Proving Accounting, Structural, Mathematical, and Other Logic of XBRL-based Financial Reports

Understanding specific situations which cause accounting logic, mathematical logic, or other logic errors and how to eliminate those situations and thus the errors

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“I skate to where the puck is going to be, not where it has been.” Wayne Gretzky, legendary Canadian hockey star

Executive summary:

- XBRL-based financial reports are logical systems\(^1\). Said another way, such reports are not arbitrary, haphazard, illogical, or random.

- There are nine specific identifiable situations which occur in XBRL-based financial reports which cause accounting logic, mathematical logic, structural logic, or other types of logical errors.

- Each of the nine specific identifiable situations can be eliminated using XBRL-based machine-readable rules and software which understands how to leverage the rules and make report creation software users aware of such logical errors so that the errors can be corrected.

- Those same XBRL-based machine-readable rules can be used by those who desire to extract information from such reports reliably and effectively.

- Today, two software applications exist which leverage these XBRL-based machine-readable rules and show high-quality XBRL-based financial reports can be reliably created.

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There are nine specifically identifiable situations which enable the possibility of accounting logic errors, mathematical errors, or other types of provable logical errors to enter XBRL-based financial reports and remain undetected. The following is a summary of these nine situations and what can be done to eliminate the possibility of these nine categories of errors:

<table>
<thead>
<tr>
<th>#</th>
<th>Description of situation</th>
<th>Elimination of situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Using an existing base taxonomy concept intended to represent one class of concept inadvertently to represent some other class of concept.</td>
<td>Formal “class-subclass” relations represented in machine-readable form within base XBRL financial reporting taxonomies will eliminate the possibility of this situation.</td>
</tr>
<tr>
<td>2</td>
<td>Lack of clarity of the meaning of extension concepts.</td>
<td>Formal “class-subclass” relations articulated in machine-readable form provide clarity of extension concept meaning.</td>
</tr>
<tr>
<td>3</td>
<td>Unreported high-level subtotals.</td>
<td>Clearly communicate what concepts might potentially be used to represent high-level financial report line items, provide machine-readable rules to derive unreported high-level financial report line items, and provide machine-readable rules to verify that the high-level financial report line items mathematical relations are intact.</td>
</tr>
<tr>
<td>4</td>
<td>Variability allowed for reporting high-level accounting relationships.</td>
<td>In order to successfully overcome the variability allowed in financial reports; each variation of balance sheet, income statement, cash flow statement, and statement of comprehensive income must be explicitly provided for in an XBRL financial reporting base taxonomy. In addition, the rules that define those fundamental high-level accounting relations must be articulated for each variation of each statement.</td>
</tr>
<tr>
<td>5</td>
<td>High-level financial report line item inconsistencies and contradictions.</td>
<td>Every variation of primary financial statement must have a set of consistency cross check rule that explain those high-level fundamental accounting concept relations of that specific variation and can then be used to make certain that no continuity errors exist because of inconsistent facts or contradictions in reported facts.</td>
</tr>
<tr>
<td>6</td>
<td>Presentation relations model structure relations illogical</td>
<td>A set of allowed relations between the parents and children of each category of report element should be explicitly and unambiguously articulated to those creating XBRL-based reports.</td>
</tr>
<tr>
<td>7</td>
<td>Verification that each report fragment is created correctly.</td>
<td>Provide a set of rules that articulate the key logical aspects of each report fragment that is to be reported. To achieve this, each disclosure must be named in order to organize this information and rules are then associated with each specific named disclosure using XBRL definition relations.</td>
</tr>
<tr>
<td>8</td>
<td>Mathematical relations are not explained using machine-readable rules and then verified against that machine-readable explanation.</td>
<td>Each report should provide machine-readable rules that can be used to explain the mathematical relations that exist in a report and to verify that the information in the report is consistent with those explanations.</td>
</tr>
<tr>
<td>9</td>
<td>Verification that each report fragment that is required to be disclosure exists within the financial report.</td>
<td>Provide a set of rules that explain when specific disclosures are expected to be provided within a financial report which can be used by software applications to verify consistency of the report to what is expected per the machine-readable explanation.</td>
</tr>
</tbody>
</table>

The following sections provide additional details that elaborate on the above summary.
Situation 1: Using an existing base taxonomy concept intended to represent one class of concept inadvertently to represent some other class of concept.

What prevents someone creating an XBRL-based financial report from using a concept intended to be used to represent one classification to incorrectly use that concept to represent some other classification of concept?

For example, the concept “Property, Plant and Equipment” is intended to be part of “Noncurrent Assets”. What prevents someone creating an XBRL-based financial report from inadvertently use the concept “Property, Plant and Equipment” to represent a “Current Asset”?

The example provided is an easy to understand example of literally thousands of possible similar situations when an XBRL-based financial report is created. What functionality does the
base taxonomy provide to (a) clearly indicate how the concept should be used and (b) enable automatable processes to check if a concept is being used incorrectly?

The screen shot below is generated from a set of XBRL definition relations. The XBRL definition relations formally document relations or associations between concepts; financial report high-level classifications such as “Current Assets” and formal, explicitly defined subclassifications that are allowed for that subclassification, for example “Cash and Cash Equivalents” and “Receivables”.

The relations were expressed in the XBRL definition relations using a proprietary arcore, “class-subClass” which was defined using global standard functionality provided by the XBRL technical syntax.

A second software tool shows the actual XBRL arcore used to express the association within the XBRL definition relations:

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2 XBRL definition relations which define class-subclass relations, [http://xbrlsite.azurewebsites.net/2019/Prototype/proof/basic-classes-definition.xml](http://xbrlsite.azurecontainers.io/2019/Prototype/proof/basic-classes-definition.xml)

3 XBRL taxonomy schema which defines arcore for “class-subClass”, [http://xbrlsite.azurewebsites.net/2016/conceptual-model/cf-arcore.xsd](http://xbrlsite.azurewebsites.net/2016/conceptual-model/cf-arcore.xsd)
While the approach of using what amounts to a proprietary “class-subClass” relation to formally express these sorts of associations works; this approach is not necessarily optimal. XBRL International provides a means to express this sort of association, the “general-special” definition relation. However, the semantics of the “general-special” arcrole are somewhat vague and the semantics are inconsistent with the OWL definition of “class-Subclass”.

Another possible alternative is the “wider-narrower” arcrole defined by the ESMA. This formal expression is provided by XBRL International via the Link Role Registry (LRR) which is good. But again, the semantics of the “wider-narrower” arcrole are different than the standard “class-subClass” relation defined by OWL.

All things considered, any of these three alternatives could work. Perhaps a more perfect solution would be for XBRL International to provide an XBRL arcrole that is define to be consistent with the OWL “class-subClass” relation semantics and make that arcrole available via the XBRL Link Role Registry (LRR).

The over-arching objective is to help users of a base taxonomy to understand the correct and incorrect use of concepts and other report elements contained within the XBRL taxonomy. Further, expressing this information formally and explicitly using machine-readable XBRL would enable software applications to detect such errors.

ELIMINATING SITUATION: Formal “class-subclass” relations represented in machine-readable form within base XBRL financial reporting taxonomies will eliminate the possibility of this situation by making these relations clear and enabling the creation of automated software processes for detecting such errors so that they might be corrected.

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6 XBRL International, Link Role Registry, [https://specifications.xbrl.org/registries/lrr-2.0/](https://specifications.xbrl.org/registries/lrr-2.0/)
Situation 2: Lack of clarity of the meaning of extension concepts.

Extension concepts tend to all get grouped into the category of “bad” when it comes to XBRL-based financial reports. However, this is a mischaracterization and over-generalization of extension concepts.

Consider the following example. An economic entity properly reports the concept “Inventories” on its balance sheet as is required\(^7\). Further, the economic entity provides a disclosure of the breakdown of the subclassifications of inventories\(^8\).

But the, suppose that an economic entity wants to provide a further breakdown of the subclassifications or components of finished goods inventories\(^9\). They do so within a separate disclosure which is not required by an economic entity to make; essentially the economic entity is choosing to provide additional information which they feel might be helpful to understating the economic entity.

And so, two economic entity extension concepts are created, “Product Alpha” and Product Bravo” which then total to the base taxonomy concept “Finished goods”.

(Note that in the actual example, all concepts are represented in one taxonomy for simplicity of creating this example. In a real report, the two concepts “Product Alpha” and “Product Bravo” would be from a separate namespace with an economic entity’s extension taxonomy, however in the example provided they come from the same namespace.)


Now, is it possible to understand that “Product Alpha” and “Product Bravo” are subclassifications of “Finished Goods” by only providing the information you see above? The answer is yes. How? The Finished Goods [Roll Up] expresses XBRL calculation relations, “summation-item”, which can be interpreted as meaning that the two extension concepts created are part of the base taxonomy “Finished Goods” concept.

However, this approach will only work for concepts that participate in XBRL calculation relations. How would information about other extension concepts be represented if they are not part of a roll up computation of if the concept is nonnumeric?

The same “class-subclass” relations used in the first situation could likewise be used to solve the issue of understanding the nature of extension concepts provided relative to a base taxonomy. XBRL definition relations can be used to show the association between an extension concept created and the base taxonomy using “class-subclass” arcroles to formally and explicitly express the association.

So here, the company would hook “Product Alpha” and “Product Bravo” to the tree as children of “Finished Goods” with the relation predicate (XBRL arcrole) “class-subclass”. Alternatively,

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11 XBRL definition relations which define class-subclass relations hooking extension concept to base taxonomy, [http://xbrlsite.azurewebsites.net/2019/Prototype/proof/basic-classes-definition.xml](http://xbrlsite.azurewebsites.net/2019/Prototype/proof/basic-classes-definition.xml)
as previously stated, the existing “general-special” or “wider-narrower” associations could be used with the same affect.

**ELIMINATING SITUATION:** Formal “class-subclass” relations articulated in machine-readable form provide clarity of extension concept meaning.

**Situation 3: Unreported high-level subtotals.**

Certain financial report line items are required to be reported. For example, the concept “Net Income (Loss)” which represents to total amount of the income statement which is then transferred to equity is generally always reported.

However, many subtotals of that total are reported only subject to the preferences of the person responsible for creating the report. Rather than being pedantic here and provide opinions about arbitrary details, it is more important to focus on the core idea that often certain subtotals are not explicitly reported within a financial statement.

For example, consider the two income statement examples below that are 100% logically equivalent but different (extreme to make a point) in the manner that they represent individual line items.

On the LEFT with the RED heading, certain line items are implied including “Operating Expenses”, “Nonoperating Income (Expenses)”, “Income (Loss) from Continuing Operations Before Tax”, and “Income Tax Expense (Benefit)”. However, on the RIGHT with the GREEN heading, 100% of the implied line items are explicitly reported.
Now, imagine the needs of a data aggregator which desires to extract information from the income statement on the LEFT and compare that information with the income statement on the RIGHT. There are exactly two approaches that could be used to convert the two reports to one common format, likely the format on the RIGHT which is the most explicit and therefore has the most detail. Remember, computers are dumb beasts and they have to be told exactly what to do in order to achieve a conversion such as this.

Approach 1 would be to write rules for each financial report and convert the report to the desired format. Approach 2 would be to write general rules that could be used universally to convert all financial reports to the same format. (For the time being, imagine that all income statements use the same basic format; the variability of reports will be considered in a separately addressed situation.)

The rules necessary to convert the representation on the LEFT to the representation on the RIGHT can be articulated using XBRL Formula\(^\text{12}\).

You will likely note that in this specific XBRL instance, the missing line items from the income statement on the LEFT that do exist in the income statement on the RIGHT do exist within the XBRL instance. But what if the missing line items did not physically exist in the XBRL instance. How then could XBRL formula be used to perform this task? The answer is that an additional step needs to be performed where by the missing facts are derived or imputed from information which does exist within the XBRL instance.

Deriving unreported line items gets more and more complicated when a high number of line items are missing from a report. For example, while it is true that the line item “Income (Loss) from Continuing Operations Before Tax” is not reported on the LEFT and neither is “Income Tax Expense (Benefit)” but you do know the value for “Net Income (Loss)”; you COULD logically deduce that “Income (Loss) from Continuing Operations Before Tax” is the same value as “Net Income (Loss)”. However, because there are two missing pieces of information and if the economic entity either made a mistake or used an extension concept; you could reach an incorrect conclusion.

Further, there is the issue of an economic entity reporting a high-level financial report line item using a more detailed concept. For example, suppose that an economic entity reported the line item “Sales” in the income statement we are showing using a more detailed concept such as “Product Sales”. How would a software application looking for the concept “Sales” understand that “Product Sales” might have been used to report the line item you are looking for?

\(^{12}\) Fundamental accounting concept relations rules, http://xbrlsite.azurewebsites.net/2019/Prototype/proof/basic-formulas-fac.xml
Finally, there is the issue of using extension concepts, not hooking the extension concepts to a base taxonomy concept and therefore making it additionally challenging to logically deduce the appropriate values for unreported line items in order to convert information to make it comparable to the reported information of another economic entity. Remember, we are assuming that every economic entity uses the state statement format for this situation which (a) makes this process even more challenging and (b) we will address that specific situation within the next section.

**ELIMINATING SITUATION:** Clearly communicate what concepts might potentially be used to represent high-level financial report line items, provide machine-readable rules to derive unreported high-level financial report line items, and provide machine-readable rules to verify that the high-level financial report line items mathematical relations are intact.

**Situation 4: Variability allowed for reporting high-level accounting relationships.**

Situation 3 covers the case where you need to convert one financial report logical format to some other logically equivalent financial report format because of (a) unreported subtotals, (b) extension concepts being used, or (c) a more detailed concept is used to report the high-level line item you might expect and need to work with.

In Situation 3 we explicitly made the assumption that every income statement we were considering was logically equivalent. The reason for this was to focus on the pieces of the puzzle that related to unreported high-level financial report line items.

Now in Situation 4 we lift that restriction and ask the question how to you adjust for Situation 3, but now also in an environment when the subtotals used to represent the high-level line items of the balance sheet, income statement, cash flow statement, and statement of comprehensive income are NOT logically equivalent?

For example, in the US GAAP XBRL Taxonomy two balance sheets are provided for: classified and unclassified (or order of liquidity). However, empirical evidence shows\(^\text{13}\) that there are 6 and possibly more different varieties of balance sheets. For example, a liquidation basis balance sheet is not provided for by the US GAAP XBRL Taxonomy or is the balance sheet used by a regulated public utility. The situation is similar for income statements, cash flow

statements, and statements of comprehensive income. Further, the situation is the same for the IFRS XBRL Taxonomy.\(^{14}\)

Finally, the same rational can be used for different alternative approaches that might be used to represent each possible disclosure reported within the notes to the financial statements.

**ELIMINATING SITUATION:** In order to successfully overcome the variability allowed in financial reports; each variation of balance sheet, income statement, cash flow statement, and statement of comprehensive income must be explicitly provided for in an XBRL financial reporting base taxonomy. In addition, the rules that define those fundamental high-level accounting relations must be articulated for each variation of each statement.

**Situation 5: High-level financial report line item inconsistencies and contradictions.**

On occasion, an economic entity creating a financial report will use a concept in an unintended manner and a logical inconsistency and/or logical contradiction will result. While detailed measurements of such high-level fundamental accounting concept relations show that 99.24% of such relations are intact, there are 0.76% that are in error.\(^{15}\) On a per report basis, 89.1% of all reports have all high-level fundamental accounting concept relations intact whereas 10.9% of reports contain at least one such error.

Here is one example of this situation. Suppose that an economic entity reporting under US GAAP created a properly represented balance sheet. In that economic entity’s balance sheet, the line item “Noncurrent assets” (i.e. us-gaap:AssetsNoncurrent) was not explicitly reported. But then, that economic entity in their geographic area disclosure used the concept “us-gaap:AssetsNoncurrent” to report the line item “Long-lived Assets” which SHOULD have been represented using the concept “us-gaap:NoncurrentAssets”. Assume that the value of the “Long-lived Assets” amount is different than the value of “Noncurrent assets”.

This misused concept (i.e. using “us-gaap:AssetsNoncurrent” when the concept “us-gaap:NoncurrentAssets” should have been used) plus the fact that rules exist to properly derive the value of the line item “Noncurrent assets” if it is NOT reported (however, in this case it actually WAS reported, but in a completely different disclosure) causes an inconsistency and a contradiction between the balance sheet and the geographic areas disclosure.


This type of high-level financial report concept inconsistency or contradiction can be eliminated by providing high-level financial report concept relations rules in machine-readable form that can be used by reporting entities to verify that these relations are in fact intact. Further, those same rules can be used by analysts and others extracting information from XBRL-based financial reports to do so effectively, reliably, and consistently. Below is an example of a summary of fundamental accounting concept relations rules. Fundamental accounting concept relations verification is already available within commercial software applications.¹⁶

<table>
<thead>
<tr>
<th>Entity</th>
<th>Period</th>
<th>ID</th>
<th>Text</th>
<th>Result</th>
<th>Accuracy</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac Equity + Fac EquityAttributableToParent + Fac EquityAttributableToNoncontrollingInterest = Fac IncomeAttributableToParent + Fac IncomeAttributableToNoncontrollingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac Equity+Fac EquityAttributableToParent+Fac EquityAttributableToNoncontrollingInterest) = (Fac IncomeAttributableToParent+Fac IncomeAttributableToNoncontrollingInterest)</td>
</tr>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac IncomeAttributableToParent = Fac IncomeAttributableToControllingInterest + Fac IncomeAttributableToNoncontrollingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac IncomeAttributableToParent) = (Fac IncomeAttributableToControllingInterest + Fac IncomeAttributableToNoncontrollingInterest)</td>
</tr>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac IncomeAttributableToControllingInterest = Fac IncomeAttributableToParent + Fac IncomeAttributableToNoncontrollingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac IncomeAttributableToControllingInterest) = (Fac IncomeAttributableToParent + Fac IncomeAttributableToNoncontrollingInterest)</td>
</tr>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac IncomeAttributableToNoncontrollingInterest = Fac IncomeAttributableToParent - Fac IncomeAttributableToControllingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac IncomeAttributableToNoncontrollingInterest) = (Fac IncomeAttributableToParent - Fac IncomeAttributableToControllingInterest)</td>
</tr>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac IncomeAttributableToParent = Fac IncomeAttributableToControllingInterest + Fac IncomeAttributableToNoncontrollingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac IncomeAttributableToParent) = (Fac IncomeAttributableToControllingInterest + Fac IncomeAttributableToNoncontrollingInterest)</td>
</tr>
<tr>
<td>GH05...</td>
<td>2020-04</td>
<td>FAC_Consistency</td>
<td>Fac IncomeAttributableToNoncontrollingInterest = Fac IncomeAttributableToParent - Fac IncomeAttributableToControllingInterest</td>
<td>True</td>
<td>1.0</td>
<td>(Fac IncomeAttributableToNoncontrollingInterest) = (Fac IncomeAttributableToParent - Fac IncomeAttributableToControllingInterest)</td>
</tr>
</tbody>
</table>

ELIMINATING SITUATION: Every variation of primary financial statement must have a set of consistency cross check rule that explain those high-level fundamental accounting concept relations of that specific variation and can then be used to make certain that no continuity errors exist because of inconsistent facts or contradictions in reported facts.

Situation 6: Presentation relations model structure relations illogical.

On occasion, a relation or association expressed between report elements in the XBRL presentation relations is illogical. While such associations for XBRL calculation relations and XBRL definition relations are enforced by XBRL processors; logic errors in the XBRL presentation relations are not enforced by XBRL processors.

For example, erroneously representing a relationship between say a [Member] and a [Concept] within a set of [Line Items] is completely illogical.

Allowed and disallowed relations between categories of report elements can easily and effectively be represented in the form of a simple table. Alternatively, these relations can also be represented using machine-readable XBRL definition relations\(^\text{17}\). Below is such a table and a report provided by software which shows the relations it has found:

<table>
<thead>
<tr>
<th>Child</th>
<th>Network</th>
<th>Table</th>
<th>Axis</th>
<th>Member</th>
<th>LineItems</th>
<th>Abstract</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
<td>Illegal XBRL</td>
</tr>
<tr>
<td>Table</td>
<td>OK</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>OK</td>
<td>Disallowed</td>
</tr>
<tr>
<td>Axis</td>
<td>Disallowed</td>
<td>OK</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
</tr>
<tr>
<td>Member</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>OK</td>
<td>OK</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
</tr>
<tr>
<td>LineItems</td>
<td>Disallowed</td>
<td>OK</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
</tr>
<tr>
<td>Abstract</td>
<td>OK</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>OK</td>
<td>OK</td>
<td>Disallowed</td>
</tr>
<tr>
<td>Concept</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>Disallowed</td>
<td>OK</td>
<td>OK</td>
<td>Disallowed</td>
</tr>
</tbody>
</table>

ELIMINATING SITUATION: A set of allowed relations between the parents and children of each category of report element should be explicitly and unambiguously articulated to those creating XBRL-based reports.

Situation 7: Verification that each report fragment is created correctly.

Below is a screenshot of the networks of a rather simple XBRL-based financial report. The simple report was used to demonstrate the notion that 100% of the report fragments (fact sets) which make up the full report can be verified at a very detailed level using automated machine-based processes. This automated verification is enabled using XBRL-based rules represented using the XBRL definition linkbase and some specific arcroles to define the relevant associations.

Yes, for this example there are only 9 report fragments (fact sets). But the Microsoft 2017 10-K has 192 report fragments and this same process works exactly the same way for that Microsoft report or any other US GAAP financial report, for any reporting scheme including US GAAP, IFRS, IPSAS, FRF for SMEs, XASB.

To step through this small report we start at the top of the report. First, an XBRL-based report can contain 1 to many has XBRL Networks. This specific report has SEVEN Networks in the report:

The Networks can contain 1 to many [Table]s (i.e. if there is NOT an explicit [Table]/Hypercube, then one is implied for each network); so here again are the Networks expanded to show each [Table]; each Network has ONE [Table] in this case.

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19 XBRL taxonomy schema that references each of the definition linkbases which contain the rules for disclosure mechanics validation, [http://xbrlsite.azurewebsites.net/2016/conceptual-model/reporting-scheme/frf-sme/disclosure-mechanics/disclosure-mechanics.xsd](http://xbrlsite.azurewebsites.net/2016/conceptual-model/reporting-scheme/frf-sme/disclosure-mechanics/disclosure-mechanics.xsd)
Each [Table] can have 1 to many Fact Sets. Here, most [Table]s have one fact set, but the balance sheet has two (Assets Roll Up; Liabilities and Equity Roll Up) and the Cash Flow Statement has Two (Net Cash Flow Roll Up; Cash and Cash Equivalents Roll Forward).
Removing the superfluous structures (Networks, Tables) which are XBRL syntax so that we can focus on the information that has been represented in the report, we have only the Fact Sets of which there are nine:

<table>
<thead>
<tr>
<th>Document Information [Set] [Hierarchy]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity Information [Set] [Hierarchy]</td>
</tr>
<tr>
<td>Assets [Roll Up]</td>
</tr>
<tr>
<td>Liabilities and Equity [Roll Up]</td>
</tr>
<tr>
<td>Common Stock, by Class [Set] [Hierarchy]</td>
</tr>
<tr>
<td>Net Income (Loss) [Roll Up]</td>
</tr>
<tr>
<td>Cash and Cash Equivalents Reconciliation [Roll Forward]</td>
</tr>
<tr>
<td>Net Cash Flow [Roll Up]</td>
</tr>
<tr>
<td>Property, Plant, and Equipment, Net, Components [Roll Up]</td>
</tr>
</tbody>
</table>

Each Fact Set has logical structure rules that can be described using XBRL definition relations (on the right) which explain the disclosure (on the left). Notice also that each computation is verified to be CORRECT by showing GREEN in the cell of the result of the computation. This relationship of a disclosure to the rules used to verify that the disclosure has been created consistently with what is expected for each disclosure in the report. In our case there are nine such fact sets, disclosures, and rules:

Fact Set 1: Document Information [Set]
Fact Set 2: Entity Information [Set]

Fact Set 3: Assets [Roll Up]

Fact Set 4: Liabilities and Equity [Roll Up]
Fact Set 5: Common Stock, by Class [Set]

Fact Set 6: Net Income (Loss) [Roll Up]

Fact Set 7: Cash and Cash Equivalents [Roll Forward]
Fact Set 8: Net Cash Flow [Roll Up]

Something is worth pointing out. While the example might seem simplistic it is not simplistic at all. Every XBRL-based financial report can be broken down into about 10 rule patterns that all disclosures follow. This is the case for US GAAP, IFRS, IPSAS, FRF for SMEs, or any other financial reporting scheme for that matter. If it is the case that some pattern is missing, that pattern can easily be added to the set of 10 existing fact set patterns. Even if another 10 or perhaps 20 or maybe even 100 different patterns were found, this same logic will still apply. As Steve Jobs points out, “Simple is the ultimate sophistication.” What you see here is not simplistic, it is actually rather complex but the complexity is hidden from the users of the software tools.
Commercially available software can already verify these sorts of structural, accounting, and other logical relations to the extent that machine-readable rules exist. The Microsoft 2017 10-K has 192 fact sets of which approximately 70 rules are available for US GAAP\textsuperscript{20}.

**ELIMINATING SITUATION:** Provide a set of rules that articulate the key logical aspects of each report fragment that is to be reported. To achieve this, each disclosure must be named in order to organize this information and rules are then associated with each specific named disclosure using XBRL definition relations.

### Situation 8: Mathematical relations are not explained using machine-readable rules and then verified against that machine-readable explanation.

Considering the fact sets provided in Situation 7 again to explain this situation; there are three categories of mathematical relations that are represented in the simple example provided:

- Roll ups
- Roll forwards
- Aggregation of a set of members across an [Axis]

Current practice is for the US GAAP XBRL Taxonomy to provide only machine-readable rules for roll ups. Similarly, the SEC requires rules only for roll ups to be provided with reports.

This practice allows mathematical errors to exist in XBRL-based financial reports because many mathematical relations go untested to be certain that the mathematical relations are, in fact, correct. No one disputes that there are many mathematical errors in the XBRL-based reports that are submitted to the SEC. It is trivial to see such errors using the empirical evidence.

XBRL Formula is perfectly capable of representing mathematical relations for roll ups, roll forwards, aggregations of a set of members across an [Axis], and other such mathematical relations.

**ELIMINATING SITUATION:** Each report should provide machine-readable rules that can be used to explain the mathematical relations that exist in a report and to verify that the information in the report is consistent with those explanations.

Situation 9: Verification that each report fragment that is required to be disclosure exists within the financial report.

Each financial report has disclosures that are always required to be disclosed such as a balance sheet, income statement, cash flow statement, statement of changes in equity, basis of reporting, nature of operations, and significant accounting policies.

Other disclosures are required if some line item exists on a financial statement such as the balance sheet, income statement, or cash flow statement. For example, inventory subclassifications is required to be disclosed if the line item “Inventories” is reported on the balance sheet. Or, property, plant and equipment subclassifications if the line item “Property, plant and equipment” appears on the balance sheet. Clearly materiality always comes into play in determining what disclosures are or are not required.

Sometimes a disclosure is required if some other disclosure is provided. Or, a policy is required if a specific line item is reported.

Many of these rules can be represented in the form of a machine-readable reporting checklist or disclosure checklist. The machine-readable information can be rendered using computer algorithms in easy to understand information that humans can consume.

Here is an example of such a machine-readable reporting checklist\(^{21}\) that can also be read and understood by humans\(^{22}\):

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ELIMINATING SITUATION: Provide a set of rules that explain when specific disclosures are expected to be provided within a financial report which can be used by software applications to verify consistency of the report to what is expected per the machine-readable explanation.