type System Functional Description (SFD) file and
2. The use of a Logical Node group types and GrRef

These are required to provide the utility engineer a better means to specify the Substation Automation System (SAS) and to manage the settings of the individual Logical Nodes.

This is based on recognising a typical engineering process and specification detail developed by the utilities.

2. PROBLEM IDENTIFICATION

The issues of the current SCL process is evident in considering the process required of the utility specification engineer for a 'traditional' specification versus development of an SSD for an IEC 61850 system.

2.1 SSD FILE SCOPE

The SSD file "*describes the single line diagram and functions of the substation and the required logical nodes*[1]".

Considering the "life" of the SSD file, it exists for only a few months for any particular project as means to collect the fundamental primary plant topology and to bind certain Logical Devices and Nodes to the primary plant.

Once the SCD file is created, the SSD file is no longer an independent file that would be used within the life of the project since all it's information is extractable from the more comprehensive SCD file. Whilst short lived, it is however the principle mechanism for the utility to specify their requirements for the SAS.

As described below, in one sense the SSD file is too detailed, whilst in another it is not sufficiently explicit. This dilemma therefore complicates the engineering process for the utility making the intended "top-down" approach extremely difficult to apply if the IED selection has not yet been made.

2.1.1 SSD Too Detailed

The SSD file assumes that the LN instance requirements are absolutely known i.e. it assumes a certain IED modelling solution. The System Specification engineer is forced to either pre-select the ICD files and hence the IEDs, or, during the process effectively 'invent' a hypothetical IED which implies a hypothetical ICD file.

If the engineer pre-selects the IEDs this pre-empts procurements processes and locks in future projects to the selected vendors which therefore limits the ability to create a suite of truly generic 'vendor-independent' bay libraries.

The hypothetical/virtual IED is rarely the real model used by the various vendors causing a significant requirement for the Systems Integrator to 'map' the SSD instances to real Logical Node data models as a 're-work' engineering process and this must be repeated for each IED variant that is used in the first and repeated again in subsequent projects with yet different IEDs.

Some examples of this are:

1. Instance of a current transformer.
   Previously the engineer simply drew one symbol as the CT group on the Single Line Diagram.

   The engineering process requires a clear understanding of the IED device integration/segregation policy of the utility e.g. line protection IED and separate busbar protection IED connected to the one CT.

   In this example, the TCTR need to be specified in both line protection and busbar IEDs – i.e. up to 8 TCTR need to be included in the SSD file to reflect the specification such as "TCTR.Rat".

[1] IEC 61850-6 Edition 2 Chapter 7

On the other hand, 'digital CT' with IEC 61850 Merging Unit output only requires 1, 3 or 4 TCTR depending on the application.

Hence the SSD will inevitably have more or fewer LNs than really required simply because individual instances are specified in order to simply show the functionality

2. Distance protection was defined as ANSI device code 21 on the drawings and the procurement spec handled whether it was 1, 2, 3, 4 or 5 zones etc.

   The SSD must anticipate how many PDIS and how they are grouped in zones, and whether there are separate ones for phase and ground faults.

   This is further complicated by the vendor's model implementation of1 x PDIS per zone or 2 (ph-ph and ph-g) or 3 (1 per phase) or 6 PDIS per zone (Aph-g, Bph-g, Cph-g, A-B, B-C, C-A).

   This therefore requires some knowledge of the IED selection at the system specification stage.

3. Disturbance recording was previously a simple matter of specifying as an example "8 analogue, 32 digital channels".

   The SSD file would need to instantiate 41 Logical Nodes to describe this same requirement (RDRE, 8 x RADR and 32 RBDR). Whilst this does define the number of LNs required in the system, this is considerable effort to instantiate each of these.

In this sense the SSD file is too detailed forcing the specification engineer to instantiate multiple Logical Nodes with a knowledge of the IED modelling solution

2.1.2 SSD Insufficient Detail

In the objective of specifying functions, the SSD file assumes that the function is described by the instance of a Logical Node. However where a particular scheme is based on communications between two Logical Nodes in two different devices, there is no mechanism to specify that scheme functionality. Similarly certain physical aspects of the primary plant are not self-evident. Hence the SSD file is not sufficiently explicit.

Example of this are

1. A reverse blocking" busbar protection scheme where the "PTOC.Str" on each of the feeders is required to block the operation of the PTOC on the incomer.

   There is no mechanism in the SSD file to specify this scheme functionality. Just specifying the existence of a PTOC doesn't indicate the reverse blocking scheme requirement. The only option is for the specification engineer to develop a 'partial' SCD at least to describe the GOOSE operation.

2. Adding a CT to the single line diagram as part of creating the SSD file is more than just nominating a CT location on the primary topology. There are a number of other pieces of information critical to the SAS overall
   a. is it a single phase CT on the earth connection of the transformer,
   b. is it 3 phase (ABC) or 4 phase (ABCN) cores – Star transformers and generators can have 4 conductors plus the earthing point each with CTs,

c. are they star connected or delta connected CTs,
d. if delta the nameplate ratio of the individual CT is not 100/5 but rather 57.7/5 to cater for the square root of 3 in the delta connection – the question is then what is the TCTR.Rat value inside the Merging Unit or relay or meter is it 100/5 or 57.7/5? I would suspect that most relays would call this 100/5 but then we have a difference between the actual nameplate rating of the CT and the ratio in the SCL files – (aside: should the TCTR model needs to be expanded to identify this difference?)
e. if delta are they connected to suit main transformer vector group of Dy1 or Dy11 etc.

Example: What is the TCTR.Rat of each phase input of this transformer differential relay? There are presumably at least 7 x TCTR instances. How many TCTR are required if it is a 3 winding transformer? Bus bar differential protection relays even far more extensive to show the TCTR requirements

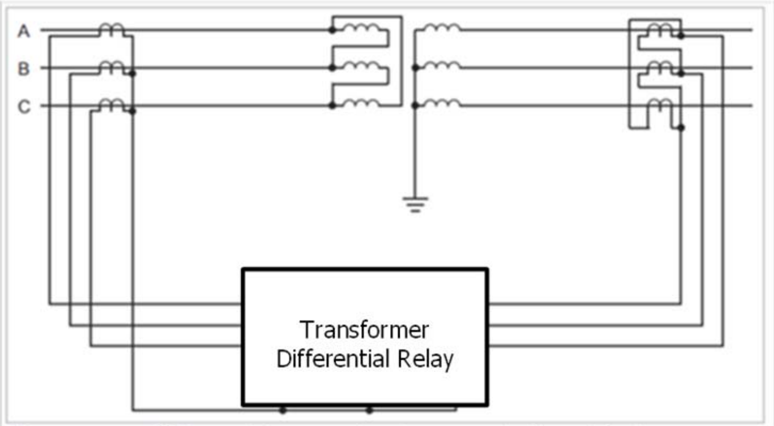


Figure 1 Example - 2 winding transformer differential - 7 TCTR - what TCTR.Rat?

2.2 MANAGEMENT OF LOGICAL NODE INSTANCES

Inevitably the processes of instantiation of Logical Nodes are related to a common function or a common piece of primary plant. When this is done there may be certain information that is effectively repeated in the data structure of the Logical Nodes but is not inherently "linked". Consequently to change a parameter related to the physical item means identifying each and every Logical Node instance where that parameter is contained and individually updating that setting.

Some examples of this are as follows depending on the models:

1. There are 1, 3 or 4 TCTR associated with a CT each requiring the setting of the TCTR.Rat CT ratio. These may also be repeated in several IEDs if they are conventional CT inputs. Previously the CT ratio was specified once on the single line diagram. If the CT ratio is ever changed it needs to be individually changed in each instance of TCTR associated with the physical CT group throughout the SCD file, i.e. appearing multiple times in multiple IEDs.

2. Distance relay models may have 1, 3 or 6 PDIS per zone depending on the vendor model. All have a common PDIS.PoRch and PctRch setting.

3. Disturbance recording using RADR will require 1, 3 or 4 RADR (one per phase) each with the same RADR.TrgMod, LevMod, PreTmms and PstTmms values.

3. SOLUTION

The attached slide show presentation uses animation to highlight the specification engineer's process.

By using a **LN type** definition of Unique or Grouped combined with a **GrRef DO**, the specification engineer can create a truly generic specification in a new **SFD** file where LN instances are not specifically enumerated (c.f. the SSD file with multiple LN instances).

The first series of slides relate to the specification of a bay with 3 CT cores (P, X and M) with a number of IEDs associated with each.

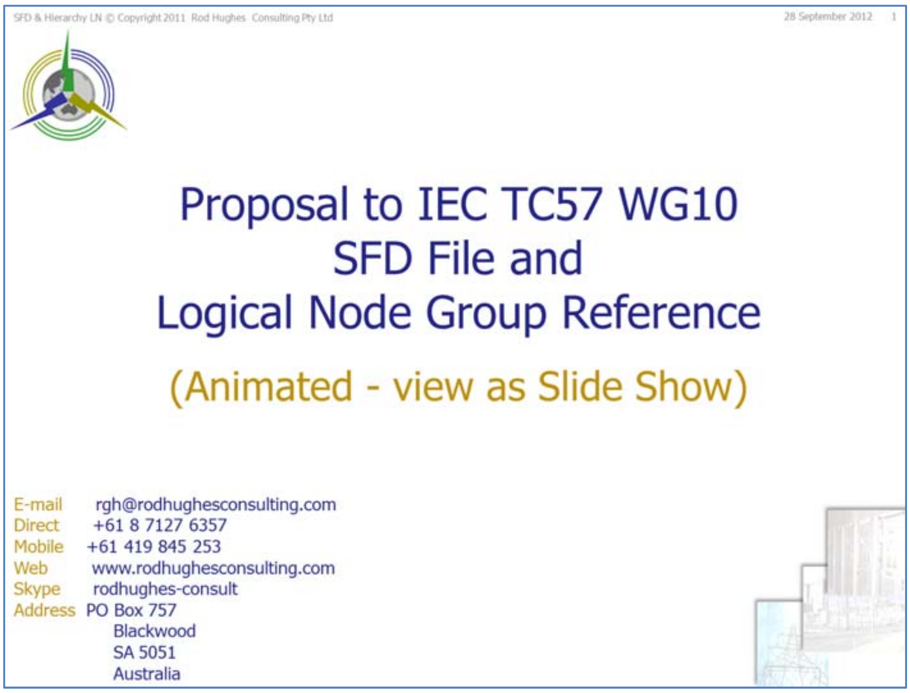
The following slides describe applications for multiple functional instance of PDIS, MMXU and RDAR.

Clearly this is only possible by some common understanding amongst the tools of how to treat these hierarchies.

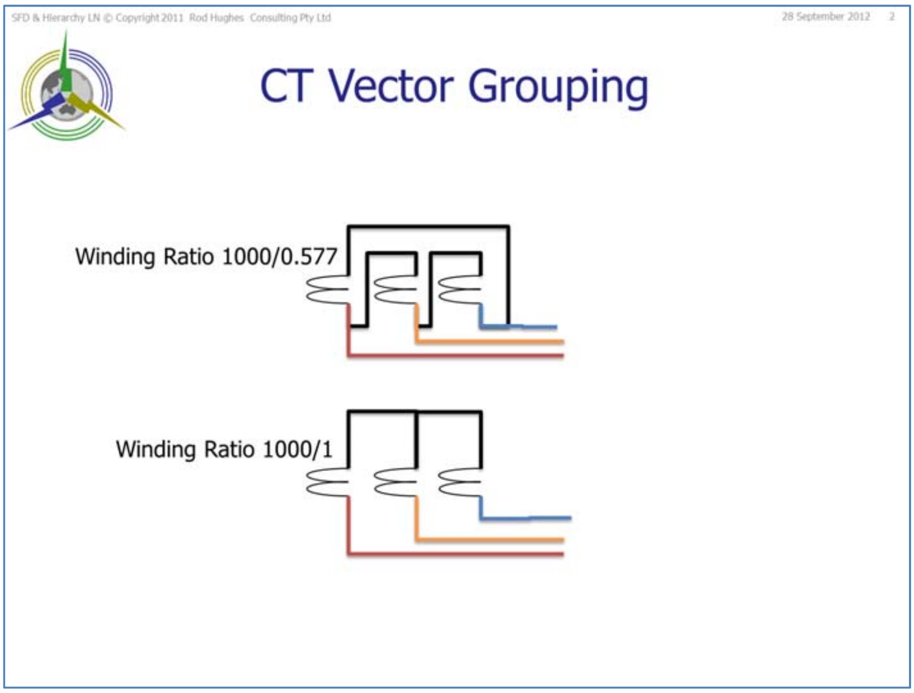
Some work may still be required to find the right terminology, however I trust the principles are clear enough to allow a rapid deployment in the Standard as well as in the IEDs and tools

Slide no

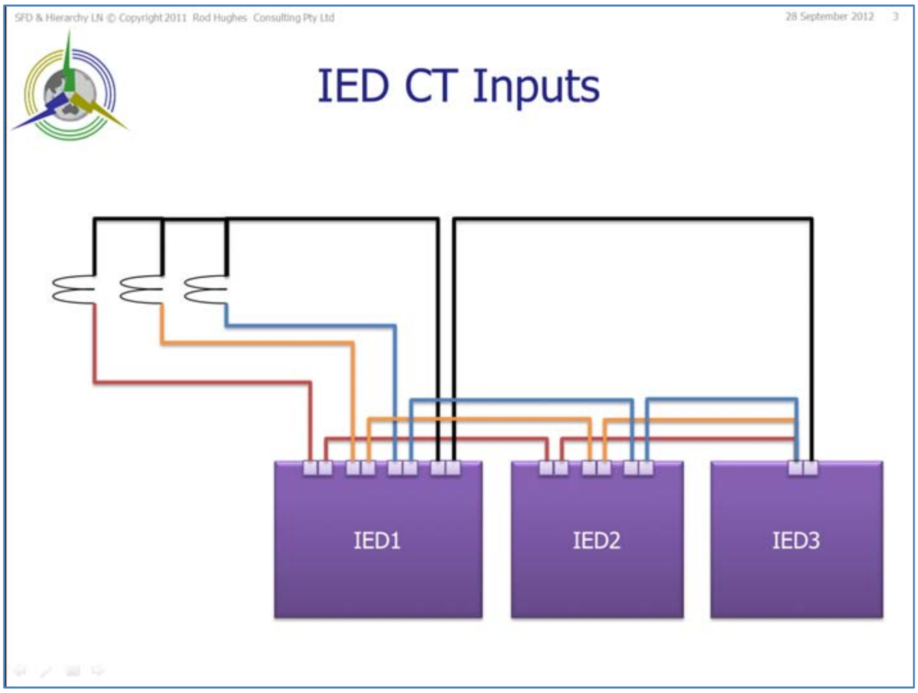
2. This shows that for any one feeder, different cores could be quite different in the physical construction and connection specifications which significantly affects the settings of the IEDs connected to them
3. This shows that for one CT group, there may be IEDs with different input configurations
4. System level info such as line ratings (1000A) are recorded
   Instantiate Cores – assume CT primary ratio matched to rated line current i.e. 1000/1
   Core 1 1000/1 class 10P100
   Core 2 1000/1 class X ….
   Core 3 1000/1 class M…
   Note: since the TCTR1, 2 and 3 have inherited some info from another item in the SFd file, it is described as a Grouped type with an associated GrRef indicating that link.
   Tools must recognise this and warn users if they are attempting to change either the individual instance that there is a grouped reference and hence does the user wish to update the parent instance as a global change
5. As the IEDs are linked to the TCTR, it can inherit the relevant settings from the grouped definition for that core.
6. When the additional cores are added, it may be that they have different characteristics so the relevant group LN is updated to reflect the difference and is changed to a Unique Type – indicating that its parameters are not inherited from a parent – i.e the GrRef may still be identified for some aspects
7. At a functional level within one IED, certain parameters may be inherited from a parent
8. The SFD file can also identify the functional requirement for a group of measurements but is actually split between two different IEDs
9. Disturbance Recording is a classic example of being able to simplify the specification engineers task at the SFD/SSD level by not having to instantiate all the RADR/RBDR at the outset – simply specify the numbers required.



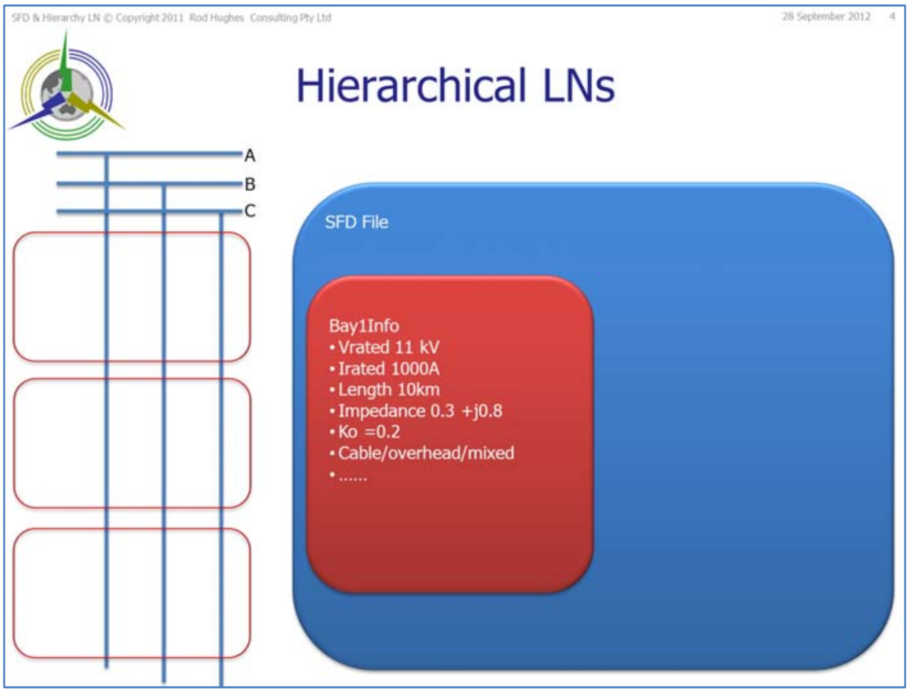
Depending on vector grouping CT Ratio may be different

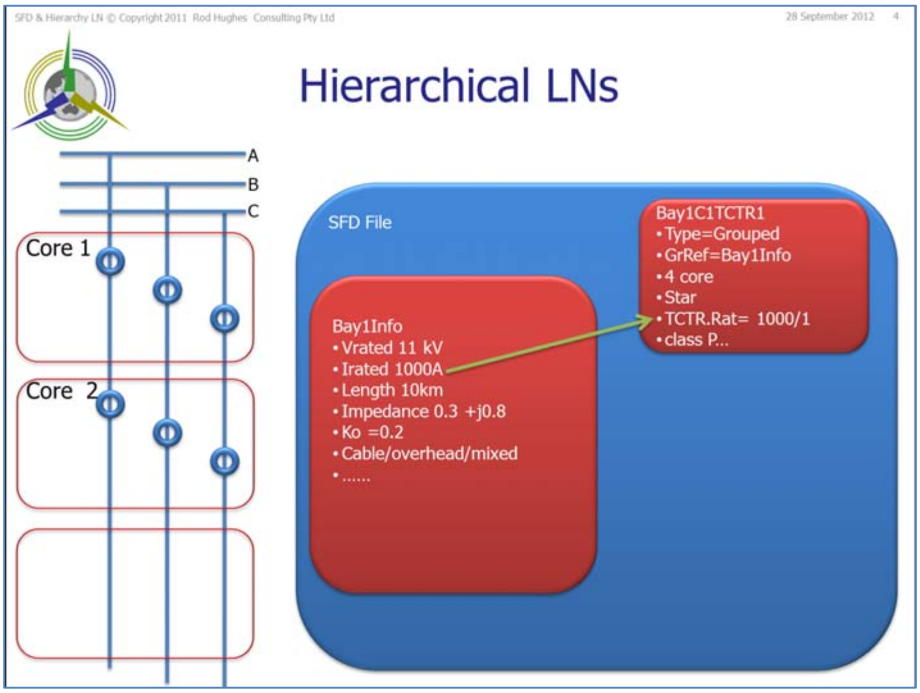


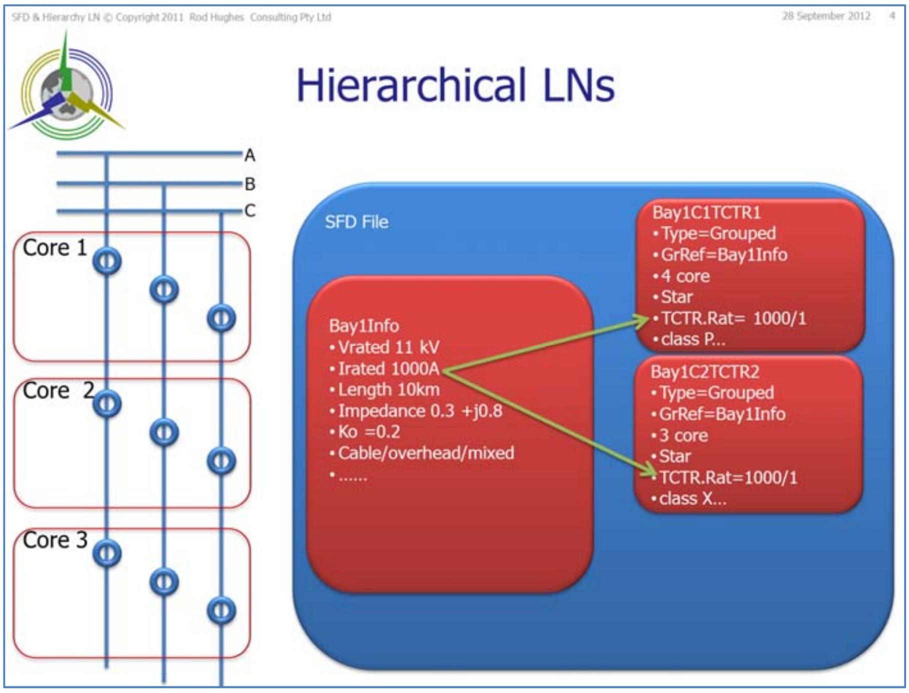
Depending on IED, it will have different numbers of inputs although connected to same CT group

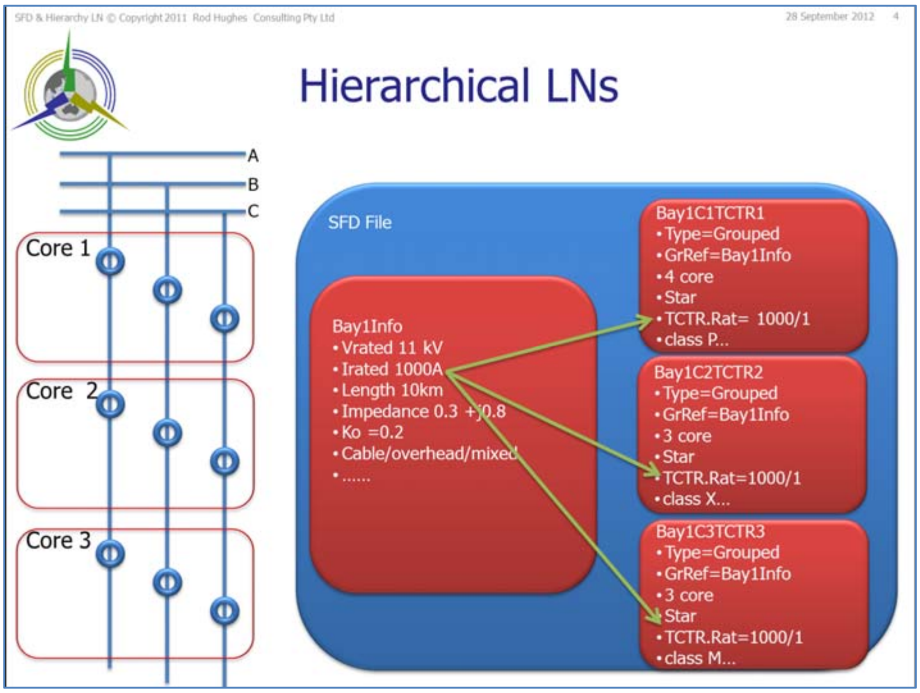


There may in fact be a common application and hence nominal ratings which should be inherited as instances are created e.g. multiple CT groups in the same Bay:

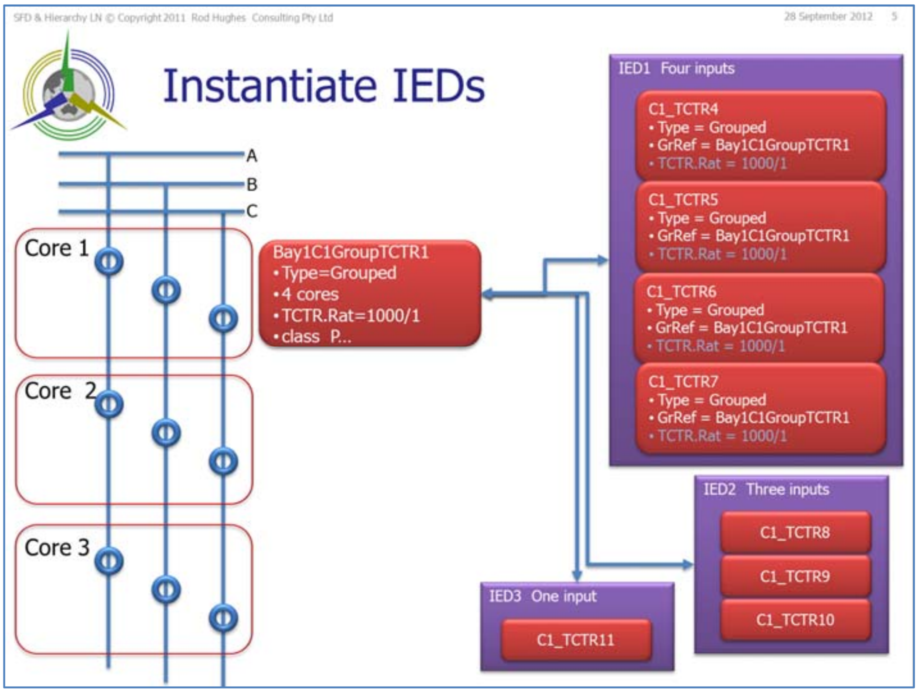



SFD & Hierarchy LN © Copyright 2011 Rod Hughes Consulting Pty Ltd
28 September 2012
4
Hierarchical LNs
A
B
C
Core 1
Core 2
SFD File
Bay1C1TCTR1
•Type=Grouped
•GrRef=Bay1Info
•4 core
•Star
•TCTR.Rat= 1000/1
•class P...
Bay1Info
•Vrated 11 kV
•Irated 1000A
•Length 10km
•Impedance 0.3 +j0.8
•Ko =0.2
•Cable/overhead/mixed
•......

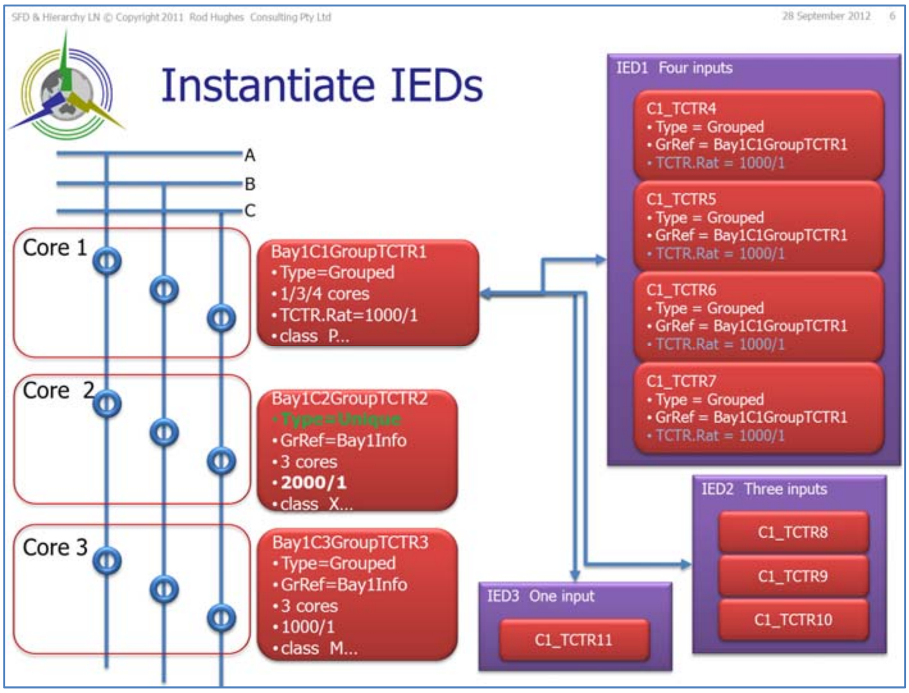

SFD & Hierarchy LN © Copyright 2011 Rod Hughes Consulting Pty Ltd
28 September 2012
4
Hierarchical LNs
A
B
C
Core 1
Core 2
Core 3
SFD File
Bay1C1TCTR1
•Type=Grouped
•GrRef=Bay1Info
•4 core
•Star
•TCTR.Rat= 1000/1
•class P...
Bay1C2TCTR2
•Type=Grouped
•GrRef=Bay1Info
•3 core
•Star
•TCTR.Rat=1000/1
•class X...
Bay1Info
•Vrated 11 kV
•Irated 1000A
•Length 10km
•Impedance 0.3 +j0.8
•Ko =0.2
•Cable/overhead/mixed
•......

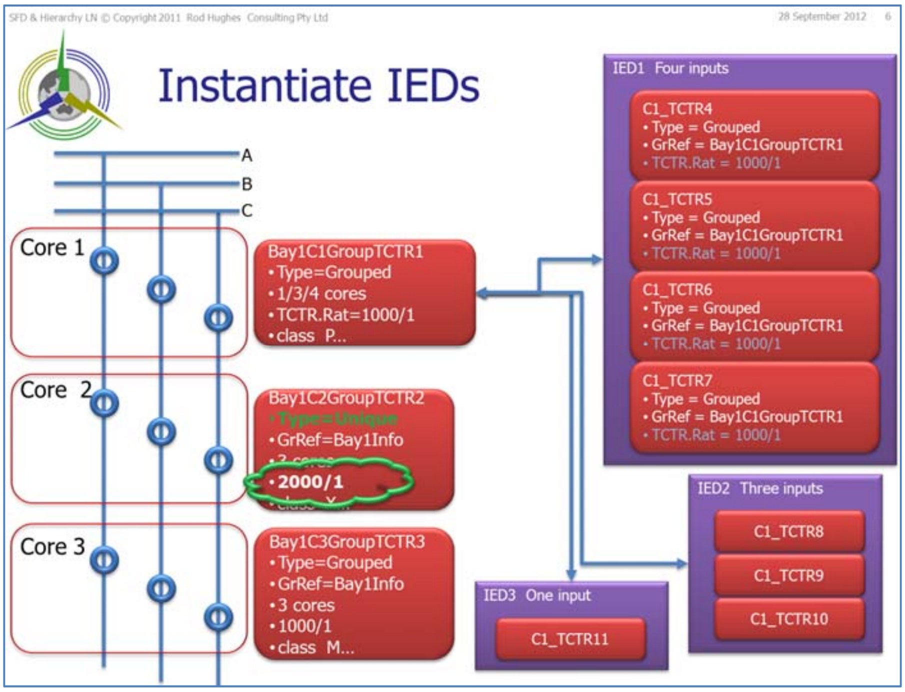


Having inherited certain physical characteristics for the multiple physical instances, this information needs to be able to be inherited by the individual LN instances to which they relate – otherwise you have to change the same setting in many different places manually eg TCTR.Rat appears in 3 IEDs and 8 LN instances needing individual update

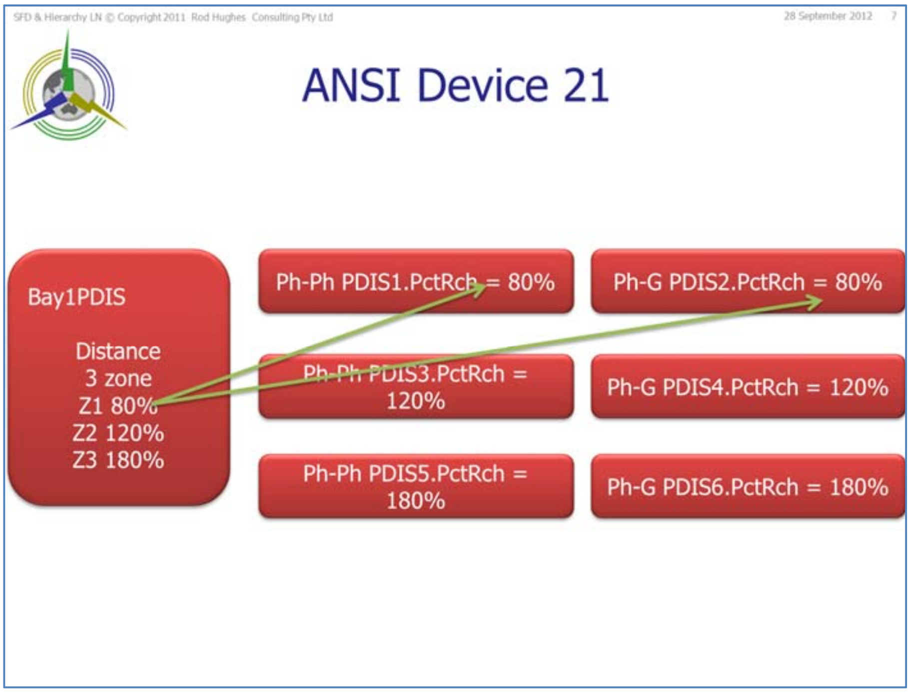


The hierarchy can be 'broken' after general instantiation if there is a different physical arrangement – e.g. one CT group has a different ratio which would then flow down to all the TCTR Instances grouped to it.

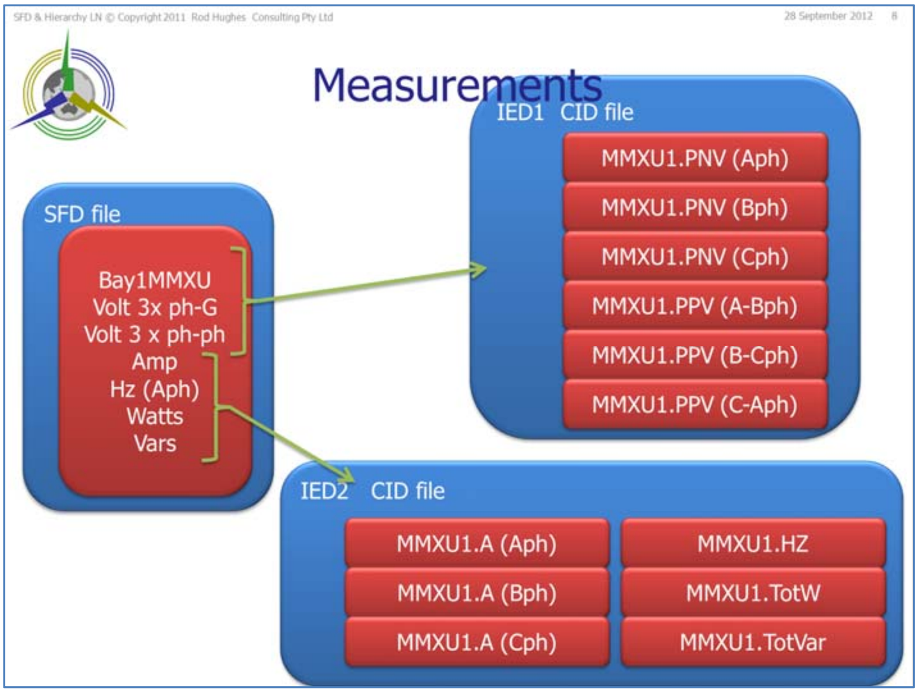


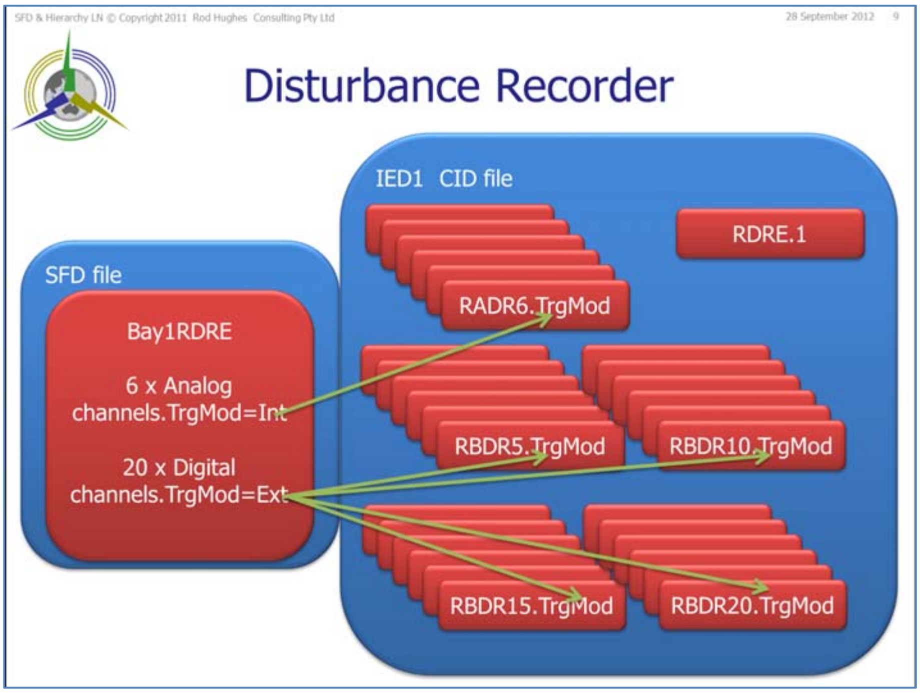


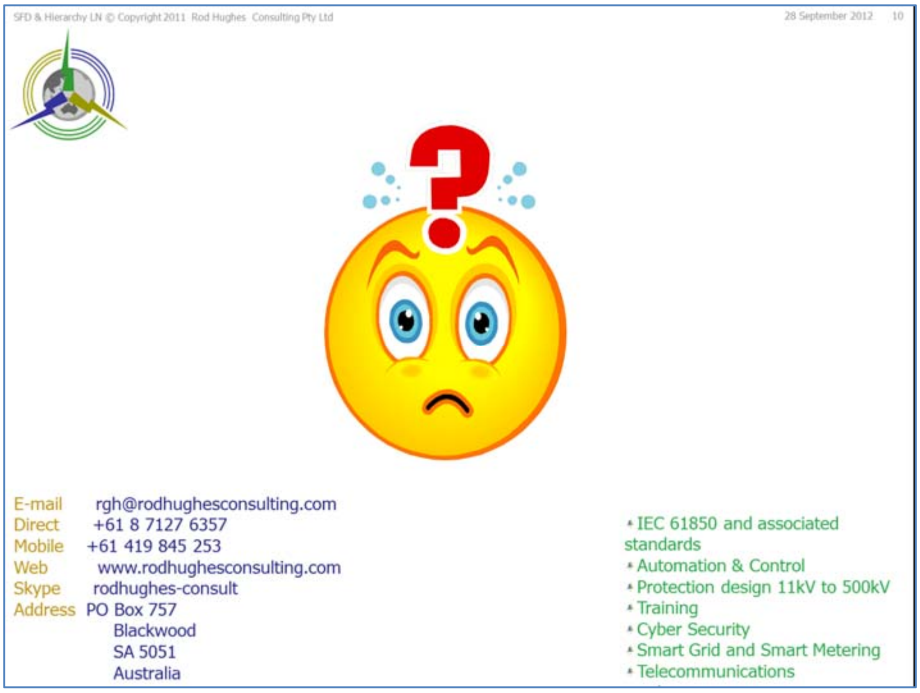
It would be even better if the functionality could be described according to the general IEEE C37.2 (ANSI) Device Number used is so many single line diagrams although they represent many individual sub/supporting functions. Tools must be able to specify using these codes and convert to a hierarchy grouped LN according to IEC 61850-5 clause 11.1.1



Whist the system may require certain pieces of information, the particular IEDs will be chosen later on depending on the vendors available data objects and attributes.




SFD & Hierarchy LN © Copyright 2011 Rod Hughes Consulting Pty Ltd
28 September 2012
9
Disturbance Recorder
IED1 CID file
RDRE.1
SFD file
Bay1RDRE
6 x Analog channels.TrgMod=Int
20 x Digital channels.TrgMod=Ext
RADR6.TrgMod
RBDR5.TrgMod
RBDR10.TrgMod
RBDR15.TrgMod
RBDR20.TrgMod


SFD & Hierarchy LN © Copyright 2011 Rod Hughes Consulting Pty Ltd
28 September 2012
10
E-mail rgh@rodhughesconsulting.com
Direct +61 8 7127 6357
Mobile +61 419 845 253
Web www.rodhughesconsulting.com
Skype rodhughes-consult
Address PO Box 757
Blackwood
SA 5051
Australia
IEC 61850 and associated standards
Automation & Control
Protection design 11kV to 500kV
Training
Cyber Security
Smart Grid and Smart Metering
Telecommunications