# Usable Security Versus Secure Usability: an Assessment of Attributes Interaction

Oleksandr Gordieiev<sup>1</sup>, Vyacheslav Kharchenko<sup>2</sup> and Kate Vereshchak<sup>3</sup>

<sup>1</sup>Banking University, 1 Andriivska Street, Kyiv, Ukraine alex.gordeyev@gmail.com <sup>2</sup>National Aerospace University «KhAI», 17 Chkalova Street, Kharkiv, Ukraine V.Kharchenko@csn.khai.edu <sup>3</sup>Luxoft, 10/14 Radisheva Street, Kyiv, Ukraine vereshchak@gmail.com

**Abstract.** Attributes of information systems quality described in standard ISO/IEC25010 (2010) are analyzed. Some of them are contradictory, dependent and competing. One of the most competing characteristics are usability and security (U&S). The article considers two main aspects of U&S interaction called "usable security" and "secure usability". The technique of qualitative assessment of the U&S interaction based on analysis of subcharacteristics and metrics is suggested. An example of the technique application to assess U&S interaction for university web-site is discussed.

**Keywords.** Usability and security interaction, usable security, secure usability ISO/IEC25010, ISO/IEC25023

**Key Terms.** Usability, security, software characteristics, software metrics, interaction

# **1** Introduction

## 1.1 Motivation

Information systems are characterized by a set of characteristics/attributes that are defined by international standards. The standard ISO/IEC 25010 «System and software quality model» [1] defines the following 10 characteristics of information systems: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, portability. Such nomenclature was formed in result their evolution during about 60 years [2]. Certain characteristics (subcharacteristics) of information systems interact at each other. I.e. there are situations when strengthening (weakening) of one of the characteristics requires or generates strengthening (weakening) of another or even a group of information

systems. In the article we will consider a couple of the most important, mutually influence and competitive characteristics – usability and security (U&S).

## 1.2 State of Art

First of all, we need give of description for U&S attributes. Usability – degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [1]. Security - degree to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization [1]. Information systems must have of Usability and Security characteristics, because they must be comfortable in use and secure simultaneously. Depending on field of information systems application, levels of U&S requirements and characteristic values are not the same. In most cases, information systems are more usable, including at the expense of security, or more secure at the expense their usability.

Problems of U&S characteristics interaction are well known, researched and presented in materials of conferences, in articles and books. Analysis of works in this field gave us possibility make some conclusions and divide of accessible works on following groups in some fields:

- most part of works are about concrete problems in U&S field and mechanisms for their solutions [3, 4, 5, 6, 7]. In particular, in [3] are viewed alphanumeric passwords problems and are presented ways for their decision;

following group of works about general conceptual questions in the U&S field
 [8, 9];

part of works about problems and peculiarities of U&S interaction on required levels [6], on processed levels [10, 11] and on model levels (including UML models) [12];

- small group includes works about U&S problems for mobile applications [13,14];

- separate works about analysis of literature in U&S problems field [15];

- some articles about U&S characteristics evolution. Authors of such works represent the evolution and interaction of usability and security characteristics [16, 2].

#### 1.3 Goal and Structure

Preliminary analysis of works in U&S field permitted to make the following conclusions and determine goal of the paper:

- firstly, characteristics of U&S which described in last program engineering standards [1, 17, 18] are one from other results of 40 years evolution [2, 16]. They represented as complex characteristics with set of depended subcharacteristics;

- secondly, analysis of U&S subcharacteristics and metrics did not conduct in existing works [3-16], which describe problems interaction of U&S characteristics;

- thirdly, separate subdivision was organized at National Institute of Standards and Technology (NIST) of USA [20], which solves tasks of U&S interaction.

However, well known works describe, first of all, influence of Usability on Security and did not take into account aspects of influence on level of their subcharacteristics.

Thus, **goal** of article is determination, analysis and assessment of U&S interaction on subcharacteristics and metrics levels.

The paper has the following structure. Main second section contains:

- description of "Usable security" and "Secure usability" interaction problem;

- analysis of U&S interaction on subcharacteristics level and variants U&S subcharacteristics interaction;

- analysis of U&S interaction on metrics level.

The third section analyses and assesses U&S interaction for university web-site and the fourth section concludes and describes directions of the future research.

# 2 Usability and Security

#### 2.1 Two Sides of the Same Coin

Exist of two possible aspects of research and development (i.e. two sides of the same coin): usable security and secure usability. Let's consider in more details what are the differences between these two aspects.

#### **Usable Security**

First aspect gives an answer on a question: how to develop functions secure access to resources such, in order to ensure acceptable/necessary level of usability of user interfaces. In order to link of U&S characteristics in the usable security aspect was more understandable, we need represent example of such an interaction. Very often procedure of registration on web-site requires from users to confirm their presence near personal computer. It needs to exclude automatic registration on the Internet. As а rule. web-site offers to users input data for CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart) [20]. In majority of cases, the CAPTCHA is information, which automatic generator on picture of web-page and which necessary input to textbox. Sometimes users have problems with input of information from CAPTCHA (i.e. have problem with Public Turing test), because information which is represented on picture periodically cannot be discernible. (Fig. 1). Defect of such technique of identification can provoke discomfort for user. For solution of such problem user necessary, periodically manually reload the picture of CAPTCHA waiting for recognizable information. User can wait long time of appearance recognizable information. User can also delay or cancel, for example, web-site registration procedure. This is an example, when «complex» security kills usability – (cSkU) Information systems developers necessary take into account such aspect, when they make project of user interfaces. We have to exclude situation, when high level of security «kills» the usability.

It should be noted, that subdivision at National Institute of Standards and Technology (NIST) of USA researches such U&S problems [19].



Fig. 1. Examples of CAPTCHAs.

# Secure Usability

Second aspect has relationships with development of user interfaces thus, in order to ensure necessary level of information security. Lets describe an example of such interaction between usability and security. Public Turing test can be maximum simple and represents one checkbox element, which necessary will set up in significance «check» (Fig. 2). From usability position such variant of Public Turing test is more better than his variant on Fig 1. But from security position such variant (Fig. 2) is more worse, because as against previous variant (Fig. 1) such variant is more simply pass (by software bots) during automatic registration without user. In other words, in such a context there is another competition. This is situation, when «simple» usability "kills" security – sUkS).



Fig. 2. More simple Public Turing test.

#### 2.2 Criteria

#### General

Thus, U&S characteristics really have interconnection in the form of two aspects and formally differences can be described through «castle» of objective function and limitations.

− in first case it is necessary to ensure the required level of usability (Ureq), at that maximize of security (Smax), i.e. S  $\rightarrow$  max, U ≥ Ureq;

- in second case it is necessary ensure the required level of security (Sreq), at that maximize of usability (Umax), i.e.  $U \rightarrow max$ ,  $S \ge Sreq$ .

We pay attention, that U&S characteristics and their sub characteristics described in article as their interpretation in group of standards ISO 25000.

#### Attributes of Security and Usability

Examined positions can be represented out in detail as:

- security – is combination of following subcharacteristics [1]: confidentiality, integrity, non-repudiation, accountability and authenticity

 $S = \{Conf, Integr, N-rep, Acc, Aut\};$ 

- usability – is combination of following subcharacteristics [1]: appropriateness recognizability, learnability, operability, user error protection, user interface aesthetics, accessibility.

 $U = \{AppRec, Learn, Oper, UEP, UIA, Acs\}.$ 

#### 2.3 U&S Subcharacteristics Interaction Analysis

We will consider interaction between U&S subcharacteristics. For that we will describe more detail formulations their subcharacteristics [1], which represented in table 1.

№	Characteristics (subcharacteristics)	Description		
1	Usability	degree eto which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use		
1.1	Appropriateness	degree to which users can recognize whether a		
	recognizability	product or system is appropriate for their needs		
1.2	Learnability	degree to which a product or system can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use		
1.3	Operability	degree to which a product or system has attributes that make it easy to operate and control		
1.4	User error protection degree to which a system protects users aga making errors			
1.5	User interface aesthetics	degree to which a user interface enables pleasing and satisfying interaction for the user		
1.6	1.6 Accessibility degree to which a product or system can be by people with the widest range of charact			

Table 1. U&S subcharacteristics formulations.

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		and capabilities to achieve a specified goal in a				
		specified context of use				
		NOTE 1 The range of capabilities includes				
		disabilities associated with age.				
		NOTE 2 Accessibility for people with disabilities				
		can be specified or measured either as the extent				
		to which a product or system can be used by				
		users with specified disabilities to achieve				
		specified goals with effectiveness, efficiency,				
		freedom from risk and satisfaction in a specified				
		context of use, or by the presence of product				
		properties that support accessibility.				
		degree to which a product or system protects				
	Security	information and data so that persons or other				
		products or				
2		systems have the degree of data access				
		appropriate to their types and levels of				
		authorization				
		degree to which a product or system ensures that				
2.1	Confidentiality	data are accessible only to those authorized to				
		have access				
		degree to which a system, product or component				
2.2	Integrity	prevents unauthorized access to, or modification				
	integrity	of, computer programs or data				
		degree to which actions or events can be proven				
2.3	Non-repudiation	to have taken place, so that the events or actions				
	1	cannot be repudiated later				
2.4	A	degree to which the actions of an entity can be				
2.4	Accountability	traced uniquely to the entity				
2.5	Authoritaity	degree to which the identity of a subject or				
2.5	Authenticity	resource can be proved to be the one claimed				

We have received set of variants of U&S subcharacteristics interaction because of U&S subcharacteristics analysis. Set of variants of U&S subcharacteristics represents table 2.

We will comment received variants. First of all, we will set the numeration as two numbers (from table 2), which includes the first number as usability characteristic and the second number as security characteristic:

1-1. Appropriateness recognizability subcharacteristic has interaction with confidentiality subcharacteristic. It is obvious, because before ensuring `Confidentiality`, user must, for example, see text boxes for input confidential information and inputted such information;

- 1-2, 1-3, 1-4, 1-5. In authors opinion, such variants of interaction between U&S characteristics are possible, but they require additional research for set up more exact of interaction type;

№	Usability characteristics/ Security characteristics	Confidentiality	Integrity	Non- repudiation	Accountability	Authenticity	
		1	2	3	4	5	
1	Appropriateness recognizability	$\uparrow \uparrow / \downarrow \downarrow$	?	?	?	?	
2	Learnability	↑↓	_	_	_	_	
3	Operability	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	
4	User error protection	$\uparrow \uparrow / \downarrow \downarrow$					
5	User interface aesthetics	$\uparrow \uparrow / \downarrow \downarrow$	?	?	?	?	
6	6 Accessibility $\uparrow \downarrow \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$						
— - inte	eraction is absent;						
$\uparrow\uparrow$ - increase of level of one characteristic incurring to increase of level of other characteristic;							
$\uparrow\downarrow$ - increase of level of one characteristic incurring to decrease of level of other characteristic;							
$\downarrow \downarrow$ - decrease of level of one characteristic incurring to decrease of level of other characteristic;							
? - int	? - interaction is exist, but type of interaction to set very difficult						
(exist necessity of additional research)							

**Table 2.** Variants of interaction of U&S subcharacteristics.

- 2-1. Such variant of interaction between subcharacteristics Learnability and Confidentiality exists, because if user receives more information abaut Confidentiality, than the level will be lower. Thus, if level of Learnability will increase, level of Confidentiality will decrease. And vice versa, if level of Learnability will decrease;

- 2-2, 2-3, 2-4, 2-5. In authors opinion, such variants of interaction between subcharacteristics are absent;

- 3-1, 3-2, 3-3, 3-4, 3-5. Such variants of interaction between subcharacteristics of Operability and Confidentiality, Integrity, Non-repudiation, Accountability, Authenticity exist, because of increase of Operability level leads to increase in such subcharacteristics, and vice versa, because of decrease of Operability level leads to decrease such subcharacteristics;

- 4-1, 4-2, 4-3, 4-4, 4-5. Variants of interaction between User error protection and Confidentiality, Integrity, Non-repudiation, Accountability, Authenticity exist, because decrease of count of user errors incurring to increase of level of characteristics Confidentiality, Integrity, Non-repudiation, Accountability and Authenticity, but increase of count of user errors incurring to decrease their level; - 5-1. User's interface aesthetics subcharacteristic has interaction with Confidentiality subcharacteristic, because, when user works with information systems interface, which has attractive design and well tidy colors, user has esthetical satisfaction, consequently, he can see textboxes for input confidential information and input her;

- 5-2, 5-3, 5-4, 5-5. In authors opinion, such variants of interaction between U&S subcharacteristics are possible, but require additional research for set up more exact of interaction type;

- 6-1, 6-2, 6-3, 6-4, 6-5. In this variants if the level of Accessibility characteristic will increase then levels of all subcharacteristics of security characteristic will decrease and vice versa, if level of Accessibility characteristic will decrease then levels of all subcharacteristics of security characteristic will increase. It is obvious, because of ensuring of Accessibility characteristic in information systems for people with disabilities in user's interfaces it is necessary to do coordinal redesign of user interfaces. As a rule, such redesign of interfaces, on the one hand, lighten of interaction with software for people with disabilities, on the other hand, it is source of level decrease for all subcharacteristics of security characteristic.

## 2.4 U&S Metrics Analysis

We will analyze of U&S metrics. For that, first of all, we will represent short description of metrics and primitives (table 3).

N⁰	Name of metric	Description	Primitives	Characteristics/
				Subcharacteristics
1.	Description	What proportion	A= Number of functions	Usability/
	completeness	of functions	(or types of functions)	Appropriateness
		(or types of	described as	recognisability
		function) are	understandable in the	
		described as	product description	
		understandable	B= Total number of	
		in the product	functions (or types of	
		description?	functions)	
2.	Demonstration	What proportion	A= Number of functions	
	capability	of	implemented with	
		functions	demonstration capability	
		requiring	B= Total number of	
		demonstration	functions requiring	
		have such	demonstration capability	
		capability?		
3.	Completeness	What proportion	A= Number of functions	Usability/
	of user	of	described correctly	Learnability
	documentation	functions are	B= Total of number of	
	and/or help	correctly	functions	
	facility	described in the	Implemented	

Table 3. Brief description of U&S metrics.

4.       Operational consistency       How consistently facility?       A = number of operations that behave inconsistently       Usability/ Operability         5.       Message clarity       How easily can messages from a system be understood ?       A = number of messages that are understood easily       Usability/ Operability         6.       Customizing possibility       How many functions an operational procedures can a user customize for his convenience?       A=Number of implemented functions requiring the customization capability.       Usability/ User error poreational procedures         7.       Input validity checking       What proportion of incorrect operation portion are customized in incorrect operation avoidance operation postibility       Na many functions have incorrect operation avoidance capability.       A = number of functions requiring the customization capability.       Usability/ User error protection         9.       Appearance interface       How many functions have interface       A = number of functions implemented to avoidance of customizability.       A = number of functions implemented to avoidance customization accessibility       Usability/ User interface elements can be customized in appearance.       Usability/ A = number of types of interface Elements appearance.       Usability/ A ccessibility         9.       Appearance interface       What proportion of incorrect operation appearance.       A = number of functions interface Elements appearance.       Usability/ A ccessibility       Usability/ Accessibility         10. <td< th=""><th></th><th></th><th></th><th></th><th></th></td<>					
4.       Operational consistency       How consistently can similar       A = number of operations that behave similarly       Usability/ Operability         5.       Message clarity       How easily can messages from a system be understood ?       A = number of messages from assignment that are understood       B = total number of messages         6.       Customizing possibility       How many functions and operational of input items provide checking for valid data.       Usability/ User error protection         7.       Input validity checking       How many functions have incorrect operation avoidance capability.       A = number of input items which need checking for valid data       Usability/ User error protection         9.       Appearance interface       What proportion of user interface capability.       A=number of tunctions malfunctions being caused by incorrect operation accessible by the dinterface elements that can be customised.       Usability/ Accessibility         9.       Appearance interface acessibility       What proportion of user interface ac			user		
4.       Operational consistency       How consistently operations be carried out ?       A = number of operations that behave inconsistently       Usability/ Operability         5.       Message clarity       How easily can messages from a system be understool ?       A = number of messages that are understood easily       Usability/ Operability         6.       Customizing possibility       How many functions and operational procedures can a user       A=Number of implemented functions which can be customised during operation during operation acustomize for his customize for his for valid data.       Usability/ User error protection         7.       Input validity checking operation       What proportion of input tiems which need checking for valid data.       Usability/ User error protection         8.       Avoidance of incorrect operation       How many functions have incorrect operation       A = number of functions incorrect operation patterns       Usability/         9.       Appearance customizability of user interface       What proportion of user interface       A=Number of types of interface elements that can be customised.       Usability/ User interface elements can be customised.         10.       Physical interface       What proportion of cuser with a physical interface       A = number of functions interface elements       U			documentation		
4.       Operational consistency       How consistently an similar operations be carried out ?       = number of operations that behave inconsistently       Usability/Operability         5.       Message clarity       How easily can messages from a system be understood ?       A = number of messages messages from a system be understood ?       Usability/Operability         6.       Customizing possibility       How many functions and operational procedures can a user customization convenience?       A=Number of implemented functions which can be customised during operation B=Number of functions requiring the convenience?       Usability/User error protection         7.       Input validity checking       What proportion of input items provide checking for valid data.       A = Number of input items checked for valid data       Usability/User error protection         8.       Avoidance of incorrect operation       How many functions have incorrect operation       A = number of functions incorrect operation       A = number of functions implemented to avoid arcitical or serious malfunctions being avoidance caused by incorrect operation       Usability/ User interface elements can be customizability         9.       Appearance customizability of user interface interface       What proportion of user interface elements can be customised in appearance.       A=Number of functions interface elements that can be customised.       Usability/ User interface aesthetics measures         10.       Physical interface       What proportion of inser interface       A = number of interface Elemen			and/or help		
4.       Operational consistency       How consistently carried out ?       A = number of operations that behave inconsistently B = total number of operations that behave similarly       Usability/ Operability         5.       Message clarity       How easily can messages from a system be quertions and operational system be can a user customize for his conventience?       A = number of messages that are understood subject of the can a user customize for his conventience?       Security/ accessibility       How many functions and operational procedures customize for his conventience?       A = Number of functions which can be customised during operation accessibility       Usability/User error protection         7.       Input validity checking       What proportion of input items provide checking for valid data.       A = number of functions malfunctions being avoidance customization       B = Number of input items which need checking for valid data.       Usability/User error protection         8.       Avoidance of incorrect operation       How many functions have incorrect operation       A = number of functions malfunctions being avoidance customizability       Usability/ of user interface elements can be customised.       Usability/ Security/       Usability/ User interface aesthetics measures of interface elements that accessible by the functions can a user with a physical handicap access       A=number of functions accessible by the disabled person.       Usability/ Accessibility measures			facility?		
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operations be carried out ?       inconsistently B= total number of operations that behave similarly         5.       Message clarity       How easily can messages from a system be possibility       A = number of messages that are understood ?         6.       Customizing possibility       How many functions and operational procedures can a user customize for his convenience?       A=Number of implemented functions which can be customised during operation Rewind the customised during operation requiring the customization capability       Usability/User error protection         7.       Input validity checking       What proportion functions have avoidance capability.       A = number of input items which need checking for valid data       Usability/User error protection         8.       Avoidance of incorrect operation       How many functions have incorrect       A = number of functions implemented to operation avoidance capability.       A = number of functions inplemented to operation B = total number of incorrect operation patterns       Usability/         9.       Appearance customizability of user interface       What proportion of user interface elements can be customised in appearance.       A= number of functions interface elements that can be customised. B=Total number of functions accessible by the disabled person.       Usability/ Accessibility measures         10.       Physical handicap access       What proportion of functions can a user with a physical handicap access       A = number of functions accessible by the disabled person.       Usability/ Accessibility <th></th> <th>consistency</th> <th>can similar</th> <th>operations that behave</th> <th></th>		consistency	can similar	operations that behave	
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5.     Message clarity     How easily can messages from a system be understood ?     A = number of messages from a system be understood ?       6.     Customizing possibility     How many functions and operational procedures during operation can a user convenience?     A=Number of implemented functions which can be customised in grocedures during operation a system be customized for his convenience?       7.     Input validity     What proportion of input items provide checking for valid data.     A = number of input items which need checking for valid data.     Ma = number of functions implemented to relate a social data.       8.     Avoidance of incorrect operation operation a void critical or serious operation avoidance customised in correct a customised in correct operation avoidance customised in correct operation avoidance of incorrect customizability.     Mat proportion of the customised. B = total number of functions implemented to accessibility.     S = total number of input items which need checking of user interface elements and avoid artical or serious malfunctions being caused by incorrect operation atom patterns     S = total number of types of interface elements that can be customised. B = Total number of incorrect operation accessibility of user interface elements and accessibility functions can a user interface elements and accessibility     Usability/     Usability/       9.     Appearance customised in appearance.     What proportion of interface elements that can be customised. B = Total number of functions accessible by the disabled person.     Usability/     Accessibility       10.     Physical accessibility     Mat proportion of functions accessible by the disabled per			carried out ?	B= total number of	
5.       Message clarity       How easily can messages from a system be easily       A = number of messages that are understood         6.       Customizing possibility       How many functions and operational procedures can a user customize for his customize for his customize for his customize for his convenience?       A=Number of functions end during operation B=Number of functions which can be customised data         7.       Input validity checking for valid data.       What proportion of input items which need checking for valid data.       S = Number of functions implemented to         8.       Avoidance of incorrect operation       How many functions have incorrect operation       A = number of functions implemented to       proceeding data         9.       Appearance customizability of user interface appearance.       What proportion of user interface appearance.       A=Number of functions interface elements that can be customised.       Usability/         10.       Physical accessibility       What proportion of accessible by the functions can a user customised in B= Total number of functions incorrect operation avoidance capability.       A=Number of functions implemented to avoid critical or serious malfunctions being caused by incorrect conserved of user interface elements that can be customised.       Usability/         9.       Appearance customised in B= Total number of functions accessible by the functions can a user with a physical handicap access       A= number of functions accessible by the functions accessible by the functions can a useret handicap accessible by the functions implemented <td< td=""><td></td><td></td><td></td><td>operations that behave</td><td></td></td<>				operations that behave	
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	11.	Access	How controllable	A= Number of detected	Security/

	controllability	is the accesses to the system?	different types of illegal operations B= Number of types of illegal operations in the specification	Confidentiality
12.	Data encryption	How correctly is the encryption/decry ption of data items implemented as stated in the requirement spec.	A = number of data items correctly encrypted/decrypted B = number of data items to be required encryption/decryption	
13.	Data corruption prevention	To what extent can the data corruption be prevented?	A = number of data corruption instances actually occurring B = number of accesses where data damage or breakage is expected to occur.	Security/ Integrity
14.	Utilization of digital signature	What proportion of events requiring non- repudiation are processed using digital signature?	A = number of events processed using digital signature B = number of events requiring nonrepudiation property.	Security/ Non- repudiation
15.	Access auditability	How complete is the audit trail concerning the user access to the system and data?	A = number of accesses to system and data recorded in the system log B = number of accesses actually occurred	Security/ Accountability
16.	Authentication methods	How well does the system authenticate the identity of a subject or resource?	A = number of provided authentication methods (e.g., ID/password or IC card)	Security/ Authenticity

Results of U&S metrics descriptions analysis gave us possibility to set up variants of their interaction (table 4).

If we compare data from table 2 and 4 we can see, that sets of variants of interaction of U&S subcharacteristics and their metrics do not identical, but very similar. Some interactions were changed in the subcharacteristics context. In table 4 such changes were marked be the grey background. Such result is obvious, because U&S metrics interact with subcharacteristics

Usebility motries (sub		2.1		2.2	2.3	2.4	2.5
subcharacteristics)/ Security metrics(sub- subcharacteristics)		Access controllability	Data encryption	Data corruption prevention	Utilization of digital signature	Access auditability	Authentication methods
1.1	Description completeness	$\uparrow \uparrow / \downarrow \downarrow$	?	?	?	?	?
	Demonstration capability	$\uparrow \uparrow / \downarrow \downarrow$	?	?	?	?	?
1.2	Completeness of user documentation and/or help facility	↑↓	-	-	-	-	-
1.3	Operational consistency	$\uparrow \uparrow / \downarrow \downarrow$	?	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$
	Message clarity	<u>↑</u> ↑/. . .	?	<u>↑</u> ↑/.	<u>↑</u> ↑/.  .	<u>↑</u> ↑/.  .	<u>↑</u> ↑/.  .
	Customizing possibility	$\uparrow\uparrow/\downarrow\downarrow$	?	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$	$\uparrow\uparrow/\downarrow\downarrow$
1.4	Input validity checking	$\uparrow \uparrow / \downarrow \downarrow$	?	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$	$\uparrow \uparrow / \downarrow \downarrow$
	Avoidance of incorrect operation	↑↑/↓↓	?	↑↑/↓↓	↑↑/↓↓	↑↑/↓↓	$\uparrow \uparrow / \downarrow \downarrow$
1.5	Appearance customizability of user interface	$\uparrow \uparrow / \downarrow \downarrow$	?	?	?	?	?
1.6	Physical accessibility	$\uparrow \downarrow$	?	↓↓	¢↓	↑↓	¢↓
<ol> <li>Usability subcharacteristics:</li> <li>1.1 Appropriateness recognizability</li> <li>1.2 Learnability</li> <li>1.3 Operability</li> <li>1.4 User error protection</li> <li>1.5 User interface aesthetics</li> <li>1.6 Accessibility</li> </ol>			2. Sect 2.1 2.2 2.3 2.4 2.5	urity subch Confident Integrity Non-repu Accounta Authentic	aracteristic tiality diation bility ity	CS	

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 Table 4. Variants of interaction metrics of U&S subcharacteristics.

# 3 Case Study

We will represent simple example of U&S interaction. First of all, worth noting, that metrics U&S equal to subsubcharacteristics (i.e. U&S subcharacteristics of second level). In this case, with usage of calculated significances, from U&S metrics, in author's opinion, it is possible to do quantitative analysis of U&S interaction. We will do such analysis for separate subcharacteristics of U&S characteristics. For example, we will consider interaction of Operability and Confidentiality subcharacteristics on basis of such interaction with metrics. For that see table. 3, which includes the description of metrics and required primitives for calculation. Object of our research will be web-site of Banking University (http://ubs.edu.ua/en/), which is on the stage of the development. We will calculate metrics of significances for web-site before making changes in this web-site (i.e. before testing). Results of calculation represented in table. 5.

Subchara	1	2			
Operability	Operational consistency	0,3	0,1		
	Message clarity	0,8	1		
	Customizing possibility	0,6	0,8		
Confidentiality	Access controllability	0,6	0,8		
<ol> <li>Metrics significances before make changes (i.e. before testing);</li> <li>Metrics significances after make changes.</li> </ol>					

Table 5. Metrics significances.

For calculation of single significance for Operability subcharacteristic use additive convolution, in which weighting coefficients for significances of metrics will be equal. In result of calculation, we give following significances:

- before making changes
- $Operability_{before} = 0,3*0,33+0,8*0,33+0,6*0,33=0,099+0,264+0,198=0,561;$
- after making changes
  - Operability<sub>after</sub> = 0,1\*0,33+1\*0,33+0,8\*0,33=0,033+0,33+0,264=0,627.

Further, we will compare received significances for Operability and Confidentiality subcharacteristics:

- before making changes Operability= 0,561, a Confidentiality=0,6;
- after making changes Operability= 0,627, a Confidentiality=0,8.

In result, we received significances for Operability and Confidentiality subcharacteristics. Such significances increased after making changes in web-site in comparison with before making changes. For Operability the difference equals 0,066 and for Confidentiality - 0,2. Thus, we have confirmation of our supposition about interaction of Operability and Confidentiality characteristics, when increase of level of one subcharacteristic incurring to increase in the level of other subcharacteristic (table 2).

# 4 Conclusions

We have considered two basic aspects of U&S interaction: usable security and secure usability. Differences in such aspects were analyzed by use of practical examples.

This work includes results of analysis of U&S interaction on the level of subcharacteristics and metrics. Results of such research give possibility to define the set of variants of the interaction of U&S subcharacteristics and metrics. Such variants of interaction of subcharacteristics and metrics are not identical, but are very similar.

In future authors are planning to make complete quantitative analysis of interaction of U&S subcharacteristics on the base of calculated metrics values. Authors suppose, that such analysis must confirm that variants of interaction of U&S subcharacteristics assessment will be correct. Also we plan to analyze interaction between U&S characteristics of information systems and another once, for example, safety.

Practical results of such assessment are improving of requirements foundation for U&S and other characteristics and correcting of design decisions.

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