



# Aggregation of security attributes based on the granularity level of the system

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by

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## **Affirmation of independent work**

I hereby declare that I wrote this thesis myself without sources other than those indicated herein. All parts taken from published and unpublished scripts are indicated as such.

Berlin, <date>

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(Artemij Voskobochnikov)

## Acronyms

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## Abstract

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# 1 Introduction

Security concepts can be used to capture the interacting system components, potential threats and countermeasures.

For large information systems such concepts can become very large because of the number of the involved sub-systems/components. Interconnectivity and interdependence amongst components may increase the overall system complexity and it might be therefore difficult to detect all potential impacts [2]. Methods for system abstraction that address this problem already exist. The abstraction here is the creation of representation layers which only reflect relevant properties of a system and therefore provide a better level of understanding for the respective user [9]. This for example can be achieved by different projections which reflect different granularity levels of a system displaying different levels of details [12].

In the security context such projections could be used to focus on the security or insecurity of certain sub-systems. Security attributes of components could thus be viewed separately and the security risk for a respective component could be derived. This might become especially useful when the security concept is incomplete or only partially available. An aggregation of security attributes based on the chosen projection will become possible. The system structure could then be used to derive security attributes for components that previously had none. Thus, potentially new information might become processable.

Aggregation methods for security attributes have already been suggested by researchers, e.g. transformation rules for security requirements by Menzel et al. [7] or aggregation rules for attack graphs by Noel et al. [8]. None of those methods take granularity levels or general system hierarchy into account whereas the goal of this thesis is to provide an approach which makes it possible for a user to select a sub-system of interest, i.e. a projection which reflects a certain granularity level and provides the corresponding security attributes. The relevant attributes as well as dependencies and possible aggregations will be shown to ensure an overall complete picture of the selected sub-system. This information can then be used to assess and improve the security level of the selected projection or its dependencies.

## 2 Background

Prior to addressing the actual approach and implementation some concepts and terms have to be introduced. Firstly, the term *security concept*, as it is used throughout the thesis, is being described. A definition of *granularity levels* and system abstraction follows. Lastly, a section covers *model transformations* and *aggregation rules* on security attributes.

### 2.1 Security

Many different definitions of security exist. Here, a slightly adapted definition of a *information security management system* (ISMS), as it is found in the ISO/IEC 27001 [1], is being used.

*„The information security management system preserves the confidentiality, integrity and availability of information by applying a risk management process and gives confidence to interested parties that risks are adequately managed“*

It is also added that the ISMS is integrated into the overall management structure and is vital for many of the organizational processes [1].

The definition above only covers information security, which in the scope of this thesis, is insufficient. Here, we define security as the preservation of confidentiality, integrity and availability of assets, where assets can be either physical or logical.

### 2.2 Enterprise Security

To define the term *security concept* one has to look at the architecture of enterprises to understand the interconnectivity and interdependence between services, security being one of them.

#### 2.2.1 Enterprise Architecture

Information systems tend to be a very complex artifacts that combine different views and requirements from various stakeholders of different backgrounds [6].

Software, IT platforms and IT related goals in general are covered in an *Information System Architecture* (ISA). ISA does not take any business-driven influences into account and is therefore insufficient when describing the complex dependencies in corporations, especially when it comes to security as described in Subsection 2.2.2.



*Enterprise Architecture Modeling* tries to overcome such possible difficulties and combines IT related concerns with business and organizational goals and shows possible interrelationships. It therefore provides an approach for an improved understanding of complex enterprise processes [13]. The Federal Deposit Insurance Corporation (FDIC) published the results of an audit of its own implementation of E-Government principles [4] and their division of information technology in Figure 1 depicts the interrelations very well.

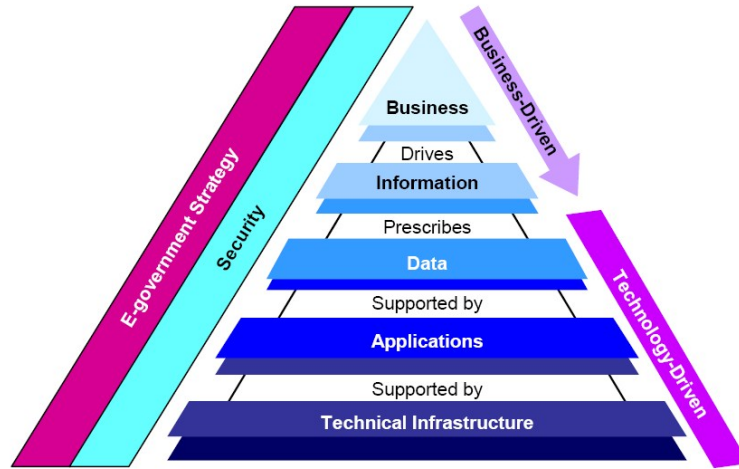


Figure 1: Division of Information Technology by FDIC

### 2.2.2 Security Architecture

Information Security has often been merely an afterthought in corporations [3] until a concept of a *Security Architecture*, published in a whitepaper by The Gartner Group [5], was introduced. According to [5] an *Enterprise Information Security Architecture* (EISA) is an essential tool for improving security processes in corporations. EISA principles stand in a direct relationship with the EA principles and should be validated against them [5]. To highlight this relationship security considerations during phases of the *The Open Group Architecture Framework Architecture Development Method* (TOGAF ADM), which is shown in Figure 2, will be briefly described.

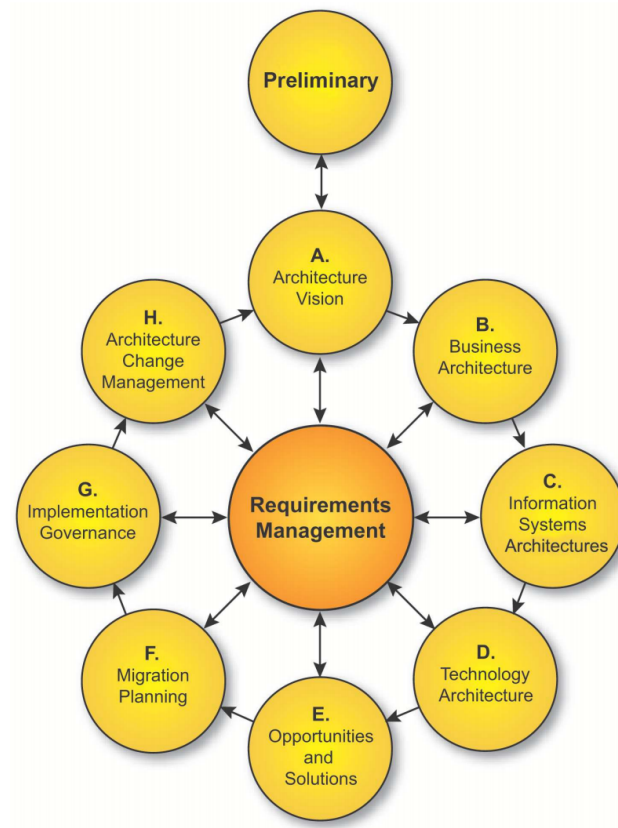


Figure 2: Overview of the phases of TOGAF

Security concerns can be found throughout the TOGAF phases which hints at the overall importance of security in corporations. TOGAF combines four architecture domains, the *Business Architecture*, the *Data Architecture*, the *Application Architecture* and the *Technology Architecture*. The following section will depict security considerations of two domains to show possible interrelations.

During the *Business Architecture* phase in the ADM actors and handlers of the system have to be identified. Costs and potential inconveniences because of security measures have to be assessed as well. In general one can say that the impacts of security/insecurity on the business/product are being highlighted. It is tried to put an emphasis on security as early as possible to prevent costly changes in later phases in the ADM.

During the *Information System Architecture* phase the classification levels of processed data have to be determined and documented. Direct dependencies to the *Business Architecture* are also listed, e.g. the identification of information lifespan according to business goals and regulations.

Similar relations can be found for security considerations from various phases of the ADM. This once again shows the overall presence of security and the high level of complexity within an enterprise.

### 2.2.3 Common Criteria

The overview of TOGAF showed the importance of security in corporations. The following section will present a way of modeling security concerns for an asset of interest.

Common Criteria proposes an evaluation by using a so called *Security Target* (ST), a construct that encapsulates the *Target of Evaluation* (TOE), threats to the TOE and countermeasures [11]. The goal of the evaluation is to show that the used countermeasures are sufficient to counter potential threats and thus implying that the TOE is sufficiently protected.



Figure 3: Overview of the Security Target contents

A description of all the contents of a ST is unnecessary here and only the key security attributes of a ST that will be used to construct a *Security Concept*

(Subsection 2.2.4) are being introduced.

The *Security Problem Definition* defines, as the name suggests, the security problem that is being addressed. Apart from containing guidelines and assumptions it contains *Threats* which are „[...] *adverse actions performed by a threat agent on an asset*“ ([1], p. 66).

A *Security Objective* is an abstract solution to the previously defined security problem. There exists a possibility to divide the *Security Objectives* into part wise solutions, one being the *Security Objectives for the TOE* and the other being the *Security Objectives for the Operational Environment*. Moreover does the ST contain traces showing which objectives address which threats, guidelines and assumptions and a set showing that all threats, guidelines and assumptions are addressed by the security objective.

*Security Functional Requirements* (SFR) are a more detailed translation of the previously defined *Security Objective*. Despite being more detailed, SFR have to be still independent from specific technical solutions.

Lastly, STs contain a TOE summary specification where it is stated how the TOE meets all the SFRs and how exactly those requirements are met on a technical level.

## 2.2.4 Security Concept

The term *Security Concept*, as it is defined here, is based on the constructs introduced in the previous chapters, namely *Security Architecture* and *Security Target*. An overview follows.

*Assets* are the to be secured objects of interest, i.e. TOE according to Common Criteria. *Assets* can be either logical or physical and can be grouped to sets, if needed.

A *Security Goal* (SG) is the equivalent to the *Security Objective*. A valid SG must address an *Asset* and a *Security Goal Class* that defines the actual purpose of the SG. In general the set of *Security Goal Classes* consists of *Confidentiality*, *Integrity* and *Availability* but can also be expanded by further classes such as *Authenticity*.

*Threats* serve the same purpose as proposed by Common Criteria. They are adverse actions performed by an entity against an *Asset*.

This information is all brought together in *Security Requirements* that are defined in natural language and show the interrelationships between elements. A *Security Goal* has to be mentioned as well as an *Asset* and a *Threat* against which the object of interest should be protected.

Lastly, *Controls* are the technical measures that counter or minimize the *Threats*.

The Table 1 depicts the relationships between all the security attributes:

Name	Contains	Description	Example
Asset	-	Digital or physical object of interest that should be secured	Sensible user data
Security Goal Class	-	Defines the purpose of the Security Goal	Confidentiality of sensible user data
Security Goal	Security Goal Class, Asset	Defines the security objective	Confidentiality of sensible user data shall be protected
Threat	Asset	Adverse action against an Asset	Eavesdropping of sensible user data
Security Requirement	Asset, Security Goal, Threat	Security Objective in natural language	The Confidentiality of sensible user data shall be protected against eavesdropping
Control	Threat	Measure to minimize or mitigate the Threat	Encryption of sensible user data with AES-256 to prevent eavesdropping

Table 1: Elements of a Security Concept

## 2.3 Modeling

To ensure a viable solution one has to think of a representation of real life systems. *Models* can be used to achieve this by depicting the key properties and processes of a certain system. According to Ed Seidewitz [10] a model is a „*set of statements about some system under study*“ with the statements being either correct or incorrect.

A system modeled using the Unified Modeling Language (UML) serves as an example. In this case such statements could be made on the relationships between classes and would only be correct if they are consistent with the actual structure of the respective system under study (SUS), i.e. the described (modeled) relationships do indeed exist.

In our case we would try to create a model that reflects the security attributes and their interrelationships in a SUS. This interpretation of a model is key because only then the model is given a meaning [10].

A definition of a model is not enough. A *metamodel* has to be clearly defined to verify whether a model is conform or not, i.e. whether a security concept instance is conform to its security concept metamodel. The following figure shows the interrelationships.

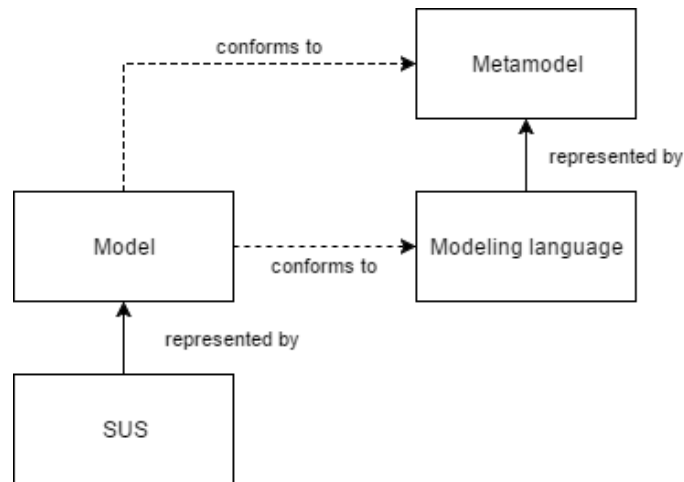


Figure 4: Relationships between Model and Metamodel

A security concept of a SUS would be modeled in a modeling language, e.g. UML which is a representation of its own metamodel. At the same time the security concept would be conform to its metamodel. This conformity, be it the security concept or the modeling language, is needed for a model to be considered valid.

### 2.3.1 Model Transformation

Throughout the introduction and the background chapter the derivation of security attributes based on structural properties of a system of interest was mentioned. Given a model  $M$  this derivation can be seen as alteration of  $M$  and therefore as a *model transformation*. The resulting model  $M'$  is different to  $M$ , both however, are conform to their metamodel  $MM$ .

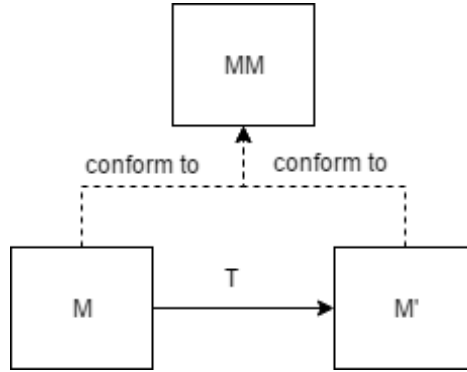


Figure 5: Model transformation

The definition of a transformation  $T$ , or better a *transformation rule set*, that alters a model  $M$  is the main goal of this thesis.

Prior to the actual rule set definition one final concept has to be introduced. A user-selected *Granularity level* serves as a second input in the model transformation.

### 2.3.2 Granularity Levels

Information systems are often complex because of the number of interconnections and interdependencies between components and therefore it might be difficult to assess potential impacts and risks of a system [2].

One logical goal would be to decrease the overall complexity to enable a better risk assessment. *System abstraction* tries to achieve this by reducing the level of details [2]. Branagan et al. differentiate between two possibilities, *Whole-part decomposition* which decomposes a system into smaller subsystems and *Distinct development perspectives* which focuses on certain parts of a system depending on the current development perspective.

In this thesis the focus will be on the *Whole-part decomposition* even though an adaption of development perspectives is certainly possible. The main difficulty would be the definition of such perspectives in the security context

because they would be highly dependent on the respective security analyst. The perspectives would not be unambiguous.

Therefore the change of the level of detail, i.e. the granularity level, will be achieved by uniting or decomposing components of a system of interest. By decomposing a larger system into smaller subsystems one could focus on only specific security attributes and dismiss others.

A user will select a certain granularity level, i.e. a certain set of components, as an input to the transformation function  $T$  as mentioned in 2.3.1. Together with the defined rule set a valid model  $M'$  will be generated which to be considered valid has to conform to its metamodel  $MM$ .

### 3 Related Work

## 4 Approach

This section presents the approach addressing the previously mentioned goal of a model transformation based on the user-selected granularity level of a system of interest. Firstly, the security concept metamodel will be thoroughly described, each element of the metamodel will be put in the security context and advantages and disadvantages of such an interpretation will be highlighted.

The second part will deal with the actual transformation rules. Model transformations will be mathematically defined and the transformation rules for each element of the model will follow. Aside from the solution possible edge cases will be presented and evaluated.

### 4.1 Security Concept

The following metamodel is based on the security elements mentioned in Section 2.2.4. It shows the interconnections between elements and adds restrictions. This metamodel serves as a base enabling the creation of model instances capturing the relations between components/assets of a specific SUS. It also provides a security context and the option for the user to select a granularity level.



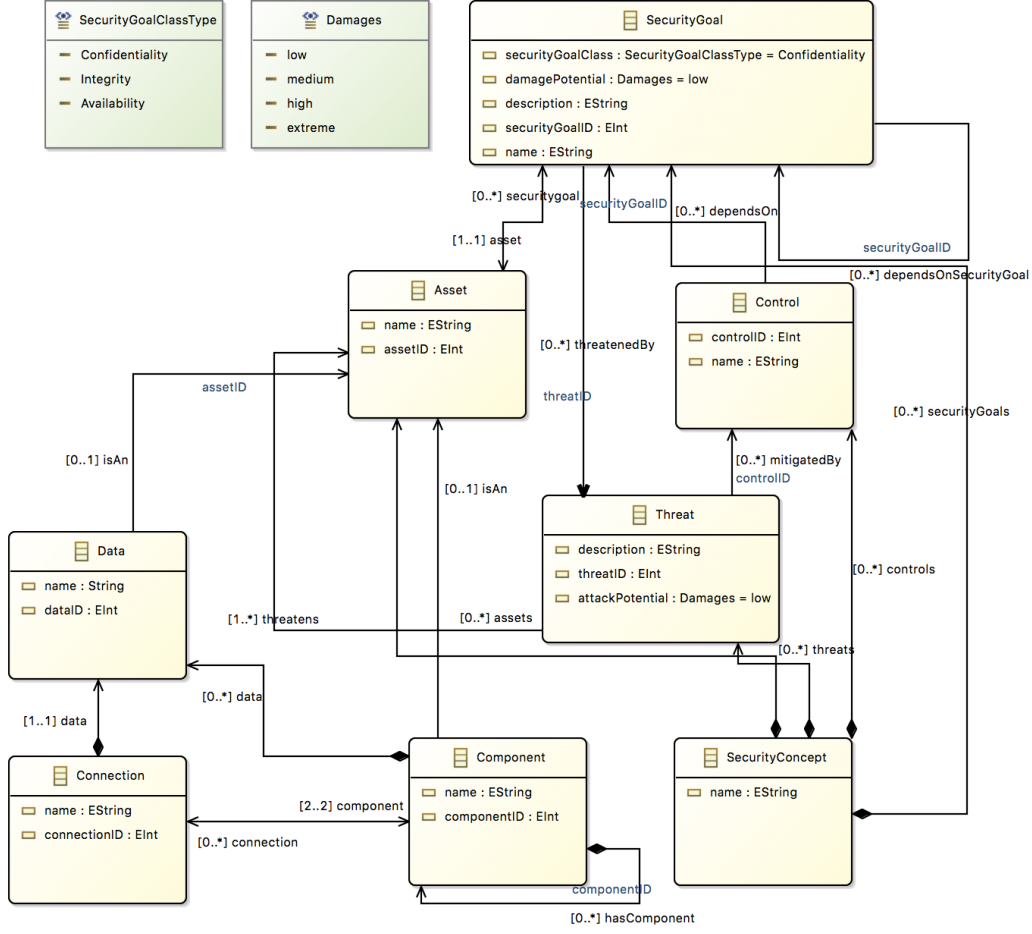


Figure 6: Security Concept Metamodel

In the figure above all the core elements *Security Goal*, *Asset*, *Control* and *Threat* are pictured. All of these elements are part of a *SecurityConcept*, which in this model will be simply identified by a name.

SGs have a *Security Goal Class* attribute which describes the purpose of each SG. The *Damage Potential* attribute indicates at the importance of a Goal, i.e. how important it is to secure a certain asset. The higher the damage potential the higher the impact if the security of an asset is breached. One key aspect of this metamodel is the dependency between SGs. A SG is dependent on another SG if both belong to the same asset and have the same security goal class. These dependencies, amongst others, have to be considered during potential transformation steps (Section 4.4).

Each SG belongs to exactly one asset whereas an asset itself can have unlimited SGs. In this thesis both physical and virtual components can be considered an asset. Both *Data* and *Component* can be assets according to

the metamodel.

There will be two different types of data. For once *processed data*, i.e. data that is being processed or kept in storage by a specific component. On top of that *transmitted data* will be considered separately since the transmission channel itself can be seen as an asset. The resulting interconnections are shown in the following figure:

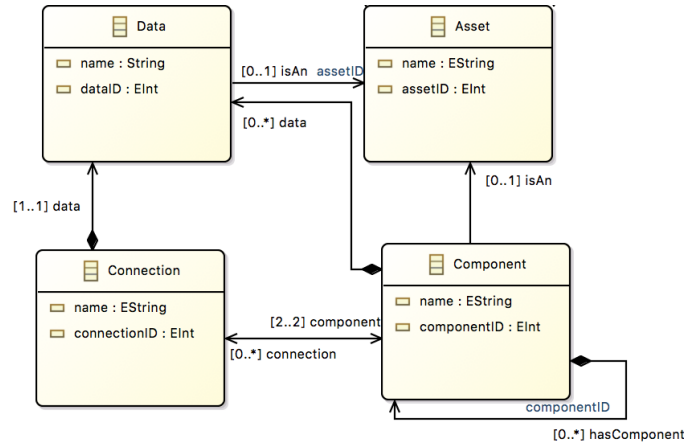


Figure 7: Two different interpretations of data

As already mentioned data can be viewed as being processed and transmitted. Therefore an element *Connection* was added. A connection is the transmission channel between two components. It must have an associated data. The processed or stored data however can be directly associated with a component. In both cases data can be viewed as an asset. There is no possibility to assign a connection as an asset, the reason being that the transmission medium itself, i.e. the cable, wire, is rarely an object of interest but more so the data which is being transmitted.

Lastly the selection of *Granularity Levels* by users should be enabled. Instead of having two different input models, one security concept model and one model depicting the system structure, one can reproduce the structural properties by adding a reference to the component element.

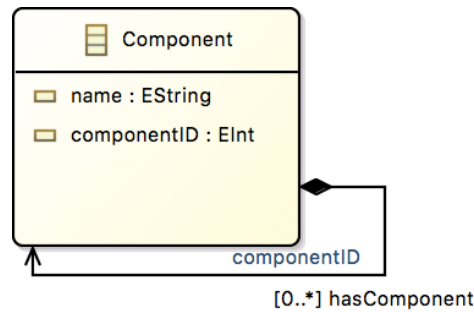


Figure 8: Structural information

Having this extra reference one can create infinitely deep structural dependencies within the model. Therefore the actual transformation will only require one model instead of two separate ones.

## 4.2 Metamodel elements and their security properties

To put all the different elements of the metamodel into a security context one has to clearly define the Security Goal Classes for possible assets. Moreover is it important to consider the edge-cases of such an interpretation and possible pitfalls.

### 4.2.1 Components

#### Physical Component

#### Virtual Component

1. Confidentiality
2. Integrity
3. Availability

### 4.2.2 Data

#### Stored Data

1. Confidentiality
2. Integrity
3. Availability

### **Processed Data**

1. Confidentiality
2. Integrity
3. Availability

### **Transmitted Data**

1. Confidentiality
2. Integrity
3. Availability

#### **4.2.3 Edge-cases and potential pitfalls**

### **4.3 Model Transformation**

### **4.4 Transformation Rule Set for Security Goals**

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