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Statistical Model to Validate A Metaprocess-Oriented Methodology based on RAS and BPMN

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ABSTRACT: *Software reuse in the early stages is a key issue in rapid development of applications. This article introduces a metaprocess-oriented methodology based on the model reuse as software assets, and starting from the domain specification and analysis phases. The approach includes the definition of a conceptual level to adequately represent the domain and a reuse process to specify the metaprocess as software assets. The methodology has been applied successfully in the field of e-health, but our work also describes advances in reuse of models for implementation in other contexts, contributing to improved productivity in software development.*
Keywords: *Metaprocess, Processes, Reuse, E-health*

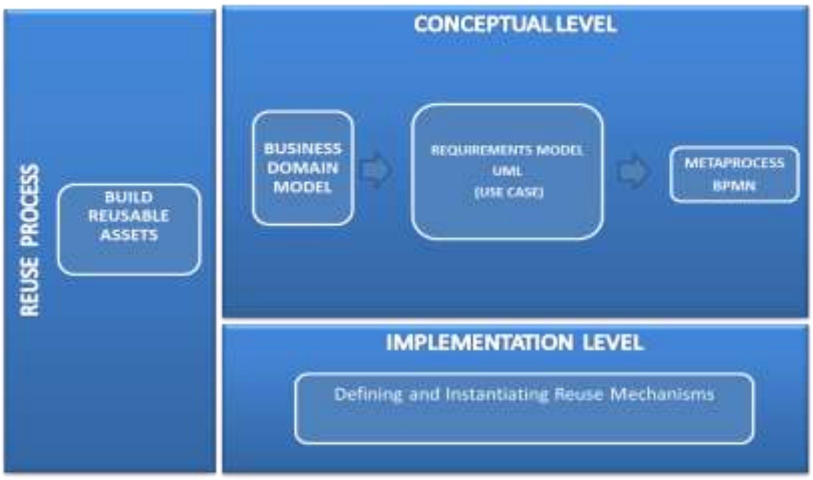
I. INTRODUCTION

Software reuse facilitates rapid development of applications. This contributes to increased productivity and quality in software development [1]. Metaprocess metamodeling and its specification as software assets require to standardize software processes.This article present a metamodeling-based approach intended to provide a conceptual process for a domain, and its specification as software assets to improve metaprocess reuse in early stages of software development. The applicability of our proposal, we presents a real example currently running on the e-health domain: a monitoring system for patients with cardiovascular risk factors. This article is organized as follows. In section 2 we discuss the methodological propose. Section 3 analyzes the proposed methodology for the specific application mentioned above. Section 4 provides a statistical model to validate the proposal. Finally, our present the conclusions and future work in Section 5.

II. A METHODOGICAL PROPOSAL FOR THE REUSE OF METAPROCESSES

This section introduces a methodology that consists of one level design for the description of metaprocesos (conceptual level) and a reuse process (see Figure 1). The representation and construction of metaprocess begin from a generic metamodel, which is specified using different models to fully represent the domain, with customization applied at different development stages, from specification of requirements to design and software applications. We seek for a sufficiently expressive and complete representation of metaprocesos in order to cover the conceptual domain with elements which facilitate the reuse in the software development.

Figure 1. Metaprocesses specification levels as software assets expressed in models



The conceptual level is a generic abstraction of the conceptual domain, which is represented through the business domain, requirements, and process models. The business domain model specifies the business cycle: mission, policies, business and process elements. The requirements model is based on use case diagrams. The metaprocess is based on the use of the BPMN standard. A metaprocess will be specified, as described below, on the basis of the business requirements captured through use cases and process elements of the conceptual domain and their relationships.

Consequently, the conceptual level is specified using three steps as depicted in Figure 1:

1. The first step encompasses the representation of the domain through the Business Domain Model (BDM). BDM specifies business activities, business tasks and business roles. BDM contains diagrams such as the business diagram and process flow diagrams. The process flow diagram specifies the business activities and roles. In this way, a business activity is conducted using one or more activities process.

2. The second step is intended to build the Requirement Model (RM), including use case diagrams.

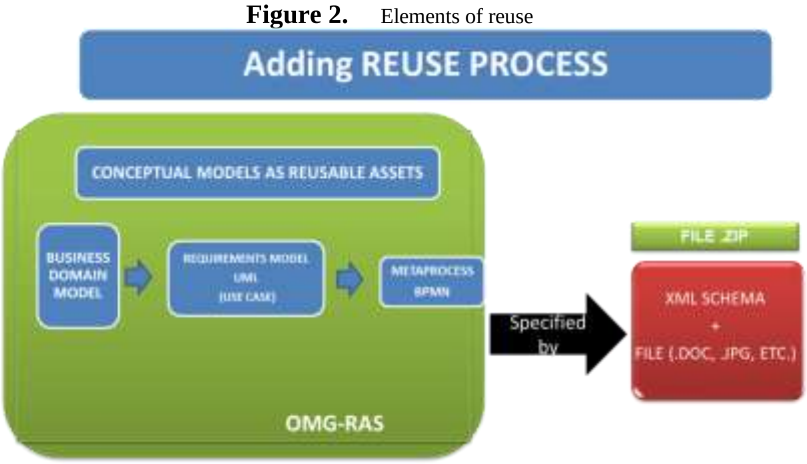
3. Finally, the third step is to build the Process Definition Model (PDM), which includes business process functionality both from a domain perspective and from the perspective of system support implementation for this software component.

This is followed by the metaprocess construction, based on information provided by the Domain Analysis, using the BPMN Notation, in which the activities (task in BPMN) and roles (swimlanes in BPMN) of the Metaprocess are clearly identified, as well as the use cases and applications or systems that support the execution of the metaprocess. Each activity and each role of metaprocess has been specified with a set of applications or systems or part thereof that support it execution for reuse in other cases as components reuse.

The reuse process enables the representation of metaprocess as reusable soft-ware asset. Hence it represents the metaprocess architecture with its constituent elements specified as software artifacts. The specification of reusable software assets metaprocess as according to the standard is done by identifying each metaprocess as a reusable software asset with its component artifacts and attributes that describe them. It is defined by use, solution and classification, profile, related profiles and related assets as reusable software component elements of asset.

The reuse process is based on the OMG-AS and OMG's RAS standard, and uses a repository of reusable software asset to enable storage and search of assets in packed files, they contain these assets and an XML manifest (XML Schema) and, they are specified as .xsd as rasset.xml residing in the root directory of the asset accompanied by the respective. XSD or XML-Schema and another set of artifacts, files or subdirectories that help specify. There components are compressed into a single file with a .Ras to facilitate management of its reusable software assets (see Figure 2).

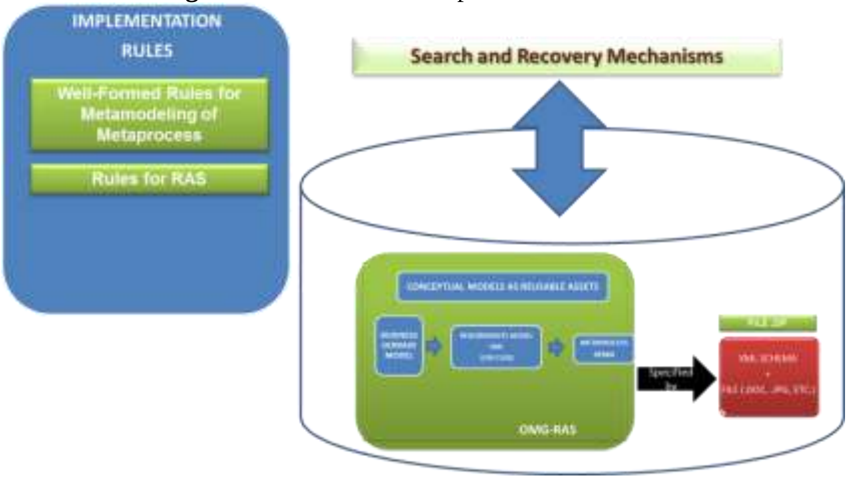
Figure 2. Elements of reuse



Finally, this propose uses the mechanisms for building well-formed models and Reusable Asset Specification (RAS).

The mechanisms for RAS facilitate the search and retrieval elements of the metaprocess as software assets (models, components, artifacts) into repositories. The OMG- RAS standard proposes the organization of the files .Ras and rasset.xml file structure, assets can be searched, retrieved and sail them through services, which can be implemented as Web Services or other approaches, which states for each service the nature of the response and the response (see Figure 3).

Figure 3. Elements of implementation level



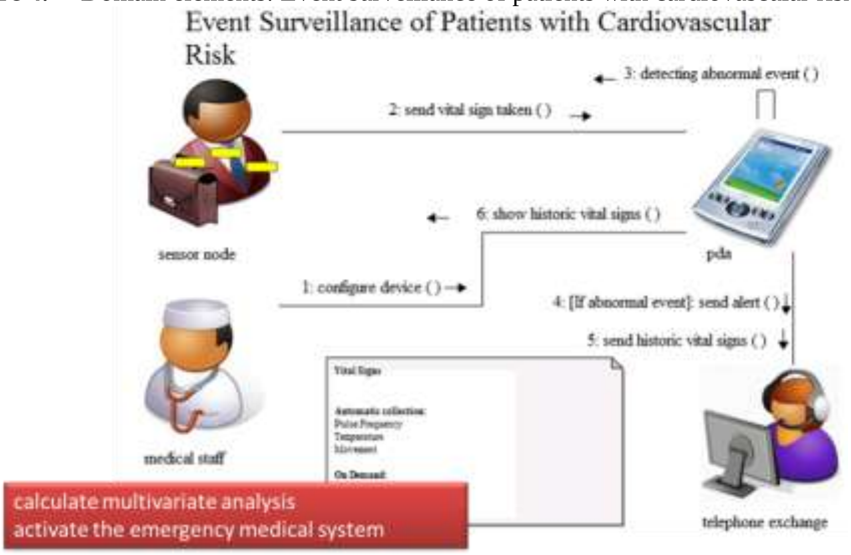
In this case the implementation of mechanisms for RAS it's possible through our own repository Actives.

III. CASE STUDY IN AN E-HEALTH DOMAIN

In order to apply the proposal, we take a monitoring system for patients with cardiovascular risk as our case study. The process description for monitoring system for patients with cardiovascular risk is as follows: firstly, the technical personnel configure the device. A body area network gathers the patient's vital signs and sends this information to a mobile device. If an abnormal event happens, the mobile device sends the alert and a set of historic vital signs to the telephone exchange. The medical staff can retrieve the historic vital signs directly from the mobile device.

Additionally, in this description the process description was refined with others activities as calculate multivariate analysis (statistical analysis to group data by factors or components) about vital signs in patients with cardiovascular risk and activates the emergency medical system. Fig. 4 depicts an overall view of the system.

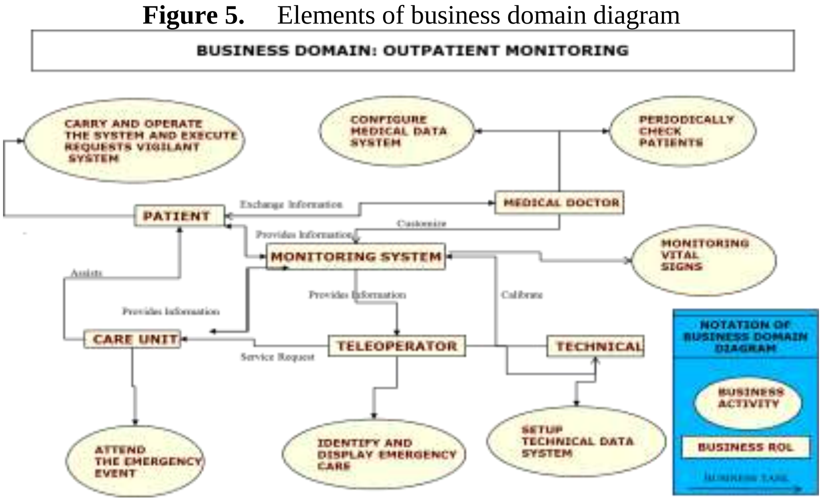
Figure 4. Domain elements: Event surveillance of patients with cardiovascular risk



The monitoring system also involves the use of metaprocesses to specify the medical guidelines and protocols to be followed by the medical staff during an emergency. The telephone exchange uses the medical guidelines and protocols when the monitoring system triggers an alert. In this article, we only focus on the specification of metaprocesses at a conceptual level and process reuse. In the next subsection the methodology phases at the conceptual level, the architecture and other technological issues are described.

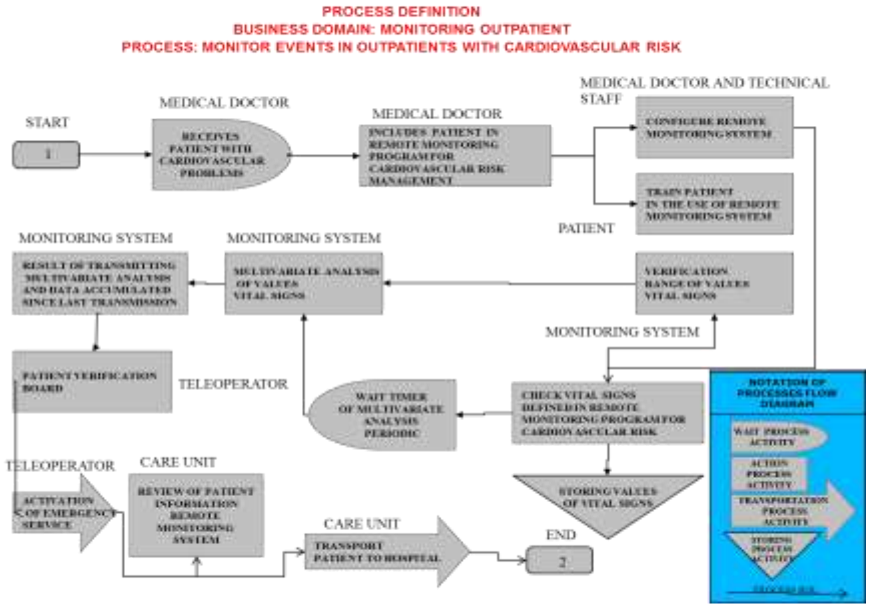
The Business Domain Model (BDM) specifies how the monitoring e-health service is provided, as well as documenting the methodology in the macroprocesses, to facilitate understanding the domain. It specifies business activities, such as configuring the medical data system, periodically checking patients, monitoring vital signs and other activities; the business tasks, such as exchanging information and customization, provide information and other tasks and business roles relating to patients, the medical doctor, teleoperator and other roles. The BDM of the case study contains diagrams including a business diagram (see Figure 5) and process flow diagrams.

Figure 5. Elements of business domain diagram



The process flow diagram specifies the process activities, such as configure remote monitoring system, patient verification board, emergency activation service and other activities and process roles, such as medical doctor, teleoperator and other roles for gathering vital signs, device configurations and triggering of alerts (see Figure 6).

Figure 6. Elements of process flow diagram

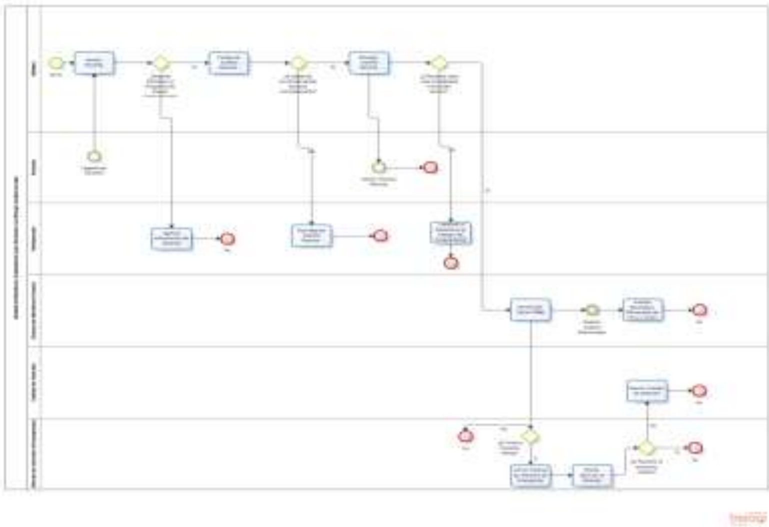


The Requirement Model (RM) includes use case diagrams (with actors such as medical staff, technical staff and patients and use cases such as configure the system, display history of vital signs, activate alerts, acquire vital signs and others).

The Process Definition Model (PDM) is shown in Figure 7 as a BPMN diagram. PDM provides metaprocess elements shown as activities. The metaprocess activities defined by the analyst and domain expert in the study case are the following: Enter Patient Information, Monitoring System Configuration, Patient Monitoring through Monitoring System, Patient Behavior Analysis through Monitoring System, Manage System

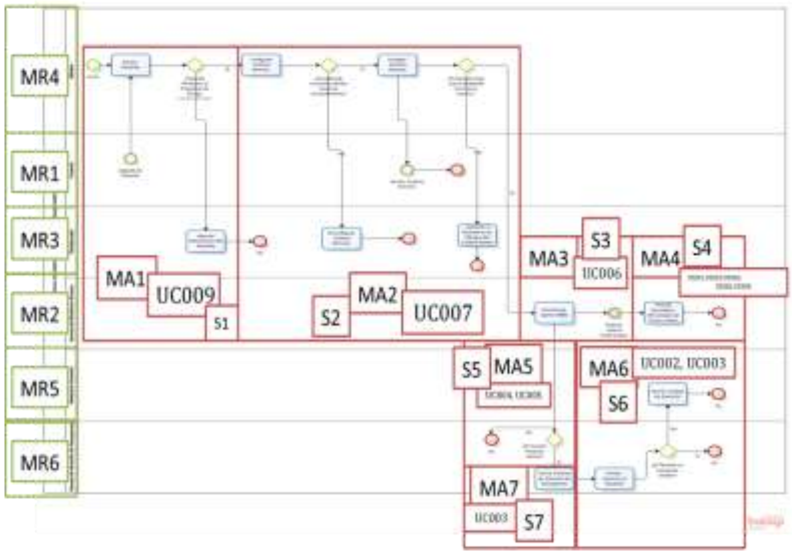
Alerts, Patient Assistance and Emergency System Activation. In the case of the metaprocess, the roles were the following: Patients, Monitoring System, Tele-Operator, Doctor, Care Unit and Emergency System.

Figure 7. Metaprocess Model



The metaprocess model (see Figure 8) enables identification of the activities (MA) and roles (MR) of Metaprocess, use cases (UC) and applications or systems (S).

Figure 8. Activities, roles and applications in the Metaprocess



These applications are the following: Patient Information System, Monitoring System Configuration, Monitoring System, Multivariate Calculation System, Alert Management System, Event Care System and Emergency Care System.In the reuse process, the metaprocess elements defined above are specified as reuse software assets for the case application, based on the RAS-OMG specification to provide a Ras Metamodelled Metaprocess.In the implementation level, the rules are defined for the reuse of reusable assets software from the repository by search mechanisms whether through keywords that identify the assets or through the storage logic route of the assets in the repository. Our efforts continue towards the specification of a first evolutionary instantiation mechanism via XML-Schema.As technological support to the previous levels and reuse process, the software assets repository for e-health domains is being constructed to facilitate the reuse tasks of e-health oriented application development. It constituted a first step towards accomplishing higher productivity and quality, as well as reducing errors and the timeframe for releasing applications.Consequently, a knowledge base and artifacts will be available to e-health users. Additionally to this, we continue to develop applications for the e-health domain, reusing models with metaprocesses specified at the conceptual level, based on the proposed methodology, as well as developing integrated repository development tools using Eclipse (see Figure 9):

Figure 9. A proposed prototype of a repository for software assets reuse

The repository will be an integrated development environment for building and reusing software artifacts in e-health and other domains, while also taking into consideration the reuse level and implementation levels of the proposal. In terms of building the metaprocess and its specification at a conceptual level for the proposed application case, the work that has been completed up to this point has enabled the building of software to remotely monitor patients with cardiovascular risk, as represented in the following architecture and the technical elements of the developed system. The elements specified at the conceptual level in monitoring systems of patients with cardiovascular risk are used to specify and build other systems, such as home care patient systems or for patients in a medical emergency system. The conceptual level described above initially allowed the development of a monitoring system for patients with cardiovascular risk.

In this level, we built models related with the domain. Models and their components have been specified at the conceptual level by a methodological proposal.

IV. STATISTICAL MODEL

Evaluation and discussion of the methodology is made in two parts, the first refers to a discussion from the conceptual approach and the second presents a statistical analysis type, in which an assessment tool was built on the perceived level of the proposed methodology. With the instrument six questions for the two components were defined to evaluate: the proposed methodology with its constituent elements and reuse. The instrument a group of experienced engineers applied in analysis and software development and a group of beginners engineering students last semester systems; in total 24 people were interviewed. The instrument is available in the Url: https://docs.google.com/forms/d/1fBPLW7Q5REvRkcVAgBl2lxdTnloEjbmHr1w4HGXIqvk/viewform?c=0&w=1.

The results of the investigation with regard to statistical analysis and multivariate statistical analysis of the results for the evaluation of the perception of the methodology and reuse as components of the proposed methodology constructs formally presented.

It can be concluded after the application of the instrument, there are differences depending on the answers given, between levels of perception experienced users and beginners in front of the methodology and reuse, presenting minor variations in the values assigned to the questions in the expert user, where values ranged from 5: Completely, 4: Properly; in the novice user, where values ranged from 5: Completely, which is the highest occurrence, 4: Properly, but qualifying results with values obtained 3: Average 2: Part 1: Hardly.

We proceeded to the quantification for multivariate treatment, via method of optimal quantification using SPSS software, since it was non-continuous variables and responses: 5: Completely, 4: Suitably, 3: Average 2: Partly, 1: Hardly, and this is the method according to the statistical literature and suggest the package used to quantify variables. Quantitation was performed using a statistical method of analysis called "optimal quantification", which assigns numerical values to the categories of variable values in a way that maximizes the relationship between observations and model data analysis used (analysis factorial, in our case), respecting the character of measurement data and facilitate statistical treatment.

The algorithm for quantification of data in SPSS enables the normalization of variables and their transformation into "quantitative" variables, i.e. variables with numerical values assigned to the categories of responses. Then, using Cronbach's alpha it is made to ensure internal consistency and dimensionality of the scales. Cronbach's alpha is an index of internal consistency that takes values between 0 and 1 and is used to check if the (survey) instrument being evaluated collects misinformation and leading to wrong conclusions or whether it is a reliable instrument making stable and consistent measurements. Alpha is therefore a squared correlation coefficient that broadly measures the homogeneity of the questions mediating all the correlations among all the items to see that they actually look. His interpretation is that the more the index is approaching the end 1, better reliability, considering a respectable reliability from 0.80. For the study, a Cronbach's alpha of 0.886, indicating that the instrument (survey) is acceptable enough to continue the description of the data was achieved.

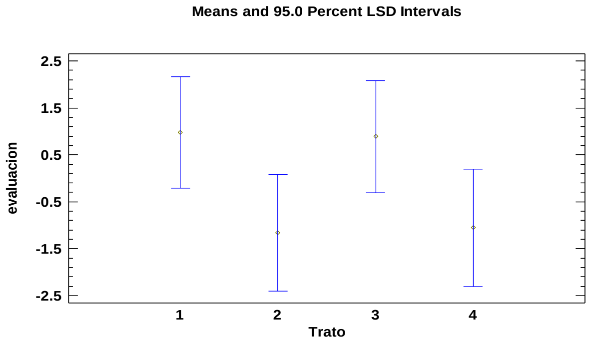
It must be noted that initially part of a survey type, with small sample of twenty-four (24) respondents, consisting of two groups: Expert Group = 1 Group = 2 users and beginners with categorical data type 5: Completely, 4: Appropriately, 3: Average 2: Clear, 1: Hardly. For categorical data analysis (ordinal) were quantified via optimal quantification method using SPSS software, allowing the sample to enable an analysis of these with measures based on location variability and procedures. Therefore, two constructs were defined: Methodology and Reuse for factor analysis for dimension reduction, based on the covariance matrix (correlation). The matrix shows very high correlations and clarifies the definition of two constructs: Methodology for the correlations of P1, P2 and P3, shown in the table as TSP1, TSP2 and TSP3 and Reuse for correlations P4, P5 and P6, displayed in the table as P4SR, TSP5 and TSP6. Since the sample data is small by nature suggest the existence of repetitions "inflate" the correlations. In this case if the value of 0.9456 for the correlation between TSP2 and TSP1 you look to be a strong correlation showing relationship between the answers to P1 and P2, whereas the value of 0.2348 for the correlation between P4SR and TSP1 will be a correlation low showing no relationship between the answers to P4 and P4 since they belong to different constructs, as will be seen in the factor analysis.

Method and reuse factor for each of the constructs analysis: Exploring and analyzing these data the two factors are calculated. Using factor analysis was done in order to reduce the number of variables, and because this study phenomena in which the variables depend on a common factor (default, not measurable). Factor analysis was made with observations from surveys of both groups; initially with the answers to questions P1 to P3 that refer to the methodology, obtaining a new variable called single method; then made with observations from surveys of both groups with the answers to the questions P4 to P6 that refer to reuse, obtaining a single new variable called Reuse; this in order to determine the weights, according to data from each of the answers given in the questionnaire.

In the case of P1 to P3 questions referring to the methodology, one known method resulting factor is obtained In this case, one factor has been extracted since it is the only one with a greater than or equal to 1.0 own value. Which accounts for 99.9438% of the covariance matrix of the quantized data. For the case of P4 to P6 questions that refer to reuse, one resulting factor called Reuse is obtained. In this case, one factor has been extracted since it is the only one with a greater than or equal to 1.0 eigenvalue. Which accounts for 100.0% of the variability in the original data.

Then, comparisons of the two groups evaluated the methodology and reuse, for which such data are rearranged so that evaluation are made, it corresponds to the results of factor method and Reuse organized into a single variable called Evaluation and Treatment, It corresponds to user groups arranged in a variable called same treatment, thus Treat = 1 corresponds to the Group Users experts against their perception of the methodology and Treat = 3 corresponds to the Group expert users from their perception of reuse; Treat = 2 corresponds to the Group Beginners against their perception of the methodology and Treat = 4 corresponds to the Group Beginners experts against their perception of reuse, as illustrated by the graph below.

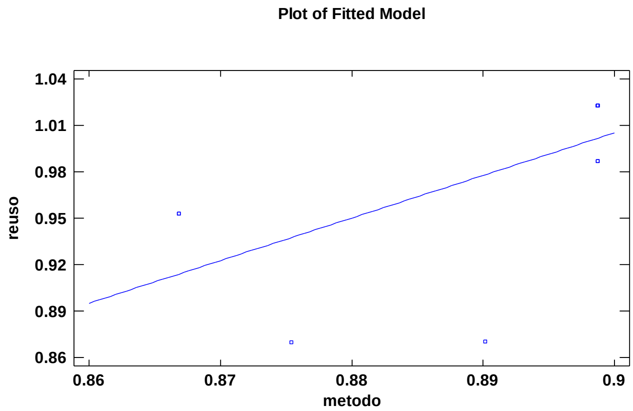
Figure 10. Chart of Comparison Means for Factors



As can be seen in Figure 10, although there is no significant difference between the two groups about their perceptions of the methodology and reuse, since according to the statistics of the ANOVA table in SPSS, p = 0.1617, value indicates that there is no significant difference between the groups evaluated in each factor with a significance level of 95%, is a p-value for the absence of significant difference "suggests" some level of trend among variables,

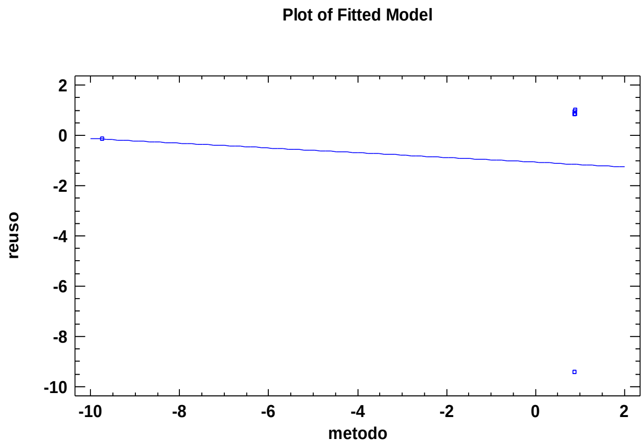
In the case of experts Users Group = 1, the two factors are related, as illustrated in Figure 11.

Figure 11. Scatter plot for the two factors in Group = 1 Experts Users



Analyzing the dispersion of data experts Users Group = 1, Figure 11 shows that there is a causal relationship between reuse and positive slope method. For Beginners Group = 2, we proceeded to relate the two factors, as shown in Figure 12.

Figure 12. Scatter plot for the two factors in Group = 2 Beginners



Can display a different trend given the level of assessment between the two groups Experts Group = 1 Group = 2 users and beginners in the questionnaire. As the Group = 1 Users experts assessed "positively" both as the Reuse and Methodology with weights between 4: Properly and 5: Completely, while Group = 2 qualifies Beginners from 3: Fair and 4: Properly. This trend in the scatterplot of the data, do regression presuppose, however, by the small amount of data and its repetitive nature, the circumstances of regression is violated.

In these figures by analysis of covariance, considering that the "Methodology" (Method) explains the "Reuse" (Reuse) for the two groups Experts Group = 1 Group = 2 Users and Beginners, a slight positive trend is observed Reuse and Methodology with a small slope for experts Users Group = 1, while Group = 2 Beginners, shows no change "Methodology" (Method) to "Reuse" (Reuse).

When analyzing the data dispersion in Group = 2 Beginners, Figure 12 is evidence that there is a causal relationship between reuse and method, which well be explained as previously suggested by the absence of more data in the sample and of variables that can explain in more detail the arrest, time of use, efficiency and other indicators against the reuse process and methodology.

V. CONCLUSIONS AND FUTURE WORK

This methodological approach contributes to specifying domains by means of conceptual levels. These levels facilitate the creation of design models independently from the platforms. In this manner, it is possible to obtain an under-standing of the domain with the purpose of correcting problems inherited through deficient requirements gathering or a lack of comprehension of the same. As a result, we obtain specific elements at a conceptual level that can be reused in the development of future applications.

The methodology proposed for the metaprocess at the conceptual specification level as software assets for reuse in the early stages of software development is intended to facilitate the development of domain process oriented applications, in this case for e-health. This methodology facilitates the software development process in one case, in which guided models contributed to the development of applications from the domain, independently from the development platforms. In turn, this conceptual level proposal has been validated and tested. Now, models, metaprocesses, components and artifacts are being used to develop other systems, such as an interoperability platform for a pre-hospital domain.

The monitoring system for patients with cardiovascular risk, and the interoperability platform for the pre-hospital domain has been implemented at IPS University Hospital (Medellín, Colombia), and this system is being requested by other countries and other regional hospitals in Colombia.

Presently, the system has been evaluated by measuring its impact on the indicators; briefly, the statistics and analysis of its implementation indicate that there is a significant improvement in the allocation of hospital resources and patient care times.

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