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Extending the Data Stream Processing Strategy to Scenario Analysis

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ABSTRACT

The real-time data processing is continuously demanded by their implications in the real-time decision-making process. The data stream processing strategy implements an automatization of the measurement process based on a measurement and evaluation (M&E) framework for supporting real-time decision making. The decision making is based on the indicators, which have a set of decision criteria established by the experts in the domain in the initial M&E project definition. However, the decision criteria are not isolated from the context in which the decision should be made. This work introduces an extension for the data stream processing strategy, incorporating the scenarios as an interpretation related to the possible states of a context. The transition between scenarios is incorporated through the transition model, obtaining feedback from the processed data for adjusting the decision criteria and their interpretation in terms of the current context. A new complementary schema to the project definition is incorporated for supporting the extensions. In this way, the data stream processing strategy now is able to support the scenario definitions, transition analysis jointly with the possibility of fitting each indicator's decision criteria to each particular scenario. Finally, a scenario analysis based on the monitoring of outpatients is outlined.

Keywords: Scenario Analysis, Multicriteria Decision Making, Data Stream, Indicator.

1. INTRODUCTION

Nowadays, the real-time decision making is increasingly taking a preponderant role in many industries because the situations require a solution in a specific instant [1], [2]. That is to say, the situation requires to choose an alternative for getting a profit, avoiding some kind of risk or even damage in relation to the outlined aim for the decision-making process[3]. This turns into a big challenge in the real-time measurement process because the concept or object which is monitored requires immediate actions in front of determined change of its measurable properties. For example, when a medical centre is monitoring an outpatient, an atypical jump in its heart rate must have an immediate associated action for avoiding risky situations for its life.

When the decision making depends directly on the measured value (e.g. in an outpatient monitoring), it is highly important to establish an agreement in relation to the terms, concepts and the relationships underlying to the measurement process for fostering the repeatability of the process, its consistency and the comparability of its results [4]. It is a key asset because when two measures obtained in two different instants should be contrasted, the underlying assumption is associated with its comparability and the possibility of doing it. A Measurement and Evaluation (M&E) framework allow defining the terms, concepts and the necessaries relationships for implementing a measurement process in a consistent way and fostering the data-driven decision making [5].

The Data Stream Processing Strategy [6] is a topology based on Apache Storm oriented to the data stream processing, which automatizes the measurement process supported by a measurement and evaluation framework. The measurement project definition is the first stage in where the domain experts define the entity to be monitored, choose the measurable characteristics, define the metric for quantifying each characteristic, choose the device for obtaining the value of each metric, etc. Thus, before the Data Stream Processing Strategy receives a given measure, it knows the expected range of values, the associated data source (i.e. the measurement device), among other aspects which allow the measurement automatization.

In the M&E framework, the metric will return a value (i.e. the measure) but it does say anything about how to carry forward its interpretation. That is to say, the value of the corporal temperature for an outpatient could be 39ºC and that is the number obtained from the metric, the critical aspect is that the interpretation of such value is not part of the metric but yes of indicators. The indicators incorporate the decision criteria from the domain experts for interpreting each measure from its associated metric. In addition, the interpretation could have an associated recommendation, for example, 39ºC corresponds with fever (the decision), and the outpatient should receive a dose of this drug between this specific time for avoiding a risky situation (the recommendation). The elemental indicators interpret the value of the metrics using the decision criteria, but the global indicator answer to the main objective related to the measurement process (i.e. the project definition), obtaining its value from a set of elemental indicators [7]. For example, for evaluating the outpatient health (i.e. global indicator), it is possible to use jointly the

level of temperature, the level of blood pressure, and the level heart rate from the outpatient (i.e. elementary indicators). Of course, each elemental indicator could have its weighting in relation to its contribution to the outpatient health, impacting more or less depending on each assumed value.
The entity under monitoring (e.g. outpatient) is immersed in a context with which establishes an interactive relationship (e.g. the sun has an incidence in the outpatient). This interactive relationship could affect the analysis of the environment related to each entity in two sense: 1) An entity could change between context along the measurement process (i.e. an outpatient could walk from its home to the beach), and 2) The same context could vary its conditions along a day (i.e. The home at the morning is fresh, at the afternoon is warm, and at the night is cold). Moreover, this kind of change of context or context variation could directly affect the indicator weighting changing the interpretation way related to each entity.

The problem resides in that the M&E framework supports an elementary indicator by each metric in a static way, provoking those decision criteria do not be updated based on the real-time data processing. Even, when the multi-criteria decision making considers inside the framework a set of elementary indicators to be jointly analyzed, each one has fixed decision criteria. This avoids updating the interpretation (i.e. using the decision criteria) of indicators to each context depending on the contextual conditions and their associated changes. Because the data stream processing strategy is based on the M&E framework, this kind of limitation affects the real-time data analyzing.

As main contributions, 1) The concept of Scenario is introduced in the M&E framework related to the Data Stream Processing Strategy (DSPS) for supporting multiple states of a context. Now, it is possible to indicate to DSPS each different scenario in where an entity could be found; 2) The concept of the Scenario Property is introduced for analyzing and modeling the changes of each scenario and its incidence in the decision criteria of the indicators; 3) The concept of the scenario change is incorporated through a transition model, which allows defining the scenario transitions and its impact in the decision criteria of the indicators; and 4) The Project Definition schema used by DSPS is updated based on the extensions for the scenario concept. Thus, DSPS can identify multiple scenarios, jointly with the effect of each change of the scenario properties or even each change of scenario in the decision criteria fostering the scenario analysis based on the multiple criteria defined from the indicator viewpoints.

The article is organized into six sections. Section 2 outlines some related works. Section 3 introduces the multicriteria decision-making method in the measurement framework. Section 4 describes the proposed changes for the context, scenario, and its impact in relation to the weightings of the indicators. Section 5 introduces a scenario analysis based on outpatient monitoring. Finally, some conclusions and future works are described.

2. RELATED WORKS

Bouhalleb and Smida [8] introduce a perspective about the scenario analysis in the health field. The authors sustain that the scenario planning is a multidimensional analysis and it is based on three main dimensions: the information gathering, knowledge spreading and scenario alternatives. It is an interesting viewpoint but even when the analysis is statistically supported a formal measurement process would not be detailed which warranties the results and its comparability along the time.

In [9] proposes a scenario modelling based on the morphological analysis. The underlying idea is that each scenario could serve as base for making future decisions. In this sense, the author suggests that it would be useful an early identification and parametrization of each scenario following a method guided by four parameters: Actor, Goal, Method, and Means. The actor is who is able to make some kind of incidence in a given context, the goal is these which guides to the actor, the method is the way in which the actor will try to reach the aim and the means represent the associated implications.

Reference [10] proposes the use of dynamic and static metrics for quantifying the behaviour related to the entity attributes in the Big Data environment. As a difference, our data stream strategy uses a formal measurement and evaluation framework, which includes an underlying ontology jointly with the process view for a detailed way in which the measurement process should be defined. Even, in this work the scenario analysis and its impact on the indicator weighting is introduced for extending the analysis capabilities.

In [11] introduces an Internet-of-Thing framework oriented to the performance measurement in a real-time environment. The authors propose a strategy guided by the design, methodology and approach focused on the supply chain context. Given the multidimensional way related to the supply chain context, the multi-objective optimization methods are used. Finally, they introduce a preference-guided technique for ordering the potential solutions following different decision criteria. As a difference with our propose, the scenario analysis is not considered. It would be a useful complementary aspect mainly thinking in the change of conditions related to the supply chain management, the decision making and the optimization itself.se either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary

3. THE MULTI-CRITERIA DECISION MAKING IN THE MEASUREMENT FRAMEWORK

The Multi-criteria decision making implies the identification of a set of criteria or considerations which allows guiding the decision making from multiple viewpoints. On the one hand, determine the presence of fever or not in an outpatient could be interpreted as a dependent of one criterion (e.g. the corporal temperature). However, it is not new that the measurement process naturally incorporates multiple viewpoints which allow concurrently analyzing the current state of an entity under monitoring. For example, an outpatient could be analyzed simultaneously through the corporal temperature, the heart rate and the blood pressure. In this sense, not just it is individually important each viewpoint but also the concurrent viewpoint configurated under the combination of the previous viewpoints. That is to say, even when the corporal temperature, heart rate and the blood pressure seem to be individually normal, this approaching analyzes the situation when all the values are interacting together on the same individual. Even, the decision criteria's original definition could sensibly change over time. In this sense, the data stream engines are dynamic architectures which should be able to analyze the data when they arrive based on its context. Thus, the decision criteria should be updated in real time for incorporating current decision criteria in case of needing to fit the online analysis.

Each viewpoint or criteria could have its own weighting because the importance of each one depends on the entity under monitoring and the associated context. That is to say, for monitoring the outpatient the corporal temperature could have 0.4 as weighting, while the heart rate 0.3 and the blood pressure 0.3. In this sense, it is important to highlight that the sum of the weighting for all the criteria must be one.

This kind of analysis is very useful because, through its application, a priority order could be given from the urgency or importance defined by the weighting. Table 1 synthesizes an example of the obtained measures from the outpatients A, B and, C for the three interest attributes.

Table 1: An example of the multiple viewpoints related to an entity under monitoring

Metric	Outpatient		
	A	**B**	**C**
Value of the corporal temperature (ºC: Celsius Degree)	37.0	38.8	37.4
Value of the heart rate (bpm: beats per minute)	100	130	160
Value of the systolic blood pressure (mmHg: Millimeter of mercury)	130	120	125

The elementary indicator for the value of the corporal temperature could say that [36.4; 37.4] ºC it is normal (indicated with a 0), while (37.4; 38] ºC it is low fever (indicated with a 1), (38; 39.5] it is fever (indicated with a 2), and upper than 39.5ºC it is high fever (indicated with a 4). The interpretation (the correspondence between each interval and the integer value) is given by the experts in the domain for representing a given situation. Under the same idea, it is possible synthetically to indicate that [90; 150] bpm it is a normal heart rate for a person around 40 years old (indicated with a 0), while (150; 180] bpm implies a person in activity (indicated with a 1), and upper than 180 it is a risky situation (indicated with a 4). Finally, following the same idea, the systolic blood pressure could be interpreted as lesser than 120 mmHg is normal (indicated with a 0), while [120, 130) mmHg it would be elevated (indicated with a 1) and upper or equal than 130 mmHg it is hypertension (indicated with a 4).

When the data stream processing strategy read the measures from the data sources, it immediately applies the interpretation from the indicators, following the stored knowledge from the experts. That is to say, the experts' knowledge is incorporated through the decision criteria, and it is able to change over time depending on the contextual situations or events. Thus, from Table 1 it is possible to derive Table 2 with the indicator values as it is shown:

Table 2: An example of Multi-criteria prioritizing using the M&E framework

Metric	Weighting	Outpatient		
		A	**B**	**C**
Level of the corporal temperature	0.4	37.0 →0	38.8 →2	37.4 →0
Level of the heart rate	0.3	100 →0	130 →1	160 →1
Level of the systolic blood pressure	0.3	130 → 4	120 →1	125 →1

Thus, using the weighting jointly with the interpreted value obtained from each elementary indicator, it is possible to define a global indicator. This global indicator uses an additive model and it is termed "Level of the risky situation". The underlying idea is to obtain a weighted sum based on the elementary indicator values and its associated weighting. In this way, a list with the risky situations could be obtained:

1. Outpatient B: 0.4*(2) + 0.3*(1) + 0.3*(1) = 1.4
2. Outpatient A: 0.4*(0) + 0.3*(0) + 0.3*(4) = 1.2
3. Outpatient C: 0.4*(0) + 0.3*(1) + 0.3*(1) = 0.6

Through an elemental example, it is possible to appreciate the way in which the weightings are defined and incorporated in the indicators jointly with its definition and interpretation. It allows the data stream processing strategy carrying forward the online interpretation by mean of the global indicators, keeping updated in memory the risky situation related to each entity under monitoring. Even, a specific action could be raised when the global indicator exceeds a given threshold.

Nowell, it is interesting to think that the original weighting defined by the experts on each indicator could change depending on the current context related to the entity under monitoring. That is to say when the outpatient is in the home the analysis is absolutely different than when the outpatient is walking on the beach. Thus, the experts in the domain could want to define different weighting depending on the context in which the outpatient is located. Moreover, the DSPS should dynamically alternate the weighting in real-time when the outpatient changes its context (e.g. when he or she walks from her/his home to the beach).

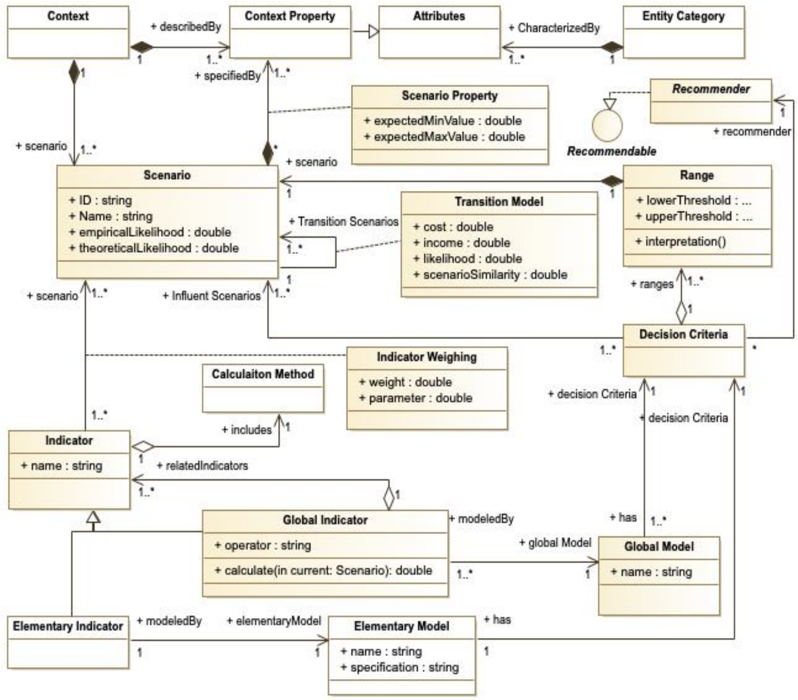

Figure 1: New Concepts and Relationships related to the Scenario Analysis in the Measurement Framework

4. THE MEASUREMENT PROCESS AND SCENARIO CHANGES

The Measurement and Evaluation framework incorporate a way in which the terms, concepts and their associated organization are structured for carrying forward a measurement process. The importance of using a framework is for fostering the repeatability of the measurement process itself (i.e. in case of doing the measurement again the steps to follow and involved concepts will be compatible). This is essential for comparing the results (i.e. measures) between two instants. For example, if it is necessary to monitor along with the time the corporal temperature for the outpatients, the underlying assumption is that the used method and procedure in time "t" and "t+1" will produce comparable measures, with the aim of analyzing the temperature variation. The Data Stream Processing Strategy read the M&E project definition and from there, it will process each received measure guided by the definition itself. Nowell, when some indicator wants to be updated, the project definition should be updated and informed to DSPS for incorporating the new interpretation in the processing. For this reason, it is said that the DSPS is a Metadata-guided architecture because each decision made on the measures is based on the project definition. That is to say, the descriptive data about the monitored concepts (i.e. metadata) allows indicating from the way in which a measure is analyzed (i.e. the associated metric, scale, unit, expected values, etc.) to its interpretation (e.g. Is 38ºC fever?).

4.1 Extending the Measurement Framework

An updating on the measurement framework for incorporating the new terms and relationships necessaries for supporting the scenario analysis are synthesized in Figure 1. The new concepts have their background filled, while the non-modified concepts keep their background with a white color for better contrasting.

The context represents the environment and it is characterized by properties, which are able to affect an entity category (i.e. the general conceptualization related to the concept under analysis). The Scenario represents each state in which the context could be present, indicating the empirical likelihood for this happens (i.e. it is based on the experience) jointly with the theoretical likelihood (i.e. an approximation). Each scenario is characterized by a combined set of *ScenarioProperty*, which allow establishing an expected variation range for each context property in a specific scenario. For example, given a context described by the environmental temperature, environmental humidity, and environmental pressure, a hostile scenario for an outpatient could be defined as a range of [37; +40] for environmental temperature, [60; 100] % for environmental humidity, and [>=1000 millibar] for environmental pressure.

However, the scenarios represented for a parametrized context through its context properties are dynamic, which imply that the transition between scenarios is possible. In effect, along a day we can transit from a hostile scenario in the morning to a "normal" scenario at the night. This is represented through the *TransitionModel* class in Figure 1, which additionally establishes the possibility of applying cost and or income to the transition itself, assign a given likelihood to the transition, and it is possible to calculate the similarity between scenarios considering the origin and the target of the transition.

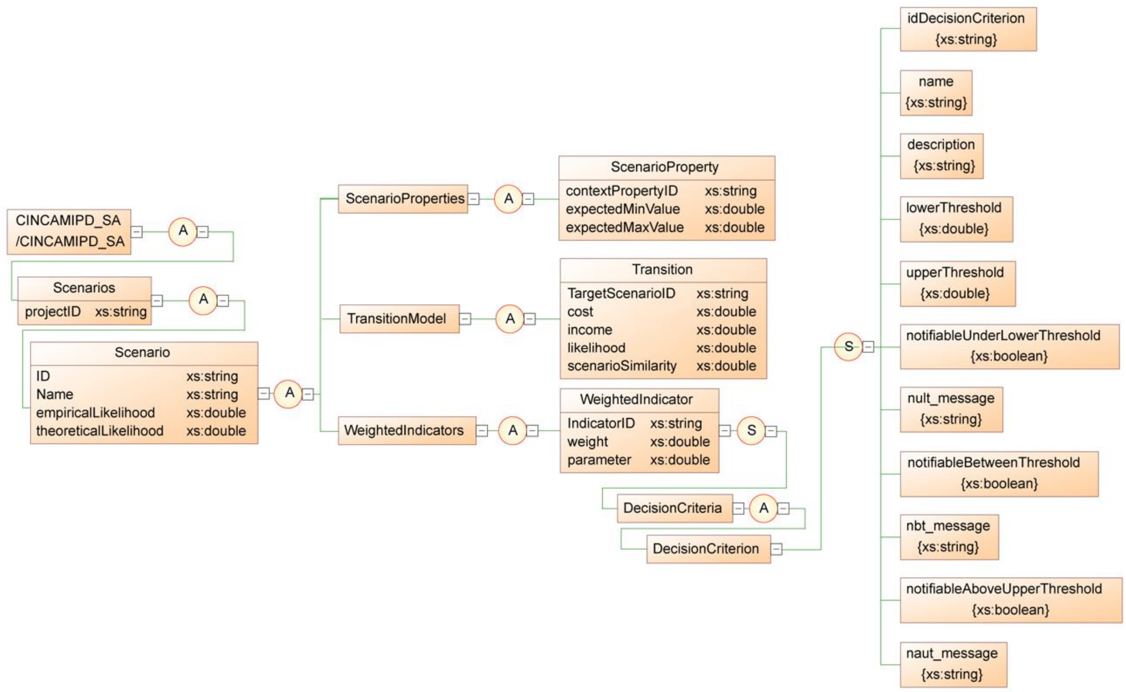

Figure 2: A Complementary Schema for supporting the Scenario Analysis in the Measurement Framework

The interpretation of a given corporal temperature, even with the same value, could be different depending on the current scenario for the entity (e.g. hostile or normal). In this sense, the *Indicator Weighting* class (See Figure 1) allows defining each weighting for the Multi-criteria decision-making method fitted to each defined scenario. Thus, Both the elementary indicator which interprets a set of metrics and the global indicator which establishes the relationship between indicators, will use the decision criteria based on the scenarios. Thus, the decision criteria will analyze each range based on the entity's current scenario before making a decision (See *DecisionCriteria* and *Range* classes in Figure 1). The *DecisionCriteria* class has a *Recommender* class associated which allows implementing the recommending strategy for giving alternatives or courses of actions when some typical situation is detected (e.g. a heart attack in an outpatient). This is especially useful because the processing strategy could send alarms jointly with recommendations. Now, the recommender will take advantage of the scenario specification for being more precise in its searching and for analyzing the associated risks considering the transitions of scenarios.

4.2 Extending the Project Definition: Incorporating the new concepts

The Project Definition Schema (known as CINCAMI/PD) [12] allows interchanging the M&E project definitions between heterogeneous measurement systems with the aim of fostering the interoperability. The data stream processing strategy uses the M&E project definition for guiding the data processing when the associated measures arrive. The conceptual extension introduced for the M&E framework is supported by a complementary schema termed CINCAMIPD/Scenario Analysis, which is based on and share the concepts involved with CINCAMIPD.

Figure 2 synthesizes the complementary schema for CINCAMIPD, termed CINCAMIPD/SA which optionally allows updating the project definition in the processing strategy. That is to say, it would be a two-phase system, the first phase loads the M&E project definition under the CINCAMI/PD schema, being ready the processing architecture for receiving measures. The second phase loads the CINCAMIPD/SA for defining the scenarios and their associated interpretations when it is present. In this sense, an M&E project can be implemented even whether has or has not a specific definition of the involved scenarios, which allows keeping the descendent compatibility.

As it is possible to appreciate in figure 2, the *CINCAMIPD_SA* tag is the highest level in the message, and it could contain a set of *Scenarios* tag, in where each one identifies its corresponding project. Under the *Scenarios* tag a set of *Scenario* tag could be found, indicating the follows attributes: i) *ID*: it identifies the scenario, ii) *Name*: the denomination for the scenario, iii) *empiricalLikelihood*: it indicates the empirical likelihood related to the scenario, and iv) *theoreticalLikelihood*: it defines the theoretical likelihood associated with the scenario.

Under each *Scenario* tag there are present the *ScenarioProperties*, *TransitionModel*, and *WeightedIndicators* tags. The *ScenarioProperties* tag describes each context property jointly with the expected range which allows characterizing each scenario. For that reason, the associated attributes identify the context property (*contextPropertyID* tag) jointly with the expected range (*expectedMinValue* and *expectedMaxValue* tags). The *transitionModel* tag describes the possible transitions considering as the source the Scenario in which this tag is contained. Thus, the targets scenario are defined in each Transition tag which contains the follows attributes: i) *TargetScenarioID*: it identifies the target scenario (i.e. the new scenario to transit), ii) *cost*: it represents an eventual cost by transiting to the new scenario, iii) *income*: it represents an eventual income by transiting to the new scenario, iv) *likelihood*: it defines the associated likelihood with the transition to the new scenario, and v) *scenarioSimilarity*: it is a coefficient which describes the similarity between both scenarios (i.e. target and source). The *WeithedIndicators* tag describes each indicator which is updated incorporating a new interpretation given a scenario definition.

The *WeightedIndicator* tag updates each indicator definition indicating in its attributes i) the indicator to be updated in the original definition (*IndicatorID* tag), ii) the new weight to be considered for the scenario in where it is contained (*weight* tag), iii) the new parameter to be considered for the particular scenario (*parameter* tag). Thus, the indicator updates the decision criteria for supporting a particular interpretation for each scenario. The structure for the DecisionCriteria and DecisionCriterion tags is exactly the same that CINCAMIPD, but in this case, each decision criteria is contextualized based on the associated scenario.

Thus, the CINCAMIPD/SA schema complements to the original project definition, allowing incorporating the scenario analysis in the data stream processing strategy. Now it is possible in DSPS to identify multiple scenarios, jointly with the effect of each change in the decision criteria of the indicators, supporting the multi-criteria decision-making method on different scenarios.

5. A SCENARIO ANALYSIS: THE OUTPATIENT MONITORING

A measurement and evaluation project are aim-driven, for that reason the first aspect to be defined is the information need. In this scenario, the information need could be defined as “Monitor the main vital signals related to the outpatients”, which allows identifying the entity category as “the outpatients”. Each particular outpatient will be considered as an entity (e.g. John).

Based on the experts in the domain (i.e. doctors) the main vital signs for monitoring an outpatient are defined as the corporal temperature, the blood pressure, and the heart rate (i.e. the entity category’s attributes). Synthetically, the corporal temperature would allow detecting indications of infection, the variation of the blood pressure allows detecting hypertension or the abrupt fall of it, and the heart rate would allow detecting activity (e.g. the outpatient is doing exercises) or atypical variations.

Table 3: Scenario definition taking a summer February day in La Pampa (Argentina)

Context Property	Summer		
	Morning	**Afternoon**	**Night**
Environmental Temperature (ºC)	[8; 22]	[22; 30]	[30; 12]
Environmental Humidity (%)	[65; 42]	[42; 26]	[26; 58]
Environmental Pressure (mb)	[1017; 1015]	[1015; 1016]	[1016; 1015]

In addition, the context is defined through the environmental temperature, environmental pressure, and environmental humidity (i.e. the context properties). The individual variation or even the joint variation of these context properties could affect in a direct way to the outpatient. A simple SmartWatch allows implementing the real-time measurement of the entity category’s attributes (e.g. Apple iWatch), while a complementary device ad-hoc incorporates into the SmartWatch the measurement related to the context properties. It is possible to define three Scenarios for the defined context: Summer morning (SM), Summer afternoon (SA), and Summer night (SA) at the province of La Pampa (Argentina). In this case, the context is dependent on geographic location and the epoch of the year. The Scenario definition (Figure 1) consist in indicating the typical variation for each context property. The scenarios are synthesized in Table 3.

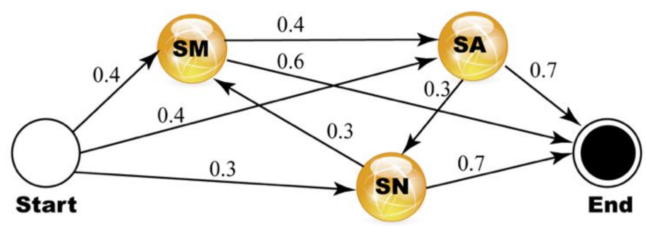

Figure 3: The transition model related to the defined scenarios for the monitoring of outpatients

Given an outpatient, the current scenario is determined using the informed values (i.e. measures) for the context properties involved in the scenario definition. The transition model in this application is analyzed considering the scenarios in which an outpatient could be present, or even to transit to another by permanency (See figure 3). The Start and End states represent the safe conditions for the outpatient (e.g. the outpatient is inside the home). The alternatives to choose by the outpatients are represented as outgoing arrows from each state. The sum of the likelihood related to the outgoing arrows (i.e. the possible decisions) is 1. In this way, an outpatient could reach the state SN in a direct way (i.e. he/she go to dinner outside), or through previous states (e.g. he/she go to make shopping in the afternoon, and next he/she go to dinner with friends). This is important because he/she could transit from the Start or SA states to SN, but no from SM to SN. Figure 3 introduces a simplified transition model limited to this example, but the scenario similarity, cost, and income could be incorporated and used as part of the Multi-criteria decision-making method.

The likelihood associated with the transition between states is very useful for computing the potential and immediate value for the elementary indicator. For example, when the outpatient is in your home (start state), the associated likelihood for going to the SA state, passing through SM, is 0.16 (0.4*0.4) while is 0.3 in a direct way. This is important because even when the current indicator value is known through the computation of the measures and the use of the decision criteria, the likelihood allows to the data stream processing strategy knows the most likely transitions and it is able to evaluate the associated risks for each one. Even more, given the current scenario, it is possible to precompute the scoring related to the most likely immediate scenario for transiting. In the beginning, when the measurement project is initialized, a set of theoretical likelihood such as Figure 3 could be used. Next, the likelihoods can be replaced using the transition frequencies as empirical likelihoods (i.e. feedback based on the processing strategy itself).

Nowell, we can define the indicators and its weighting for each scenario, incorporating specific decision criteria in terms of the current scenario related to the outpatient (Table 4). In other words, the relative importance that each Scenario has for each elementary indicator is represented through a coefficient. Though this is not new, the possibility to extending the M&E framework incorporating the decision criteria as a real-time updatable concept represents an interesting advance for the data stream processing strategy, who is benefited from the ability for instantly adjusting its data interpretation.

Table 4: An example of weighting for the indicators based on the current scenario of the outpatient

Elementary Indicators	**Summer**		
	Morning	**Afternoon**	**Night**
Level of the corporal temperature	0.30	0.25	0.20
Level of the heart rate	0.40	0.50	0.30
Level of the blood pressure	0.30	0.25	0.40

Each elementary indicator could have a value between 1 (No healthy) and 10 (healthy) directly affected by the historical immediate states and its associated transitions which are known (See figure 3). But now, we can define a global indicator termed “Level of the global health” (LGH) which is a weighted sum from the elementary indicators defined in Table 4. This expresses an example in which the weighting of each indicator could vary depending on the current scenario.

$$LGH = w_{ct} * LCT + w_{hr} * LHR + w_{bp} * LBP \quad (1)$$

Where the level of global health (LGH) is obtained as a weighted sum (See the operator attribute in the *GlobalIndicator* class at figure 1) of the level of the corporal temperature (LCT), level of the heart rate (LHR), and level of blood pressure (LBP). Each elementary indicator is weighted through the associated weighting depending on the current scenario. For example, suppose that an outpatient is walking on the street in the afternoon of February in La Pampa (i.e. summer afternoon), the elementary indicators indicate (7, 6, 7) for (LCT, LHR, LBP). The global indicator should send an alarm when it has a value lesser or equal than 6.5. In this way, the reached value by the global indicator is obtained using the formula 1:

$$LGH_{SA} = 0.25 * 7 + 0.5 * 6 + 0.25 * 7 = 6.5 \quad (2)$$

The data stream processing strategy will send an alarm when the indicator value is obtained under the mentioned scenario, because a risk situation by the outpatient was detected in terms of the decision criteria defined by the experts in the domain (See formula 2, LGH is equal to 6.5 in the SA scenario). In addition, the same values for the elementary indicators would give 6.6 and 6 for the SM and SN scenarios respectively. It implies that keeping the constant the values, the alarm would be raised just under the SA and SN scenarios. This represents an advance in the data stream processing strategy because the scenario analysis is possible defining the weighting and decision criteria of the indicators accordingly. Even, the transition model incorporates the possibility of considering likelihoods, cost, income and similarity and its incidence in the elementary indicators for determining its value. Both the scenario definitions, transition model as the updated decision criteria incorporating the weighting are jointly incorporated under the CINCAMIPD/SA schema.

6. CONCLUSION

In this work, an extension for the measurement and evaluation framework related to the data stream processing strategy has been introduced. The scenario was introduced as a concept described from a particular configuration of the context properties. The scenario property describes a characteristic of the scenario under the way of an expected variation range for the values of a context property. Thus, a scenario is defined through a set of expected measures for each context property, for which the experts in the domain consider that have a given incidence.

In addition, and considering that the scenario is a dynamic concept, a transition model based on the defined scenarios is introduced with the aim of modelling the data related to the transition itself. Even more, data such as the income, cost, scenario similarity, among others are able to be used for the scenario and risk analysis. This detail is very useful for determining the most likely target scenarios from a given current scenario, and even for determining the associated risks related to the indicators through the corresponding weighting. Jointly with the extension of the measurement and evaluation framework, a complementary schema for the project definition was incorporated. This new optional schema termed CINCAMIPD/SA allows incorporating together the definition of scenarios, transition model, and the weighting of indicators in each scenario. In this way, the data stream processing strategy could be initialized using the project definition (i.e. CINCAMI/PD message), and once it is initialized, a second message using the CINCAMIPD/SA schema allows incorporating the full definition of scenarios and their associated transitions. This is very useful because allows keeping the descendent compatibility in case of some old project have not the defined scenarios.

The possibility of incorporating the Scenario definition jointly with the transitions as part of the M&E framework allows bringing dynamism to decision criteria used for interpreting the real-time data. Thus, the Data Stream Processing Strategy is benefited from being able to update its interpretation jointly with the decision criteria updating.

Here, a scenario analysis related to outpatient monitoring was introduced with the aim of demonstrating a conceptual practical application of the underlying idea. In this sense, the context jointly with their characterization could be as complex as necessary, which affect in a direct way the decision criteria related to the metrics responsible for the quantification of each characteristic. In this aspect is where the importance of Scenarios takes particular interest considering the data stream processing strategy and its real-time data interpretation for making decisions.

Because the scenario represents in some way the potential states related to a context, the analogous thinking could be applied to the entity. An entity could have a set of associated states, which could have a direct incidence in the weighting of the indicators. As future works, the analysis of entity states jointly with its impact on the decision making inside the measurement framework will be carried forward.

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