# Governing Roles and Responsibilities in a Human-Machine Decision-Making Context: A Governance Framework



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*Abstract*—**Proper decision-making is one of the most important capabilities of an organization. Therefore, it is important to have a clear understanding and overview of the decisions an organization makes. A means to understanding and modeling decisions is the Decision Model and Notation (DMN) standard published by the Object Management Group in 2015. In this standard, it is possible to design and specify how a decision should be taken. However, DMN lacks elements to specify the actors that fulfil different roles in the decision-making process as well as not taking into account the autonomy of machines. In this paper, we re-address and - present our earlier work [1] that focuses on the construction of a framework that takes into account different roles in the decision-making process, and also includes the extent of the autonomy when machines are involved in the decision-making processes. Yet, we extended our previous research with more detailed discussion of the related literature, running cases, and results, which provides a grounded basis from which further research on the governance of (semi) automated decision-making can be conducted. The contributions of this paper are twofold; 1) a framework that combines both autonomy and separation of concerns aspects for decision-making in practice while 2) the proposed theory forms a grounded argument to enrich the current DMN standard.**

***Keywords-Decision-Making; DMN; RAPID; Autonomy.***

## I. INTRODUCTION

In September 2015, the Object Management Group (OMG) released a new standard for modelling decisions and underlying business logic, DMN [2]. In line with the DMN standard, a decision is defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing.*" [3]. Furthermore, business logic is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual decisions."* [2].

Proper decision-making is one of the most important capabilities of an organization [4]. In the previous decades, decision making was a capability only executed by human actors. However, given the technical developments in computer hard- and software, the possibilities to automate decision-making increases. Examples of techniques applied during automated decision making are: business rules systems, expert systems, and neural networks [5]. To achieve proper decision-making, organizations must design and specify their decisions and decision-making processes. One aspect that influences the specification of the decision and the decision-making process is the level of automated decision-making. Machines can execute decisions only when the decision and the underlying business logic is specified formally [6]. Furthermore, when organizations choose to specify their decisions and decision-making processes, the level of detail is of importance. This is based, amongst others, on the type of decision and the actor that executes the decision. For example, a strategic decision needs to be specified on a different level of detail compared to an operational decision and therefore needs a different type of specification and a different decision-making process.

While DMN is mainly applied to express operational decisions that will be automated, it can also be used for manual (strategic) decision-making. In this paper, the focus is on operational decision-making. Yet, the current DMN standard lacks a formal concept to specify a governance structure for each decision. In this context, a governance structure is defined to express the roles and responsibilities relevant to a decision and the underlying decision-making process. This becomes important when a decision is executed by instantiating a decision-making process that features both human and machine actors. Research on specifying a proper governance structure for decision-making already concluded that assigning clear roles and responsibilities are the most important steps in the design and specification of decisions and result in better coordination and quicker response times [3][6].

Another aspect of designing and specifying decisions and decision-making is the use of machine actors instead of human actors. Assigning machine actors to parts of the decision-making process requires organizations to evaluate the autonomy of the machine. Machine autonomy refers to the system's capability to carry out its own tasks and making decisions [8]. As Parasuraman, Sheridan and Wickens [9] stated in their work, the question now is: "*which system functions should be automated, and to what extent?*" For example, when possible, do we want to let a machine decide whether a person should or should not be admitted to enter a given country, based on the premise that the machine is more accurate compared to a human actor in determining the eligibility of a person.

One reason why it is essential to include proper governance structure when designing and specifying decisions and decision-making processes are the increasingly stricter laws and regulations on digital privacy and data regulation, i.e., the Health Insurance Portability and Accountability Act (title II) and the General Data Protection Regulation [10]. Such laws and regulations can prohibit the use of machine actors in decision-making, and when it allows organizations to include them, poses exactly what is allowed and what is not allowed. For example, how exactly personal data is processed, and which roles have access to it. Thus, to design compliant decisions and decision-making, an organization must be able to define exactly what actors are responsible for what, and when a machine is made responsible, how autonomous it will operate.

In literature, studies are conducted that resulted in a model to define, for example, the autonomy of a machine in decision-making [8][10][11]. Moreover, studies are conducted that specify the roles that are used to design decision-making processes between stakeholders [3][12]. However, to the knowledge of the authors, no studies exist that combine both. One notable industry in which roles and, to some extent, responsibilities are explored and made explicit is the medical domain. Examples are [14][15][16], and [17]. However, these are, to the knowledge of the authors, not explored in a human-machine context.

Therefore, in this paper, a model is proposed that includes the roles and responsibilities aspect, taking into account human-machine interaction, while also including the autonomy level of a machine as part of the human-machine interaction in decision-making. To be able to do so, the following research question is addressed: "*How can a governance structure of the decision making process be made explicit?*"

The remainder of this paper is organized as follows. First, a literature overview is presented in section two in which the existing models that define the possible interaction between a human and a machine are explored and compared. This is followed by the construction of the model in section three. Next, in section four, the case to demonstrate and validate the model is described, which is followed by the actual demonstration of the model. Lastly, the conclusions are drawn and we propose directions for future research in section five.

## II. Background and Related Work

The DMN standard consists of two levels; the Decision Requirements Level (DRD) and the Decision Logic Level (DLL). The DRD level consists of four concepts that are used to capture essential information with regards to decisions; 1) the decision, 2) business knowledge, which represents the collection of business logic required to execute the decision, 3) input data, and 4) a knowledge source, which enforces how the decision should be taken by influencing the underlying business logic, see Figure 1. The contents of the DLL level are represented by the business knowledge container in the DRD level. In the current version of DMN, two standard languages are suggested for expressing business logic, FEEL and SFEEL. However, it also allows the use of other, more adopted languages like JavaScript, Groovy, and Python. Still, the language selected to represent the decision logic does not influence the decision requirements level. Analysis of the DMN standard reveals that no formal elements exist to specify roles in the decision-making process. To add to the DMN standard, roles and responsibilities should be taken into account.

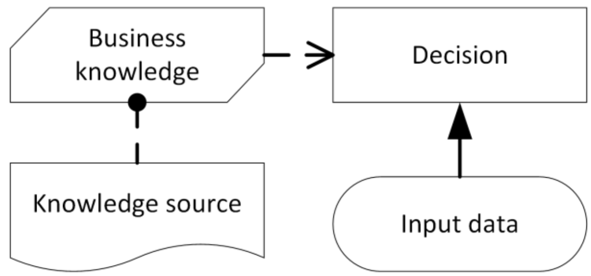


Figure 1. DRD-level elements

### A. Roles and responsibilities in decision-making

In the current body of knowledge, frameworks that define roles and responsibilities in decision-making processes exist. These studies focus on different perspectives in the decision-making process. For example, there are studies that focus on the influences of decision-making roles, i.e., family/collegial pressure and gender or cultural preferences [13][14]. In addition, there are also studies that focus on specific application areas for decision-making, i.e., transportation, medical, financial and governance [15][16]. For example, in a patient-doctor context where a treatment has to be decided, multiple roles are relevant, i.e., the patient, different medical specialists, the doctor, a nurse, and in some cases family members of the patient [21].

Another research stream in decision-making comprises group-based decision-making. Group-based decision-making is explored because the context comprises multiple stakeholders that should be taken into account during decision-making, thus fulfilling roles and having responsibilities during the decision-making process. To the knowledge of the authors, a lot of contributions have been published on group-based decision-making processes, e.g., on group-based decision-making in the utility industry to determine wind farm site locations [22], trip planning as part of the transport industry [23], the allocation of primary health care services [24], group-based R&D project selection [25], and the performance of group-based decision making [26].

However, as the scope of this paper lies on the creation of a framework which can be applied to define the governance structure of any decision, a more generic set of roles and responsibilities is required.

The work of Rogers and Blenko [4] features a generic model titled RAPID, which presents five different roles that are applied during the decision-making process. However, one limitation of the original study is the focus on decisions that are only executed by human actors. To ground our framework construction, a detailed description of the RAPID framework is provided here.

RAPID focuses on assigning a set of specific roles with regards to a decision. This framework is characterized by a simple, yet grounded in practice approach and consists of five different roles and underlying responsibilities that are related to a decision. The first role is ***Recommend***, which is responsible for making a proposal and gathering input for decision-making. This role communicates with the input role to ensure their viewpoints are embedded in the recommendation. The second role is ***Agree***, which is responsible for evaluating a proposal provided by the recommender. This role has veto power over the recommendation. When this role declines a recommendation, a modified proposal has to be made. The third role is ***Input***, which is responsible for providing input (data) to make the decision and are typically consulted on the decision. The opinion of this role is non-binding, but should be taken into account to ensure the decision does not falter during its execution. The fourth role is **Decide**, which is responsible as the formal decision maker and is accountable for the decision and its results. This role has the most authority compared to the other roles as it is able to resolve the decision-making between the previous roles by making the actual decision. By doing so, this role has the power to commit an organization to action based on decision-making. Lastly, the fifth role stands for **Perform**, which is responsible for executing the actual decision of the organization after it is decided by the previous role.

Based on RAPID, Taylor [13], in a professional article, adapted the RAPID model but made a distinction between a human and a machine for decision-making processes in which he stresses that the action component can be different between these two. For example, when a decision must be executed in an organization, human actors perform the actual decision and also handle possible exceptions. When a machine executes decisions, exceptions are filtered out and send to human actors for further examination. Another significant difference between a human and a machine actor is the explicitness of business rules that a machine must be able to execute, and therefore must be maintained adequately versus the implicit knowledge for the decision-making utilized by human actors in the actual decision-making process.

A non-generic framework which originates from the military domain is the Observe, Orient, Decide and Act (OODA) loop [27]. The OODA loop is arguably the basis for decision-making for many succeeding decision-frameworks in the military domain and also shown to influence decision-making processes and frameworks outside of the military domain as well [28][29]. OODA features four activities that represent the roles and responsibilities that should be adhered to in order to make grounded decisions in military situations. The comparison shows that RAPID and OODA show overlap in roles, e.g., decide (identical in both frameworks) and Act (OODA) versus Perform (RAPID). Multiple extensions have been proposed, based on the original OODA framework [30]. These extensions are proposed due to the fact that OODA is considered 1) a very high-level representation with abstract concepts that do not provide the kind of details needed for the OODA loop to be used as an analytical tool for improving decision-making, and 2) It has no representation of the feedback or feed-forward loops needed to effectively model dynamic decision-making [31]. The latter, however, is included in the RAPID framework.

### *B. Autonomy level of stakeholders in human-machine interaction*

Machine autonomy broadly refers to a machine's capability to carry out its own processes and tasks, along with the decision-making needed to do so [8].

With regards to machine autonomy, also referred to as robot autonomy or computer autonomy, many authors added a framework to the body of knowledge that defines autonomy levels. Both general and context-specific frameworks for levels of autonomy (LOA) exist, while some define very detailed levels of autonomy, others utilize autonomy as a concept without exactly defining the spectrum of autonomy [32]. In this paper, the focus is on generic LOA frameworks. Regarding generic LOA frameworks, the work of Sheridan and Verplanck [33] and later Parasuraman, Sheridan and Wickers [9] defined ten levels of autonomy for decision-making with automation (i.e., machines/computers), also abbreviated to LOADAS. Their classification ranks from full human decisions and actions (level 1) until full autonomy without interaction with humans (level 10) and takes into account several variants with alternatives. For example, veto voting by human actors and the level of interaction between a machine and human actor. This LOA framework is, to the knowledge of the authors, the most popular work as it is cited numerous times and used in the construction of many other theoretical and practical constructs. However, the ten LOA levels described in the work of Parasuraman, Sheridan and Wickers [9] are too much prone to interpretation, which can be concluded by how the different authors of subsequent LOA frameworks and related work described this framework. For example, the work of Endsley and Kaber [34] describes that the first of the ten levels is not fully manual as it is handed over to the machine to execute it. This is in contrast with the interpretation and description by Miller and Parasuraman [35], which describes that a human actor is responsible for everything in the decision-making process, including the execution of the decision. A second example of an interpretation that is not specific enough with regards to this framework is the notion of levels one and two in the work of Beer, Fisk and Rogers [8], which states that these two levels are exactly the same. This would mean that the model contains a redundant level.

Endsley and Kaber [11] defined in their work ten categories of the level of automation along with definitions for the level of autonomy for each category, based on earlier work by Endsley [34]. However, the ten levels, which are all activity focused, are grounded by five levels of autonomy defined by Endsley [34], which are: 1) manual support, 2) decision support, 3) consensual AI, 4) monitored AI, and 5) full automation. This framework's strength is its simplistic approach to autonomy, which is also its drawback. Compared to the framework of Parasuraman, Sheridan and Wickers [9], this framework lacks proper detail with regards to the possibilities a machine nowadays has. For example, based on the five levels of autonomy it is based on, it is unclear how recommendations are provided and how the human actor is informed about executing the actual decision or the result of the decision after execution by a machine.

A third generic framework is the Autonomy Levels For Unmanned Systems (ALFUS) [12]. This framework includes increasingly complex environments in which a machine makes decisions and executes actions. The LOA levels included in ALFUS, range from zero (remote control) to ten (full intelligent autonomy). At the lowest LOA, there is 100% interaction between a human and machine actor, while at the $10^{th}$ LOA, almost no interaction between a human and machine actor is present. While ALFUS describes in more detail the amount of interaction between human and machine actors, the composition of this interaction is left implicit as it requires the ALFUS generic framework to be instantiated into program specific ALFUS frameworks [12].

The currently available frameworks very accurately describe what levels of autonomy could be taken into account and how the interaction is possible between human and machine actors. However, as pointed out earlier, the existing frameworks lack the exact separation of tasks and responsibilities in complex human-machine interaction environments. Therefore, in the next section, a framework is proposed that combines both the roles relevant for decision making with the different levels of autonomy possible for machines in human-machine interaction to overcome this gap.

## III. Governance Framework construction

For the construction of our framework that fills the gaps identified in the previous section, two perspectives have to be merged: detailed decision-making roles and detailed LOA's. Regarding the decision-making roles, the RAPID framework [4] is adopted due to its generic nature, thus is applicable in all contexts. Then, with regards to autonomy, the LOADAS framework [8] has been adopted due to the fact that it is utilized by many newer autonomy frameworks. However, the low level of detail and different interpretations of this framework and those that preceded LOADAS were already considered a drawback for the design and specification of decisions and decision-making as discussed in the previous section. Therefore, these theories have been analyzed to identify Situational Factors (SFs) that need to be taken into account for the construction of the governance framework. By doing so, the governance framework adopts all essential constructs from related work on the subject of autonomy. Analysis of the models resulted in five SF's. The five SFs identified from the literature are: 1) type of actor, 2) alternatives, 3) veto, 4) inform, and 5) deadline.

The first SF is the type of actor, see for example "*The **computer** informs the human only if asked*" [9]. Simply stated, when decision-making is defined, a choice has to be made whether this should be performed by a human actor only (variant one), a combination of a human and a machine actor (variant two) or solely by a machine (variant three). The second SF concerns the alternatives and the number of alternatives that are provided by a machine actor to the human actor, see for example "*The computer narrows the selection down to a few **alternatives***" [9]. This SF comprises three possible variants. The machine actor could provide a full list of possible alternatives to the human actor, offering no filtering or selection at all (variant one). In the second variant, the machine actor could provide a selected set of alternatives for evaluation by a human actor. This means that the machine actor already filtered out one or more alternatives. The amount of alternatives in this variant depends on the context of the decision-making, and therefore is not fixed compared to the first and third variant. Lastly, the machine actor could provide one alternative to the human actor, which means that the machine actor performs the complete selection for the human actor, which only has to decide whether to execute the provided alternative or not (variant three). The third SF is veto, which encompasses the time a human actor is provided by the machine actor to activate a veto over the decision-making by the machine actor, see for example "*Allows the human a restricted time to **veto***…" [9]. The amount of time provided by the machine actor to veto depends on the context of the decision-making, which results in two possible variants, decision-making including a veto possibility regardless of the time specified to do so (variant one) or decision-making without the possibility to veto (variant two). The fourth SF comprises the interaction between the human and machine actor regarding the output of the decision-making, see for example "***Informs** the human only if the computer decides to*" [9]. This interaction could entail four possible variants. The first variant requires the machine actor to always inform the human actor with the result of the decision-making by the machine actor. The second variant requires the human actor to file a request for information about the decision-making by the machine actor. The third variant leaves the responsibility to inform the human actor about the decision-making in the hands of the machine actor, which has to decide whether it is necessary. For example, this could be determined by the machine actor based on pre-programmed or self-learned exceptions. The fourth variant is a fully autonomous state regarding decision-making by the machine actor, ignoring the human actor. The fifth SF comprises the maximum amount of time (predetermined or calculated) a role has to execute a certain activity, e.g., the input role gathering and sensing decision-making essential data, which must be completed within a timeframe of 24 hours. This SF must be considered for each step in the decision-making process as a decision can be time-critical for an organization, ranging from a product or service that need to be delivered in a normal timeframe to military [36] or High Frequency Trading (HFT) [37] contexts in which decisions need to be executed within a minute or even a second [36].

Combining the RAPID roles and the five identified SFs a framework is created that supports the detailed design for a governance structure, see Figure 3. In the governance framework, each role involved (five in total) is characterized by five SFs in the decision-making process and should be specified accordingly.

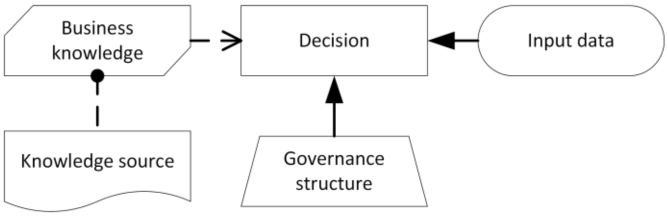


Figure 2. Governance structure to complement DMN 1.1

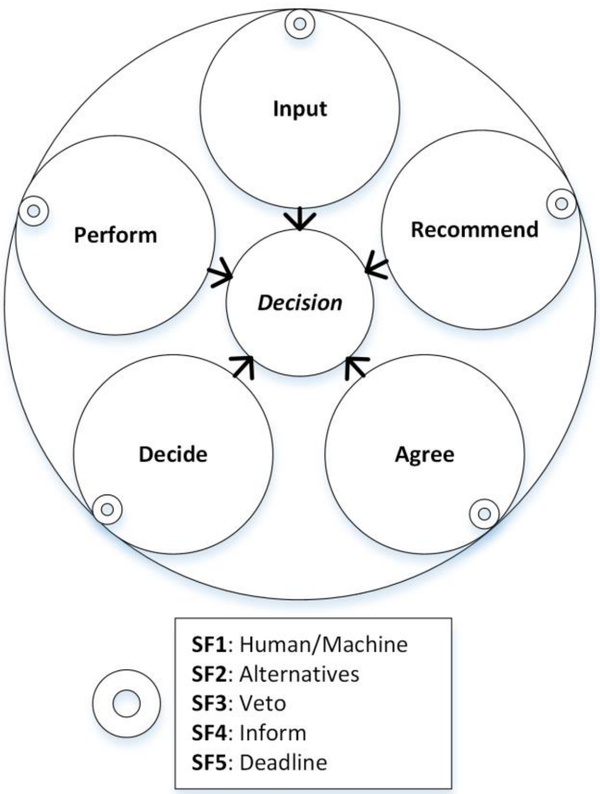


Figure 3. Governance Framework for Decision-making

Based on Figure 3, a governance structure for each decision can be taken into account. Therefore, an additional element to enrich the current DMN standard is proposed, see Figure 2.

## IV. Case Description & Application

The hypothesized application of the framework is demonstrated using three scenarios with three variants each, the first two variants are based on case study data, while the third variant is based upon a real-world situation, but is not an exact real-life organizational interpretation of it (simulation). In the next section, a demonstration on case study data is applied. This allows us to use data from an actual case while fully controlling the execution of the framework and input variables. The selection of the scenario's was based on three criteria: 1) the scenario must be a decision on the operational level, 2) the scenario's must significantly differ from each other in terms of industry/application, and 3) the data must be accessible for the research team.

### A. *Description of scenario*

The first scenario used to demonstrate the framework embodies a governmental institution that is responsible for providing digital services to apply for child benefits, see Figure 4. In this scenario, civilians need to provide information for the governmental institution to be assessed whether the household is eligible to receive child benefits, and when this is the case, the amount of the child benefits and for what period the child benefits can be received. In this scenario, a citizen applies for child benefits, see for example [38].

The second scenario used to demonstrate the framework embodies trading and High-Frequency Trading (HFT). In this context, the focus lies on the decision to buy or sell stocks. To be able to do so, certain criteria need to be taken into account. When humans are involved, HFT is not possible, however, in this scenario, we cover the differences between human and machine decision making roles in the determination to buy/sell stocks, see for example [39].

The third scenario used to demonstrate the framework embodies the usage of drones by a military institution. In this scenario, a drone is utilized to determine whether a target should be terminated or not. This scenario progresses from the full control by human actors towards fully autonomous control by the drone itself, see for example [40].

### B. *Application of the model*

The application of the framework is demonstrated by using three variants per scenario. Each of the variants is characterized by a different composition of roles and corresponding SFs. In the context of this demonstration, three steps are required before the framework can be demonstrated; 1) the decision has to be modelled in DMN. In this context, this means that the DRD for this particular decision has to be established (the decision, its input data, its ruleset and relevant sources), see Figure 1. 2) The governance structure element has to be added to the DRD, connected to the appropriate decision, see Figure 2. Lastly, 3) The roles and SFs need to be specified. An example template to do so is presented in Table I.

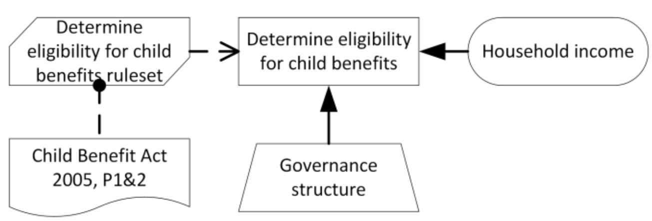


Figure 4. DRD for the decision: determine eligibility for child benefits

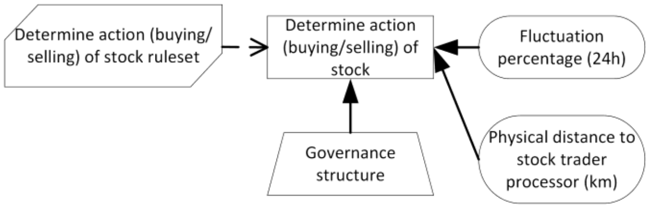


Figure 5. DRD for the decision: Determine action (buying/selling) of stock

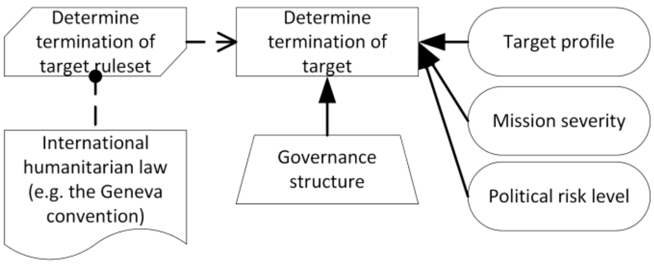


Figure 6. DRD for the decision: Determine termination of target

To demonstrate the usefulness of this template, the governance structure for the scenario in this demonstration is also specified in Table I. For each variant, the design is changed and depicted in a new table.

**Scenario 1: Governmental service context**

*Variant 1: Manual human decision-making*

TABLE I. GOVERNANCE STRUCTURE FOR VARIANT ONE

| | SF1: | SF2: | SF3: | SF4: | SF5: |
|---|---|---|---|---|---|
| **I** | Human (applicant) | N.A. | N.A. | Always | N.A. |
| **R** | Human (template) | N.A. | N.A. | Never | N.A. |
| **A** | Human (manager) | N.A. | N.A. | Never | 7 days |
| **D** | Human (employee) | N.A. | N.A. | Always | 7 days |
| **P** | Human (employee) | N.A. | N.A. | Always | 14 days |

In the first variant, the applicant fills in a paper template and delivers it to the governmental counter (**Input**). Then, the governmental employee assesses the situation by analyzing the information in the template (**Recommend**) and decides for which benefits the household is eligible (**Decide**) based on a discussion about the case with the manager (**Agree**). In practice, it can be the case that one actor fulfils multiple decision-making roles. When the decision is made, the governmental employee enters the outcome into the governmental system (**Perform**). This allows the applicant to, on a monthly basis, pick up the appointed benefits at the governmental counter. Lastly, the applicant is informed by letter regarding the outcome of the decision and is able to make an appeal within two weeks.

The template used contains information about the different benefits available and thus guides the decision-making for both the input and decide roles.

*Variant 2: Machine-supported decision-making*

In this variant, see Table II, the applicant fills in an application template and uploads it to the online governmental portal (**Input**). Then, the governmental employee receives a notification of the system, which also provides a suggestion (**Recommend**) with regards to the eligibility of the application. The governmental employee decides (**Decide)** based on a discussion about the case with the manager **(Agree**), taking into account the suggestion of the system. Next, the system notifies the applicant and transfers the benefits automatically once a month (**Perform**).

In this variant, the machine generates a suggestion and is provided with the result of the decision as it needs to apply machine-learning to increase and maintain the accuracy of suggestions.

TABLE II. GOVERNANCE STRUCTURE FOR VARIANT TWO

| | SF1: | SF2: | SF3: | SF4: | SF5: |
|---|---|---|---|---|---|
| **I** | Human (applicant) | N.A. | None | Always | N.A. |
| **R** | Machine (system) | One | None | Always | 10 seconds |
| **A** | Human (manager) | N.A. | N.A. | Always | 7 days |
| **D** | Human (employee) | N.A. | N.A. | Never | 7 days |
| **P** | Machine (system) | N.A. | None | On request | 1 day |

*Variant 3: Autonomous decision-making*

TABLE III. GOVERNANCE STRUCTURE FOR VARIANT THREE

| | SF1: | SF2: | SF3: | SF4: | SF5: |
|---|---|---|---|---|---|
| **I** | Machine (system) | None | None | Always | 364 days |
| **R** | Machine (system) | None | None | Never | 1 day |
| **A** | Human (citizen) | None | 30 days | Always | 30 days |
| **D** | Machine (system) | None | None | On request | 1 day |
| **P** | Machine (system) | None | None | Always | 1 day |

In this variant, see Table III, the citizen's data (all digitally available) is evaluated on a yearly basis by a machine to determine the eligibility for benefits (**Input**). Based on this, the citizen is informed about the pre-filled applications and is able to veto the data in the pre-filled applications or veto the eligibility in general. For this example, the time to veto is one month (**Agree**). When no veto is cast by the citizen, the system decides to process the relevant benefits (**Recommend & Decide**) and the benefits are automatically transferred once a month (**Perform**).

In the last variant, the citizen is informed about his/her pre-filled and analyzed data on top of the actual confirmation after the benefits are approved after no veto has been cast by the citizen.

**Scenario 2: (High-Frequency-)Trading context**

*Variant 1: Manual human decision-making*

In the first variant, see Table IV, the stock trader collects information by conducting a technical and financial analysis of corporate performance, which is used in determining whether to buy or sell stocks per given portfolio (**Input**). Then, based on a holistic overview of information, experience, and gut feeling, the stock trader aims to buy a large amount of stock of an organization, for which the stock trader contacts the financial office he or she works for to provide a recommendation (**Recommend**). This is required because the financial organizations' policy states that very large buy orders should be verified by a second opinion (human) before being processed (**Agree**). Based on the collected input of the stock trader and the received agree on the decision, the stock trader processes the buy order, but with a reduced order amount of 25% (**Decide**). This is followed by a verification of the stock exchange against certain financial rules of conduct. When the result of this verification process is positive, the stock trader processed the buy order into the system of the financial organization he or she works for (**Perform**).

TABLE IV. GOVERNANCE STRUCTURE FOR VARIANT ONE

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Human (Trader) | N.A. | N.A. | Always | 2 minutes |
| **R** | Human (Trader) | N.A. | N.A. | Always | 2 minutes |
| **A** | Human (Risk Officer) | Three | N.A. | Always | 5 minutes |
| **D** | Human (Trader) | N.A. | N.A. | Always | 5 minutes |
| **P** | Human (Trader) | N.A. | N.A. | Always | 5 minutes |

*Variant 2: Machine-supported decision-making*

In this variant, see Table V, the stock trader is provided technical and financial information from a machine that collects data from multiple in-company and online sources (**Input**). Based on the data collected and provided to the stock trader, the machine also provides a best next action (**Recommend**). By default, this action is processed by the machine after 60 minutes (**Decide**), however, only when no veto is cast by the stock trader (**Agree**). When no veto is cast, the machine processes the buy order into the system of the financial organization (**Perform**).

In this variant, the machine generates a suggestion and is provided with the result of the decision as it needs to apply machine-learning to increase and maintain the accuracy of recommendation.

TABLE V. GOVERNANCE STRUCTURE FOR VARIANT TWO

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Machine (system) | N.A. | None | Always | 1 minutes |
| **R** | Machine (system) | One | None | Always | 5 micro seconds |
| **A** | Human (Trader) | None | 60 minutes | On request | 5 minutes |
| **D** | Machine (system) | None | None | Always | 1 minute |
| **P** | Machine (system) | None | N.A. | On request | 1 micro second |

*Variant 3: Autonomous decision-making*

In this variant, see Table VI, one trading machine collects data (e.g., financial, performance, sentiment) 24/7 (**Input**). Based on the data, the machine considers buy/sell orders per stock in the portfolio. In this variant, another machine, solely focused on calculation tasks, provides predictions that represent recommendations for the algorithm to take into account (**Recommend**). Furthermore, as is usual with HFT, performance is critical for the profit margin, so redundant activities should be prevented as much as possible. However, another machine of the stock trader simultaneously needs to, independently, come to the same conclusion regarding the considered stock in order to execute a buy or sell order (**Agree**). When both machines agree, the order is sent (**Decide**). Because the machine (and its underlying algorithms) is validated for its compliance, the stock exchange does not have to verify the transaction and can instantly process the change of ownership of the given stocks. Then, the machine processes the buy order into the system of the financial organization (**Perform**).

TABLE VI. GOVERNANCE STRUCTURE FOR VARIANT THREE

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Machine 1 (system) | None | None | Never | 1 minute |
| **R** | Machine 2 (system) | One | None | On request | 5 micro seconds |
| **A** | Machine 3 (system) | None | None | Never | 5 micro seconds |
| **D** | Machine 4 (system) | None | None | On request | 1 micro second |
| **P** | Machine (system) | None | None | On request | 1 micro second |

**Scenario 3: Military use of drones context**

*Variant 1: Manual human decision-making*

In the first variant, see Table VII, a human operator fully controls the military drone that is on patrol in a conflict territory, defending certain strategic assets. Human mission specialists provide data that the drone and its human operator requires to operate in the mission area (**Input**). When on patrol, the drone's infrared sensor detects two heat signatures and alerts the human operator, providing two possible scenarios that could be relevant in the given context. Based on the data and sensor readings, the drone provides two recommendations with probability percentages (**Recommend**). The human operator considers the recommendations, assesses the situation via the drone's sensors, and considers to execute a given action (**Agree**). Depending on the situation at hand, the human operator controlling the drone could veto the agree role, e.g., when the context drastically changes in a very short amount of time in combination with human assets that could be at risk. Based on all data relevant to making the decision, the human operator, which is always the highest ranking employee present, decides upon the best next action to proceed (**Decide**), and orders the drone to eliminate the targets (**Perform**).

TABLE VII. GOVERNANCE STRUCTURE FOR VARIANT ONE

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Human (specialist) | N.A. | None | N.A. | 12 hours |
| **R** | Machine (drone) | Two | None | Always | 5 minutes |
| **A** | Human (operator) | N.A. | None | N.A. | 5 minutes |
| **D** | Human (highest rank) | N.A. | None | N.A. | 10 minutes |
| **P** | Machine (drone) | None | None | Always | 1 minute |

*Variant 2: Machine-supported decision-making*

In this variant, see Table VIII, the drone receives input data from mission specialists beforehand, using machine parameters so that the machine can operate autonomously (**Input**). In this variant, the human operator does not control the drone constantly as described in the previous variant. However, the human operator controls the drone only when an alert is generated by the drone indicating a situation that needs human attention. Before the alert is generated, the drone autonomously calculates, based on mission and sensor data, one next best action with a probability percentage (**Recommend**). Then, the human operator consults the highest ranked employee present to ask permission to execute a given action (**Agree**). Based on the previous interaction the human operator approves or rejects the recommended next best action proposed by the drone (**Decide**). The outcome of the decision is executed by the drone, in this case resulting in either returning to patrol pattern, keep monitoring the situation or eliminating the target (**Perform**).

TABLE VIII. GOVERNANCE STRUCTURE FOR VARIANT TWO

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Human (specialist) | N.A. | None | N.A. | 1 hour |
| **R** | Machine (drone) | None | None | Always | 2 minutes |
| **A** | Human (highest rank) | N.A. | None | N.A. | 5 minutes |
| **D** | Human (operator) | N.A | None | N.A. | 1 minute |
| **P** | Machine (drone) | None | None | Always | 1 minute |

*Variant 3: Autonomous decision-making*

In this variant, see Table IX, the drone collects mission parameters and data from different military sources autonomously to assess the mission context (**Input**). The drone's sensors detect suspicious behavior and generates likely scenarios and corresponding recommendations in terms of actions (**Recommend**). Based on these scenarios, several additional data sources are evaluated and a next best action is calculated by the drone. The drone communicates to mission command that it detected suspicious behavior in the mission area and reports upon the derivation towards the next best action and the corresponding actions the drone is going to execute (**Agree**). Then, mission command has three minutes to evaluate the situation and the drone's decision and veto the decision if required (**Decide**). When no veto is cast by the human operators' part of mission control, the drone executes the next best action, returning to the original patrol protocol (**Perform**).

TABLE IX. GOVERNANCE STRUCTURE FOR VARIANT THREE

| | **SF1:** | **SF2:** | **SF3:** | **SF4:** | **SF5:** |
|---|---|---|---|---|---|
| **I** | Machine (drone) | N.A. | None | On request | 1 minute |
| **R** | Machine (drone) | None | None | Always | 1 minute |
| **A** | Human (operator) | N.A. | 3 minutes | N.A. | 3 minutes |
| **D** | Machine (drone) | N.A. | None | Always | 5 seconds |
| **P** | Machine (drone) | None | None | Always | 30 seconds |

The three scenario's each accompanied by three variants provide an overview of a decision-making process, the role distribution between humans and machines, the autonomy of the machine, and SF's that have to be taken into account. The framework can also be applied to guide the creation of a roadmap, as it shows how decision-making processes can be further automated and plan accordingly.

## V. FRAMEWORK VALIDATION

To validate the framework, a qualitative research approach is selected given the first cycle of validation required [41]. Qualitative research aims to capture phenomena and its relationships using rich data sources. Data sources are always real-world context-based, and therefore support the exploration of a phenomenon in its natural context [42]. One widely-accepted qualitative research technique is a focus group.

A focus group is a qualitative face-to-face data collection technique that allows for broad interactions on a topic [43]. It is a more efficient method of data collection than qualitative interviews because, physically, more participants can be involved at a given point in time. Furthermore, utilizing focus groups also allows for cross-participant discussion about a subject to achieve a greater sense of detail about that subject as well as shared decision-making, i.e., validating artifacts [43]. Before a focus group can be executed, a number of factors need to be considered; 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group [43], [44].

(1) For the research team, the goal of the focus group was to validate the framework.

(2) The selection of participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied [42]. In this study, organizations and individuals that deal with (semi)automated decision making processes at a large scale form the phenomenon studied; examples are financial and governmental institutions. To find relevant experts on this topic, the research team requested that the framework could be discussed during the monthly meeting of the Business Rules Management (BRM) expertise forum. This group consists of experts working for different Dutch governmental institutions, namely the Dutch Tax and Customs Administration, Dutch Immigration and Naturalization Service, Netherlands Enterprise Agency, Dutch Employee Insurance Agency, Dutch Education Executive Agency, Ministry of Education, Culture and Science, the Department of Waterways and Public Works, and Dutch Social Security Office. All of such governmental institutions are responsible for executing law and regulations.

(3) In total, six experts were present during the meeting that agreed to participate. Each participant represented one Dutch governmental institution and are all involved in designing semi(automated) decision making. The respondents had following roles: one enterprise architect, two business rules analysts, business rules architect, one business analyst, and one BRM project manager. Each of the participants had at least five years of experience within the domain of decision-making using BRM.

(4) Delbecq and van de Ven [44] and Glaser [45] state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has a Ph.D. in BRM, has conducted seven years of research on the topic, and has facilitated many (similar) focus group meetings before.

(5) The focus group could not be recorded due to confidentiality of the decision-making cases discussed alongside the framework. However, the facilitation made notes regarding a prepared set of questions per participant. The duration of the focus group was approximately one hour.

(6) The focus group had a protocol that consisted of three phases. The first phase comprised the preparation of the participants where they were invited to already study the framework, its concepts and their definitions. The framework's documentation was sent three days in advance to the participants. The second phase comprised the actual focus group in which the following questions where addressed: 1) "*Do you believe that the framework adds value for the governance of decision management?"* 2) "*Are the roles described recognizable?*", 3) "*Are additional roles needed, and why?*", 4) "*Are all SF's recognizable?*", 5) "*Are there SF's that are missing?*", and 6) "*Do you believe that DMN will be enriched using the proposed element?*"

The facilitator started with a short presentation about the framework and its components (i.e., the roles, their responsibilities, and the SF's that need to be taken into account per role). Regarding question one, the participants agreed with each other that the information in the framework needs to be captured, thus are recognizing the need for such an addition for DMN. Note that DMN is becoming an accepted standard, especially in the Dutch governmental. An example mentioned that also shows the need to structure and capability to share decision-making data is the new General Data Protection Regulation [10] which states that automated decisions must be explainable to both regulators, but more importantly to, European civilians. Furthermore, from a theoretical point of view, the participants agreed that a lot of research is conducted and published regarding the design and production of decisions and underlying rules, but lacking contributions regarding the governance of decisions. Then, with regards to question two and three, the participants stated that the roles were recognizable and that none are missing. This was mainly because the participants were aware of a close variant of the RAPID model, the RACI model. However, there was some discussion about the absence of a dedicated role for informing relevant stakeholders, when necessary. When the facilitator explained that the ability to inform is actually a separate SF designed to be taken into account for each role the respondents agreed that it is not an actual role but indeed a situational factor. Furthermore, there was some discussion regarding the labelling of the roles. The main discussion was about the fact that specific roles, e.g., recommend and perform, are formulated as activity names and not real role names. Although three participants identified this as a problem, the other three did not agree and thought the role labels were clear. As we adopted these best practice labels from existing literature, the research team chose to not change the labels as is. Lastly, the participants argued that, depending on the input of a given decision, the stakeholders can differ in practice. The participants discussed the possibility to define multiple governance structures based on the input for the same decision, however, this would lead to (too) much extra administration, i.e., when more than two or three variants need to be defined. This is followed by question four and five. Discussion regarding both questions mainly was about the SF inform. This is due to the fact that informing stakeholders can be done on different levels. The framework does not take this into account. An example is the difference between informing a stakeholder about the outcome of the decision made versus informing about the outcome of the decision made in addition with extra information, for example, information on how the decision is executed, how the decision has been made as well as which data is used in the decision-making process. The participants added that this difference significantly affects how the decision-making process is facilitated by both tooling as well as the stakeholders involved, and should be taken into account as part of the inform SF. Furthermore, regarding the inform role, when multiple stakeholders from different organizations are involved in decision-making, the framework should take into account possible conflicts of interest and provide the possibility to specify how stakeholders are involved. As our current definition of the SF inform does not dictate who to inform and how the actual role/person should be informed. Organizations are free to apply additional localized business rules on the framework, thereby managing conflict of interest. For example, one organization can define inform to only inform customers about the outcome of the decision, while other organizations want to inform their customers on a different level, by communicating the outcome of the decision-making as well as the data and rules utilized. Lastly, one of the participants argued that the deadline SF is not always relevant and should be interchangeable with other SF's. While the other participants disagreed, on this topic the framework allows to change SF's (the example of budget was mentioned by the participant as a replacement for deadline). With regards to question six, the participants agreed that DMN could benefit from the element proposed to support the registration of important governance information about decisions modelled.

One general remark was about the presentation of the governance framework and its contents. Although not in scope of this study, the participants added that the presentation is important for acceptance, as the contents are usually read and utilized by people instead of machines. They argued that the current proposed element for DMN presented in Figure 2 seems simple yet very appropriate.

## VI. Discussion and Conclusion

Since the DMN standard is getting more commonly utilized in practice, more decisions are being modelled explicitly for documentation or automation. However, the current DMN standard does not take into account roles and autonomy regarding decisions and the underlying decision-making process. In this paper, a governance structure framework is being proposed to complement the design and specification of decisions in the DMN standard. To do so, the theoretical constructs of decision-making roles (RAPID) and autonomy levels together with five SFs (LOADAS) are combined to answer the following research question: '*How can a governance structure of the decision making process be made explicit?*'. One could solely consider the currently available models and frameworks (i.e., RAPID and OODA) to answer this question. However, this results to an incomplete assessment of the situation. To illustrate this finding we this base our example on the drone usage by military institutions. When an analysis of this situation is made based on the RAPID model, an overview of the different stakeholders is provided in the decision to assess the use of lethal force. The autonomy of each role is not described. In a normal military operation this is tackled by the normal hierarchy of command. However, machines (killer drones) are increasingly being utilized and their decision power progressively becomes larger. As such drones are designed to analyze and act themselves, without human intervention. So, in the context of the military usage of drones, it is unclear what the drone can decide on its own and whether it should or should not inform human operators, since only the roles and their activity is clear.

The other way around, when solely considering autonomy levels for machines in decision-making (i.e., LOADAS and ALFUS), it is explicit how machines operate in a decision-making process. For example, what responsibilities the drone has with regards to informing human operators after executing lethal force to eliminate targets or the whether a human operator has the possibility to override a decision made by the drone. However, in such a situation it is unclear what roles and responsibilities are involved in the decision-making and how they work together to achieve a certain added value. Thus, for this example, the drone does not know which role is able to veto the decision and therefore the combination adds value

The proposed governance structure framework has been presented using three scenario's each based on three variants. For each variant, the roles, responsibilities and SF's (human-machine, alternatives, veto and inform) are different. These variants demonstrate that various choices in decision-making processes lead to design considerations that should be taken into account. For example, when machines autonomously decide on which benefits are relevant, what is the best method of informing humans in a specific context, or the appropriate timeframe applicable to veto a decision by a human, in a specific context.

The suggested framework has its limitations. The framework is a suggested solution derived from the existing knowledge base in the area of decision management, decision-making and machine autonomy, and thereby the result of a 'generate design alternative' phase [46]. However, we believe that the proposed framework reached a level of maturity such that it can enter a detailed validation phase. In a planned study, a collection of cases will be used to further validate the framework and to further demonstrate its practical usefulness. We note that the framework is widely applicable if every decision-making context can be modelled so that all stakeholders are aware of their roles and responsibilities in a given decision-making context.

Lastly, several future research directions are described, which are based on the theoretical findings as well as the focus group conducted.

The first direction comprises the need for a practical approach when a decision has multiple, i.e., more than three, variants of which the governance structure must be made explicit with the framework. For example, the decision-making to grant a work visa for a county could be very diverse based on the data inserted by the applicant. When an applicant enters that a work visa has been revoked earlier, additional criteria, actors and decision-making factors (such as deadlines or the possibility to veto) are relevant, yet for the same decision. Future research should therefore focus on the incorporation (and how that could be achieved) of multiple layers for the same decision, as the Subject Matter Experts (SME's) suggested that the framework could become difficult to use in practice otherwise.

The second research direction comprises the presentation of the element in DMN (DRD level) as well as the presentation of the governance information in the matrices e.g., in tables IV-VI. Although not in the scope of this research study, the SME's stated that this is an important factor to take into account. This partly overlaps with the previous research direction as the presentation of multiple possible variants of the same decision needs to be presented effectively, according to the SME's. It is therefore likely that the current proposed matrix changes to accommodate effective information transferal.

As this study proposes an addition to enrich the DMN standard, future steps should focus on approaching the OMG to discuss incorporation of governance structures in the next version of the DMN standard. However, before such steps are taken, it is imperative that the framework undergoes more validation rounds to ensure more SME's and even whole organizations endorse the framework. Future research would therefore mean that more SME's are included as well as from industries other than the governmental setting, which was the demarcation of the SME selection for the focus group in this study. Involving different industries for the validation of the framework would probably yield other interesting improvements as well as future research directions.

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