1. Associations

The purpose of this section is to explain the notion of associations and how associations are used to in the representation of XBRL-based digital financial reports. Before you take on this section be sure to have gone through the section related to terms.

1.1. Associations and Smart Software Applications

Authors Dean Allemang and James Hendler say it well in their book *Semantic Web for the Working Ontologist*[1]:

> "In the hands of someone with no knowledge, they can produce clumsy, ugly, barely functional output, but in the hands of a skilled craftsmen, they can produce works of utility, beauty, and durability. It is our aim in this book to describe the craft of building Semantic Web systems."

A brick wall is made of exactly two things: bricks, mortar.

But a brick wall created by a master craftsman, or mason, and a brick wall created by a "weekend warrior" with no knowledge of masonry will be very different. Master craftsmen are created and that process takes time and effort.

The term "mason" can be further broken down in to more detailed distinctions. In the Middle Ages, the terms rough masons, row masons, stone setters, layers and freemasons[2] were used to signify differences in skills. Freemasons who were the most skilled were paid the best[3].

Masons built our physical world. Knowledge engineers will construct our digital world and associations are a key in a digital world.

Financial reports are rich with associations. Representing that rich set of associations in the form of machine-readable metadata creates the capabilities for software applications that can read and understand those associations to perform what seems like magic.

Good tools in the hands of master craftsmen that are understandable, useful, durable, and perhaps even beautiful and elegant truly sets information free! Information wants to be free from imperfections.

Even smart software applications appear "dumb" if they are not provided the right information. "Dumb" includes information that is wrong, contradictory, inconsistent, disconnected, and is not otherwise synchronized.

On the other hand; properly organizing information enables sophisticated software applications to perform to their potential. This information is provided in the form of machine-readable models and other metadata that help accountants perform their

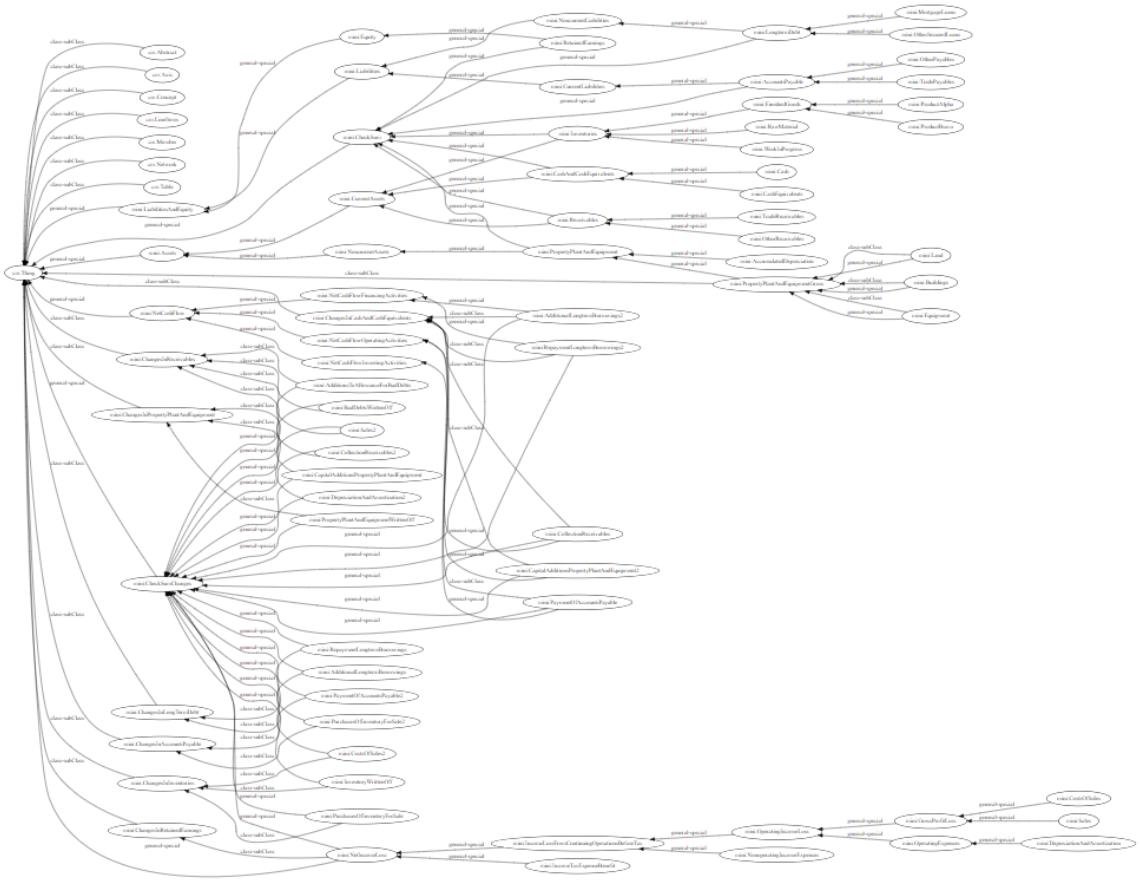
[1] Dean Allemang and James Hendler, *Semantic Web for the Working Ontologist*, page 1, https://www.amazon.com/Semantic-Web-Working-Ontologist-Effective/dp/0123859654

[2] Wikipedia, *Freemasonry*, https://en.wikipedia.org/wiki/Freemasonry

[3] *How are Masons and Freemasons Different?*, https://www.jeffersoncountylodge.org/post/2019/08/11/how-are-masons-and-freemasons-different

work effectively. How exactly to create those associations and what the associations might look like are up to debate. Regardless of how that debate might turn out; associations are important.

Below is a set of associations from a rather small financial reporting scheme[4]:



David Weinberger points out in his book *Everything Is Miscellaneous*[5] two very important things:

- That every classification scheme ever devised inherently reflects the biases of those that constructed the classification system.
- The role metadata plays in allowing you to create your own custom classification system so you can have the view of something that you want.

Mr. Weinberger continues in his book by pointing out the notion of the three orders of order:

- **First order of order**. Putting books on shelves is an example the first order of order.

[4] Type-subtype associations, MINI financial reporting scheme, generated by Pacioli, http://accounting.auditchain.finance/reporting-scheme/mini/reference-implementation/pacioli/typeSubTypeGraph.html

[5] David Weinberger, *Everything Is Miscellaneous*, https://www.amazon.com/Everything-Miscellaneous-Power-Digital-Disorder/dp/0805088113

- **Second order of order**. Creating a list of books on the shelves you have is an example of second order of order. This can be done on paper or it can be done in a database.
- **Third order of order**. Adding even more information to information is an example of third order of order. Using the book example, classifying books by genre, best sellers, featured books, bargain books, books which one of your friends has read; basically, there are countless ways to organize something.

Associations and classification are two very important tools of the information age. Those that understand how to use these tools, those who are craftsmen and perhaps the information age equivalent to a freemason will construct our digital world.

1.2. Introduction to Associations

An association (a.k.a. relation, predicate) is a type of statement that specifies a permissible relationship, a permissible structure, or specifies a property of a term. An association is generally a verb.

Associations can be represented in numerous ways. Consider the simple terms "Assets", "Liabilities", and "Equity" of the accounting equation and the complex term "Balance sheet" that is used to specify a structure.

We represented this accounting equation in the form of a model which looked something like the following in our gentle introduction to XBRL-based financial reports[6]:

Label	Object Class	Period Type	Balance	Report ElementName
Balance Sheet [Arithmetic]	Abstract			ae:BalanceSheetArithmetic
Assets	Concept (Monetary)	As Of	Debit	ae:Assets
Liabilities	Concept (Monetary)	As Of	Credit	ae:Liabilities
Equity	Concept (Monetary)	As Of	Credit	ae:Equity

Another way to view the associations might be as follows[7]:

Component: (Network and Table)	
Network	**01-Balance Sheet** (http://www.xbrlsite.com/ae/role/BalanceSheet)
Table	(Implied)

#	Label	Report Element Class	Period Type	Balance	Name
1	**01-Balance Sheet [Table]**				(Implied)
2	*Balance Sheet [Arithmetic]*	[Abstract]			ae:BalanceSheetArithmetic
3	Assets	[Concept] Monetary	As Of	Debit	ae:Assets
4	Liabilities	[Concept] Monetary	As Of	Credit	ae:Liabilities
5	Equity	[Concept] Monetary	As Of	Credit	ae:Equity

Yet another way to represent the associations might be:

Label	Report Element Class	Period	Balance	Preferred Label Role	Name
Balance Sheet [Arithmetic]	[Abstract]			Standard Label	ae:BalanceSheetArithmetic
Assets	[Concept] Monetary	As Of	Debit	Standard Label	ae:Assets
Liabilities	[Concept] Monetary	As Of	Credit	Standard Label	ae:Liabilities
Equity	[Concept] Monetary	As Of	Credit	Standard Label	ae:Equity

[6] Accounting Equation, Very Basic, http://xbrlsite.azurewebsites.net/2020/introduction/ae-basic/ae_ModelStructure.html

[7] Accounting Equation, Very Basic, XBRL Cloud Evidence Package, http://xbrlsite.azurewebsites.net/2020/introduction/ae-basic/evidence-package/contents/index.html#NetworkStructure-BalanceSheet-Implied.html

All of the above are human readable representations in different software applications of information. Each representation should convey the exact same meaning given that each represents the exact same information. However, different humans reading the information might interpret the associations differently if they don't have some common meaning.

Here is another representation of exactly the same information:

Associations

ID	StructureType	NetworkIdentifier	AssociationFromName	AssociationRole	AssociationToName	Sequence
131	Presentation	BalanceSheet	ae:BalanceSheetArithmetic	Parent-Child	ae:Assets	1
137	Presentation	BalanceSheet	ae:BalanceSheetArithmetic	Parent-Child	ae:Liabilities	2
140	Presentation	BalanceSheet	ae:BalanceSheetArithmetic	Parent-Child	ae:Equity	3

Using the XBRL syntax there are three structure types that can be represented: presentation, calculation, and definition associations.

Each set of associations must be within a specific network. Each association is **from** one term, **to** some other term, the association has a specific **role**, and the associations are in a specific **sequence** or order. We will get into this in more detail in a moment.

There are three fundamental types of associations:

- **Is-a**: An is-a association specifies a general-special or wider-narrower or class-subclass or type-subtype type relation between terms. (generalization/specialization)
- **Has-a**: A has-a association specifies a has-part or part-of type relation between terms and contributes to information about a structure. (meronymy, composition)
- **Property-of**: A property-of association specifies that a term has a specific quality, trait, or attribute. (property)

Let us break down each of these types of associations down a bit more and match each XBRL association to these three fundamental types.

1.3. Is-a Associations

XBRL has the power to represent the following types of specific "is-a" associations.

XBRL definition relations specify a "general-special" association such as that where the concept "Equity Attributable to Controlling Interests" and "Equity Attributable to Noncontrolling Interests" are specified to be specializations of the general concept "Equity".

-	Arcrole	Order
[Equity]	http://www.xbrl.org/2003/arcrole/general-special	7
[EquityAttributableToControllingInterests]	http://www.xbrl.org/2003/arcrole/general-special	51
[EquityAttributableToNoncontrollingInterests]	http://www.xbrl.org/2003/arcrole/general-special	52

XBRL definition relations specify a "domain-member" association such as that "ae:Assets" and "ae:Liabilities" and "proof:Equity" are members of the domain of line items that make up a statement of net assets.

-	Order	Arcrole
[NetAssetsLineItems]	0	
[Assets]	1	http://xbrl.org/int/dim/arcrole/domain-member
[Liabilities]	2	http://xbrl.org/int/dim/arcrole/domain-member
[NetAssets]	3	http://xbrl.org/int/dim/arcrole/domain-member

1.4. Has-a Associations

XBRL has the power to represent the following types of specific "has-a" assocations. First, XBRL presentation relations specify a "parent-child" association between terms. For example, from the term "ae:BalanceSheetArithmetic" to the term "ae:Assets" with the role "parent-child" indicates that the term "ae:BalanceSheetArithmetic" has-a part "ae:Assets".

Label	Report Element Class	Period	Balance	Preferred Label Role	Name
Balance Sheet [Arithmetic]	[Abstract]			Standard Label	ae:BalanceSheetArithmetic
Assets	[Concept] Monetary	As Of	Debit	Standard Label	ae:Assets
Liabilities	[Concept] Monetary	As Of	Credit	Standard Label	ae:Liabilities
Equity	[Concept] Monetary	As Of	Credit	Standard Label	ae:Equity

XBRL calculation relations specify a "summation-item" association between terms. For example, XBRL calculation "summation-item" associations can be used to represent that the summation or total "proof:NetIncome" is composed of the items "proof:Revenues" which is added, "proof:Expenses" which is subtracted, "proof:Gains" which is added, and "proof:Losses" which is subtracted. Visually, it might look something like this within a software application:

Label	Report Element Class	Balance	Weight	Name
Net Income	[Concept] Monetary	Credit	0	proof:NetIncome
Revenues	[Concept] Monetary	Credit	1	proof:Revenues
(Expenses)	[Concept] Monetary	Debit	-1	proof:Expenses
Gains	[Concept] Monetary	Credit	1	proof:Gains
(Losses)	[Concept] Monetary	Debit	-1	proof:Losses

Weight of 1 indicates that the item is added to the summation; weight of -1 indicates that the item is subtracted from the summation.

For more information on has-a assocations, see *Toward Understanding Whole-Part Relations*[8].

1.5. Property-of Associations

XBRL has the power to represent additional properties of report elements however the vast majority of properties are specified by the XBRL technical specification and properties tend to not be added. As such, "property-of" associations tend to be hard coded into the XBRL technical specification for the properties of report elements such as data type, period type, balance type, label, and references.

Adding new properties is very possible and very useful, but is a more advanced topic and will not be covered here.

[8] *Toward Understanding Whole-Part Relations*, http://xbrl.squarespace.com/journal/2015/1/20/toward-understanding-whole-part-relations.html

1.6. Allowed Associations Between Categories of Terms

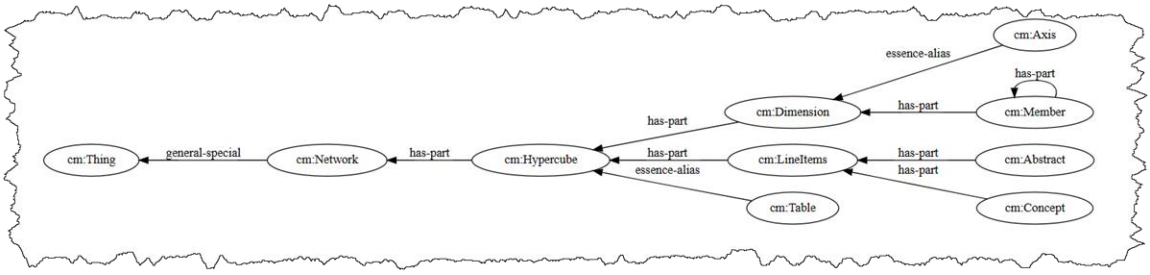
As described in the section which explained terms; terms can be grouped into categories. Those categories are: Network, Hypercube, Dimension, Member, Line Items, Abstract, and Concept.

The following table shows the permissible and disallowed associations between a parent term category and a child term category[9]:

		Parent						
		Network	Hypercube	Dimension	Member	LineItems	Abstract	Concept
Child	Network	Illegal XBRL	Illegal XBRL	Illegal XBRL	Illegal XBRL	Illegal XBRL	Illegal XBRL	Illegal XBRL
	Hypercube	Permitted	Disallowed	Disallowed	Disallowed	Disallowed	Permitted	Disallowed
	Dimension	Disallowed	Permitted	Disallowed	Disallowed	Disallowed	Disallowed	Disallowed
	Member	Disallowed	Disallowed	Permitted	Permitted	Disallowed	Disallowed	Disallowed
	LineItems	Disallowed	Permitted	Disallowed	Disallowed	Disallowed	Disallowed	Disallowed
	Abstract	Permitted	Disallowed	Disallowed	Disallowed	Permitted	Permitted	Disallowed
	Concept	Disallowed	Disallowed	Disallowed	Disallowed	Permitted	Permitted	Disallowed

The XBRL technical specification does not enforce parent-child associations rules between different types of report elements. These associations tend to be rather straight forward and uncontroversial in most cases.

Another approach to representing the relationships allowed between the different categories of terms or report elements is to use a knowledge graph[10]:



1.7. Type-subtype Associations

Concepts can be related to other concepts. For example, "Cash" is a type of "Cash and Cash Equivalents" or "Finished Goods" is a type of "Inventories". Other names used to describe this category of association is the "general-special" relations or the "wider-narrower" association.

Is-a or type-subtype or general-special or wider-narrower rules relate to the proper use of a concept relative to another concept. When the creator of a base model allows that base model to be adjusted, such rules are necessary enforce permissible use of one concept relative to another concept or can be used to define the type of some new concept added by an economic entity creating a report.

For example, consider the balance sheet fragment below. The concept "Inventories" is clearly a current asset per the balance sheet that is shown below. Suppose an

[9] Model structure rules represented using XBRL definition relations, http://xbrlsite.com/seattlemethod/cm/model-structure-rules-strict-def.xml

[10] Model structure associations knowledge graph, https://auditchain.infura-ipfs.io/ipfs/QmXsXSQzpRELwKBZTBNRAaGdiaRnwjX2rR21wUuQhmR16Z/typeSubTypeGraph.html

economic entity creating a report and inadvertently used the concept "Inventories" to represent a fact that was included within the set of Noncurrent assets.

That would be an improper use of the concept "Inventories" which is clearly a current asset to represent a noncurrent asset. Is-a associations rules prevent this sort of error from occurring by providing information about the allowed and perhaps disallowed relations between totals and the line items contributing to that subtotal.

Balance Sheet [Abstract]	Period [Axis]	
	2018-12-31	2017-12-31
Balance Sheet [Abstract]		
Assets [Roll Up]		
Current Assets [Roll Up]		
Cash and Cash Equivalents	4,000	3,000
Accounts Receivable	2,000	1,000
Inventories	1,000	1,000
Current Assets	7,000	5,000
Noncurrent Assets [Roll Up]		
Property, Plant, and Equpment, Net	6,000	1,000
Noncurrent Assets	6,000	1,000
Assets	13,000	6,000

All class/subclass type relations should be represented within a representation of the model of the financial report.

Form more information on types, see *A Theory of types*[11].

1.8. How type-subtype Associations work

This section explains how type-subtype associations currently work. The explanation is provided using simple examples written in pseudo code.

Type-subtype (a.k.a. special-general, class-subclass, or wider-narrower) associations are used to test XBRL calculation "summation-item" associations to determine if all summation-item associations are consistent with a specified set of permitted type-subtype associations of a base XBRL taxonomy.

For example, give a set of BASE TAXONOMY association:

- base:CashAndCashEquivalents >> type-subtype >> base:Cash
- base:CashAndCashEquivalents >> type-subtype >> base:CashEquivalents

base:PropertyPlantAndEquipmentGross >> type-subtype >> base:Land

[11] LinkedIn, *A Theory of Types*, https://www.linkedin.com/pulse/types-instances-things-graham-berrisford-nouee/

base:PropertyPlantAndEquipmentGross >> type-subtype >> base:Buildings

base:PropertyPlantAndEquipmentGross >> type-subtype >> base:FurnitureAndFixtures

And given the REPORT XBRL calculation associations:

base:CashAndCashEquivalents >> summation-item >> base:Cash

base:CashAndCashEquivalents >> summation-item >> base:CashEquivalents

No inconsistency would be reported because the summation-item associations represented in the report are consistent with the specified type-subtype associations of the base taxonomy.

However, given the following XBRL calculation associations:

base:CashAndCashEquivalents >> summation-item >> base:Cash

base:CashAndCashEquivalents >> summation-item >> base:Buildings

THEN and inconsistency would be reported because "base:Buildings" is defined to be a subtype of the type base:PropertyPlantAndEquipmentGross and NOT a subtype of the type base:CashAndCashEquivalents.

Further, type-subtype associations are transitive meaning that in the type-subtype associations defined "base:PettyCash" is a valid subtype of "base:CashAndCashEquivalents" because "base:Cash" is a valid subtype of the type "base:CashAndCashEquivalents" and the subtype "base:PettyCash" is a valid type of "base:Cash".

For example, give the following defined type-subtype assocations:

base:CashAndCashEquivalents >> type-subtype >> base:Cash

base:CashAndCashEquivalents >> type-subtype >> base:CashEquivalents

base:Cash >> type-subtype >> base:PettyCash

The following report summation-item relations would be deemed permitted:

base:CashAndCashEquivalents >> summation-item >> base:PettyCash

base:CashAndCashEquivalents >> summation-item >> base:CashEquivalents

Finally, if an item in a set of summation-item associations is not defined to exist in any type-subtype associations; then the item is permitted to exist as an item in any summation-item associations.

For example, given the following base taxonomy type-subtype associations: (noting explicitly that the base:PropertyPlantAndEquipmentGross associations are NOT DEFINED in this specific example)

base:CashAndCashEquivalents >> type-subtype >> base:Cash

base:CashAndCashEquivalents >> type-subtype >> base:CashEquivalents

The following summation-item associations are all deemed to be permitted because the items "base:Buildings" and the item "base:PettyCash" are not defined explicitly to be part of any other type-subtype associations:

base:CashAndCashEquivalents >> summation-item >> base:Cash

base:CashAndCashEquivalents >> summation-item >> base:Buildings

base:CashAndCashEquivalents >> summation-item >> base:PettyCash

1.9. Equivalent Type Associations

Concepts can be equivalent to other concepts. For example, "Net Assets" is equivalent to the concept "Equity" per SFAC 6, Elements of Financial Statements. Equivalent type associations are represented by XBRL's "essence-alias" definition arcrole.

1.10. Where Associations are Going

The book The Knowledge Graph Cookbook: Recipes that Work[12], discusses why association semantics should be made explicit and provides the following table that summarizes the different types of associations:

[12] ANDREAS BLUMAUER AND HELMUT NAGY, *The Knowledge Graph Cookbook: Recipes that Work*, page 35, https://www.poolparty.biz/wp-content/uploads/2020/04/the-knowledge-graph-cookbook.pdf#page=35

BUILDING BLOCKS	EXAMPLES	KOS
Synonyms	Emmental = Emmental cheese	Glossary, synonym ring
Handle ambiguity	Emmental (cheese) *is not same as* Emmental (valley)	Authority file
Hierarchical relationships[19]	Emmental *is a* cow's-milk cheese Cow's-milk cheese *is a* cheese Emmental (valley) *is part of* Switzerland	Taxonomy
Associative relationships	Emmental cheese *is related to* cow's milk Emmental cheese *is related to* Emmental (valley)	Thesaurus
Classes, properties, constraints	Emmental *is of class* cow's-milk cheese Cow's-milk cheese *is subclass of* cheese Any cheese *has exactly one* country of origin Emmental *is obtained from* cow's milk	Ontology

1.11. Interface for Entering Associations

Below you see a very basic interface for entering associations: