Argumentative Agents for Justifying Decisions in Audit

Ioan Alfred Letia, Adrian Groza and Radu Balaj
Computer Science Department
Technical University of Cluj Napoca, Romania
letia@cs.utcluj.ro
adrian.groza@cs.utcluj.ro
radu.balaj@student.utcluj.ro

***Abstract*—This research focuses on justifications in an audit context. An argumentation framework based on the formal model of justification logic is applied for audit dialogues in the fish industry. Different forms of justifications used in audit like net persuasive evidence, breadth of issues, and framing evidence are formalised in the proposed framework.**

I. Introduction

Statements on Auditing Standards (SAS) provide guidance to external auditors on generally accepted auditing standards (GAAS). For instance, SAS 31 requires the auditors to obtain evidence supporting or attacking the management assertions, whilst SAS 56 forces the auditor to obtain evidence regarding the managent explanations of significant fluctuations. If management is unable to provide an acceptable explanation the auditor should perform additional procedures to investigate those fluctuations further [1].

Auditors use different forms of justifications, depending on context, such as: i) net persuasive evidence, ii) breadth of issues, or iii) evidence framing. Auditors with both high managerial and technical knowledge tend to enumerate more supporting versus attacking justifications and to consider a wider breath of issues, if they know that the reviewers of their reports have dissimilar task preferences. If the preferences of the reviewers are anticipated to be similar, an evidence framing approach would be employed by stressing out the consistent evidence against the inconsistent ones [2]. In many situations, the justifications stressed out by the auditors are intended to persuade the reviewers of the audit report about the appropriateness of the reached conclusions [3]. Auditors receiving corroborating evidence documented the fewest justifications, while those who received inconsistent evidence, or even no evidence at all, needed more justifications [4].

The agent being audited has the obligation to provide supporting evidence regarding its business activity. Auditors determine the appropriate amount of this evidence. There are seven categories of evidence from which the auditor can choose: physical examination, confirmations, documentation, analytical evidence, written representations, mathematical evidence, oral evidence, or electronic evidence. An auditor needs a preponderance of persuasive evidence for each assertion to have a reasonable basis for a conclusion. When a reasonable support exists an unqualified, qualified or adverse opinion will be issued. Otherwise, a disclaimer of opinion will be issued.

Argumentation is an adequate way of resolving contradictions Multi-Agent Systems (MAS) and helps agents to better understand the environment they live in, and the information they rely on. Besides knowing how to argue, argumentative agents need evidence, the building blocks of any argument. The justification logic that we employ here is aimed specifically at evidence, or justifications, by enabling agents to constantly ask for, challenge, and evaluate proofs. During the process of auditing, two or more parties exchange justifications or explanations, detailing that different norms are complied with or not.

The remaining of this paper is structured as follows: Section II introduces distributed justification logic and the argumentation framework built on top of it. Section III details the system architecture and norms representation. Sections IV and V illustrate the arguments conveyed during the quality audit and within the work-papers, respectively. Finally, related work is presented and conclusions are drawn.

II. Arguing in Distributed Justification Logic

A. Distributed Justification Logic

Justification logic provides an evidence-based foundation for the logic of knowledge [5], where "F is known" is replaced by "F has an adequate justification". Even in its infancy, justification logic seems the adequate technical instrumentation to respond to the observations raised by Walton [6] regarding the use of knowledge in argumentation. The notation $t : F$ means "F has justification t", while the notation $t_i : F$ is used in the multi-agent version of justification logic to mean that "agent i has justification t for believing F is true". The distributed justification logic [7] (DJL) is exploited in our approach.

Definition 1: The language $\mathcal{L}$ contains proof terms $t \in \mathcal{T}$ and formulas $\varphi \in \mathcal{F}$

$$t ::= \quad c \mid x \mid t \bullet t \mid t + t \mid !_i t \mid ?_i t \mid t \succ t$$
$$\varphi ::= \quad \gamma \mid \varphi \star \varphi \mid \neg\varphi \mid t :_i \varphi$$

978-1-4577-1481-8/11/$26.00 ©2011 IEEE

A_0 : classical propositional axioms
$A'_1 : t :_\varepsilon F \to F$ (e-reflexivity)
$A'_2 : s :_i (F \to G) \to (t :_j F \to (s \bullet t) :_k G)$ (distributed application)
$A'_4 : t :_i F \to !^j t :_i (t :_i F)$ (positive proof checker)
$A'_5 : \neg t :_i F \to ?^j t :_i (\neg t :_i F)$ (negative proof checker)
$A'_6 : s :_i F \wedge t :_j F \to (s+t) :_i F, s+t \succ t$ (accrual)
$A'_7 : F \to t :_i F$ (internalisation)
$C_1 : r :_j (t :_i F \wedge s :_i \neg F)$ (justified inconsistency)
$C_2 : F : s :_i \to (s+t) :_i F$
$C_3 : t :_i F \to t :_j F$ (transferring evidence)

Fig. 1. The axioms of distributed justification logic.

The axioms in figure 1 have the following informal semantics: According to $e-reflexivity$, if all the agents in the system have a justification for F, only then F is taken to be a fact. Based on axiom A'_2, an agent k can create its own compound justification $s \bullet t$ based on evidence t brought by agent j and the implication $F \to G$ validated by agent j based on the piece of evidence s. A'_4 allows the agent i's justification t for the sentence F to be verified by another agent j. When $j = i$ positive introspection occurs. If agent i does not accept t as sufficient for proving F, agent j can request a justification for this preference (axiom A'_5). According to A'_6, if two agents i and j have different justifications for proving F, then the union of two pieces of evidence $(s + t)$ represents stronger evidence for F, where $\succ$ represents a preference order relation over justifications. The internalisation axiom says that if formula F is true, then at least one agent i has accepted it as fact, based on evidence t. From the argumentation viewpoint, every argument should have a justification in order to be supported. Consequently, self defending arguments are not allowed in distributed justification logic.

B. Argumentation Framework

Agents can communicate their justifications, allowing for complex scenarios. For instance, the C_1 patterns says that agent j has evidence r that justifies agent's i inconsistency. In the C_2 communicative pattern, the evidence t is not strong enough to convince agent i that his evidence s is not sufficient to prove F: $r :_j (t :_i F \wedge s :_i \neg F)$. Here, the agent i is inconsistent because it has accepted two pieces of evidence supporting opposite conclusions. For the C_3 case, the agent j accepts agent's i evidence, thus accepting formula F.

An argument A is consistent with respect to an evidence t if A does not contradict any evidence in t. We say that a piece of evidence t does not defeat evidence s of an agent i if $s :_i F \to (s + t) :_i F$.

Definition 2 (Undercutting defeater): The evidence t is an undercutting defeater for F justified by s if the joint evidence $s + t$ does not support F any more. Formally: $s :_i F \to \neg(s + t) :_i F$

Corollary 1 (Justified undercutting defeater): Note that the undercutting defeater is an implication, which is a formula in justified logic. So, based on the internalisation axiom A'_7, it should have a justification: $q :_i [s :_i F \to \neg(s + t) :_i F]$. Informally, q is agent's i justification why the piece of evidence t attacks evidence s in the context of F formula.

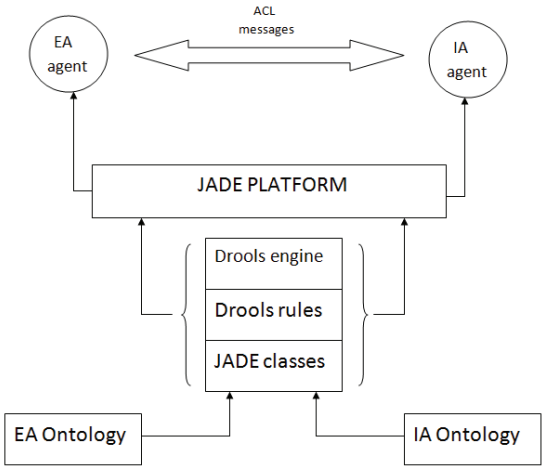

Fig. 2. System architecture.

Definition 3 (Rebutting defeater): The evidence t is a rebutting defeater for F if it is accepted as a justification for $\neg F$.

III. Verifying Norm Compliance

The definition of audit that is of interest to us regards the evaluation of a process or product, commonly known as quality audit. According to the ISO 10011-1:1990 standard, a quality auditor is responsible of determining if a process complies with regulatory requirements and it is in conformity to recognised quality standards.

The scenario is taken from the food industry, where the level of scrutiny has increased impressively. Not only does it matter if the final product is suitable for human consumption, but also the processes involved in production. The running scenario considers an external quality auditor e, who is responsible for the legal monitoring of norms, and an internal auditor i who provides specific evidence supporting the conformance of the business entity with the active norms. After the quality audit, the external auditor prepares his working papers, which are usually double checked by a reviewer.

A. System Architecture

Figure 2 illustrates the top view architecture of the system. The ontologies of both agents are created in Protege and using the OntologyBeanGenerator plug-in, these ontologies were exported as Java classes for use within the JADE environment. Drools tool is used to develop rules according to the justification logic model (figure 4). Agents are developed in JADE and use ACL messages to communicate their justifications.

Drools is a Business Logic integration platform that allows for creating complex business processes, and executing them [8]. It includes a rule engine, Drools Expert,

```
rule "Temperature6_eviscerated"
    when
        v : Vessel ( tuna_size > 9, storing_temperature6 > 4.4, temp_check == 1, eviscerated == true)
    then
        v.setTemp_check(2);
        update(v);
        System.out.println("Norm temperature at 6hrs for eviscerated fish is violated!");
end
rule "Temperature6_not_eviscerated"
    when
        v : Vessel ( tuna_size > 9, storing_temperature6 > 10, temp_check == 2, eviscerated == false)
    then
        v.setTemp_check(3);
        update(v);
        System.out.println("Norm temperature at 6hrs for eviscerated fish is violated!");
end
rule "Temperature9"
dialect "mvel"
    when
        v : Vessel (tuna_size < 9, storing_temperature9 > 10, temp_check == 3, eviscerated == false)
    then
        modify(v) {
        temp_check = 4;}
        System.out.println("Norm temperature at 9hrs is violated!");
end
rule "Temperature12"
    when
        Vessel (tuna_size < 9, storing_temperature12 > 4.4, temp_check == 4, eviscerated == false)
    then
        System.out.println("Norm temperature at 12hrs is violated!");
end
```

Fig. 4. Drools rules for 'StoringNorms' component

and a language for describing rules. Drools comes with its own graphical representation of a process, similar to BPMN, but the user is left with the option of creating an equivalent BPMN visualisation.

In the fish industry, business processes present specific tasks that show how different business entities work together in order to provide the customer with the needed services. Norms represent food safety regulations that are imposed in order to make sure that the final product is, suitable for human consumption. Norms are represented as rules in Drools, aiming to automatically verified when a business process is executing. One advantage of using rules is the ability to dynamically change them at runtime and separate data and business logic. In figure 3, a business process is modeled that deals with fishing of tuna, the storage on vessel and unloading of fishery products on land.

Norms are identified by RuleFlowGroups like *Location*, *Storing*, or *Unloading* norms. The system checks whether or not a norm was complied with while the process is still executing. That is, the norms for storing fishery products are verified right after the step of storing is executed, and before the norms on unloading are verified. The active norms regarding the storage constraints are exemplified in figure 4. A rule in Drools can be written either in a Java dialect (the default approach), either in "mvel" (see rule "Temperature9" in figure 4).

After the execution of the process, a log file is generated, comprising of the data gathered during the execution, and the norms that failed. This allows the auditor to evaluate the process at any time and in case a norm was breached, it starts the communication with the internal auditor. Table I captures specific values regarding the storing temperature for tuna fish on vessel, values that are used in the next sections to provide an adequate debate scenario.

B. Agents background knowledge

Figure 5 presents a partial tree view of EA's ontology. At the top of ontologies is the class Concept which is

Tuna size(Kg)	On-board preparation	Time constraints (hours)	Temperature constraints(°C)
<9	none	≤ 9	≤ 10
<9	none	≤ 12	≤ 4.4
≥ 9	evisceration	≤ 6	≤ 4.4
≥ 9	none	≤ 6	≤ 10

TABLE I
TEMPERATURE REGULATIONS FOR ON-BOARD STORING OF FRESH TUNA FISH.

the class that should be sub-classed in order for OntologyBeanGenerator to properly create corresponding Java classes. On the second level of the ontology tree, there are the classes that represent the norms. The exception is Tuna, which is part of all norms, but since you can not subclass multiple classes, it is conceptually linked to norms through class properties (e.g. Tuna hasStorageTemperature StorageTemperature). From the third level on, more detailed norm concepts are presented.

The classes and properties are instantiated, which completes the knowledge base of an agent with specific data that can be used in the argumentation process (instances are extracted from the ontology through the Protege API). Agent EA captures in his ontology the right values regarding the norms he is monitoring, while agent IA has slightly different values to allow the possibility of a debate.

C. Communication protocol

The agents modeled in JADE implement the AchieveRE (Achieve Rational Effect) communication protocol, a FIPA compliant protocol. The EA agent implements the AchieveREInitiator role, because he is the one who initiates the dialogue once a norm in the business process is breached, by informing the other agent of the fact that a norm was violated. Consequently, the IA agent implements the AchieveREResponder role.

Firstly, the EA agent sends an inform ACL message that specifies the norm being violated, in the presented scenario, we can call it $TemperatureNorm$. Upon receiving the message, the IA agent searches in his ontology for a concept named $TemperatureNorm$. In case the concept is not in the ontology, IA sends back a not-understood response. This evidentiates the role of ontologies in sharing common knowledge for agents: if the IA agent has no concepts related to a norm, even if EA does, he can not effectively communicate. There is another undesired response called refuse, in which agent IA refuses to take part in the communicative act. Refuse takes into account the autonomous nature of agents, which are free to refuse to perform an action if they want. Both responses, not-understood and refuse, are undesired for the IA agent because in both cases EA overrules him, EA being the greater legal authority to whom IA must respond to. A third possible response is $failure$, in case the agent fails to perform an action. Since an action in the system is the act of argumentation (evaluating different rules and

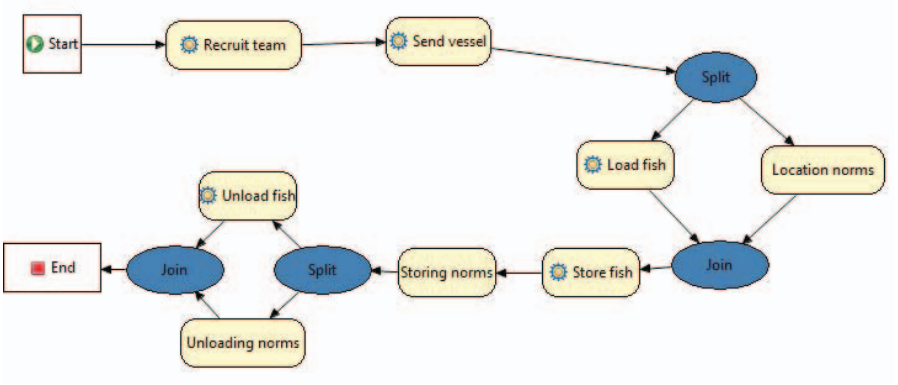

Fig. 3. Interleaving norms and processes in Drools.

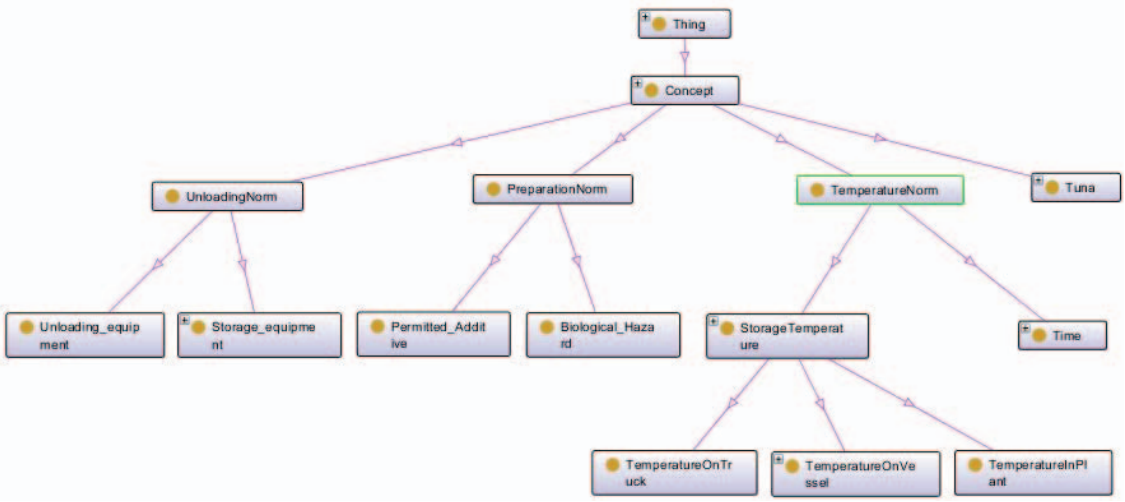

Fig. 5. Ontology tree view.

responding appropriately), *failure* is likely to occur unless there is a Java exception thrown. The fourth possibility is the *agree* response, as in the agent agrees to take part in the debate and performs his action.

Once the exchange of arguments starts, both agents can ask for justifications or give justifications for their conclusions. Asking for a justification from the other agent corresponds to axiom A'_4 : (positive proof-checker) from figure 1. Axiom A'_5 : presented in the same figure corresponds to justifying why the response given is not sufficient to prove the other agent's formula.

The figure 6 bears out the action an agent performs when a message is received. Note that * signals a line that only the agent EA can perform.

IV. Technical Audit

Each agent has a knowledge base represented by an ontology. The axioms in the ontology refer to elements of business processes that are essential to the normative side of the business process like the temperature the fish have to be stored at different times and locations like fishing vessels transportation trucks or in-plant (see table II), the adequate equipment that has to be used while handling fishery products or the chemicals involved in the preparation of fish.

Agents have different, yet similar ontologies in order to make disagreement possible, not to mention that different knowledge bases for different agents is the case in real-life scenarios. Still, ontologies have to entail the same concepts so the agents can communicate effectively with one another. What can differ are the instances of classes, the attributes and relations. Table II presents a simple example for each of these.

Normally, the external auditor agent has the right knowledge about the norms he is monitoring. That does not make him prevail the entire debate by default, the internal audit can still find loopholes in order to overrule his opposition. The external auditor has also access to information regarding the execution of the process he is monitoring. This is not part of his ontology, but provided by the system at time of execution of a business process.

The dialogue goes like this: first of all, the external auditor e informs the internal auditor i that a specific norm was violated (figure 7). The i then asks for a justification; the e

```
if message == "Give justification for F" then
   Extract ontology instances
   *Extract business process data
   Reply with justification
end if
if message == "Give more information for norm N" then
   Reply with information from ontology or
   *business process data
end if
if message == "Here is my justification for F" then
   Search own knowledge base for the terms in justifications
end if
if received information == own information then
   Search knowledge base for other concepts related to norm N

   if no additional information then
      Reply "I give up!"
   else
      Apply axiom A'5 on the new information
      Send reply "Here is my justification F"
   end if
else
   Apply axiom A'5
   Send reply "Here is my justification ∄F"
end if
if message == "I give up!" then
   stop
end if
```

Fig. 6. Agent action upon receiving a message.

Ontology component	Component details	External auditor	Internal auditor
Class instance	Instance for class PermittedAdditive	VitaminC	CalciumOxide
Class attribute	Temperature value at 6 hours after catch for on board eviscerated tuna	4.4°C	5.3°C
Class property	$TunaFish \sqsubseteq \forall hasBiologicalHazard.$	Bacteria	Pathogens

TABLE II
KNOWLEDGE AND EXPERTISE DIFFERS AMONG AUDITORS.

(1) e: The norm on temperature was violated
(2) i: Why do you say the norm was violated?
(3) e: The fish were stored at 5 degrees, instead of 4.4 as regulated.
(4) i: But 5.3 is the right temperature, therefore the process is compliant. Do you refer to the temperature storage on vessel, not in-plant?
(5) e: Yes, the norm in question is referring to the temperature on vessel.
(6) i: At what time the temperature was recorded?
(7) e: 5 hours after storing the tuna.
(8) i: I know that at 9 hours, the temperature has to be under 10°C only. Since tuna was stored at 5°C at 6 hours, the norm wasn't breached.
(9) e: I refute your justification: the tuna was eviscerated on board, which requires a storage temperature of 4.4°C in 6 hours.

Fig. 7. Requesting explanations during the technical audit.

(1) $T3\_breached \rightarrow t :_e T3\_breached$
(2) $!^i t :_e t :_e T3\_breached$
(3) $(regulated.LessThan\_4.4) \wedge recorded\_temp.5) :_e T3\_breached$
(4) $recorded\_temp.5 :_i \neg T3\_breached$
(7) $recorded\_Time.5hours :_e T3\_breached$
(8) $rule\_temp9 \bullet (recorded\_Time.6hours \wedge recorded\_temp.5) :_i \neg T3\_breached$
(9) $eviscerated : \neg[rule\_temp9 \bullet (recorded\_Time.6hours \wedge recorded\_temp.5)] :_e$
(10) $\neg T3\_breached$

Fig. 8. Conveying arguments in distributed justification logic.

agent justifies this by referring to the evidence available to him from his ontology and from the data collected during process execution. The i can either accept the information, offer a justification of why he thinks the information does not make the e's case, or ask for more information. The communication ends when the auditor considers he has gathered enough evidence and explanations to prepare his reports and when the internal auditor has run out of justifications that can save his case.

The internal auditor finally runs out of justifications or information requests that can save him, therefore the external auditor, having justified his formula ($NormViolated$), wins the debate. A scenario where i could overrule would be one that stops at step (8): the e takes into consideration i's justification, verifies its validity with his information about how the process was executed and his ontology, and accepts agent i explanations. In this case, the information about the storing temperature checks out with his own ontology, and the fish were not eviscerated on board according to the information about the executed process.

The dialogue is modeled according to the formal justification logic in figure 8. By conveying that the norm $T3$ was breached, according to axiom A'_7, the auditor e should have a justification for its statement (1). This explanation is requested by the internal auditor i (2). Two pieces of evidence saying that the recorded temperature points towards the value 5^0C, while the acceptable temperature should be below 4.4. According to i's ontology, the evidence $recorded\_temp.5$ represents a rebutting defeater for the conclusion in hand (4). Entymemes are present in this dialogue: the justification $regulated\_temp.LessThen4.4$ is not explicitly expressed by the agent i in the defeater above. Similarly, the dialogue so far has refered to the storage temperature. At the technical level, the agents are aware of two types of temperatures $VesselStorageTemp \sqsubseteq StorageTemp$, respectivily $PlantStorageTemp \sqsubseteq StorageTemp$. In (8) the norm $temp9$ in Drools is mentioned as a justification by applying the given premises. In (9) the external auditor concludes that given the fact that tuna was eviscerated on board, the provided explanations by the other party are not strong enough to support the not breach conclusion.

Preparers' Conclusion	Pro arguments	Con arguments
Require Additional Allowance for Doubtful Debts	Comparing the ageing report of 1999 and 2000, 2000 sees an increase in the debts between 0-90 days.	Hired two experienced "credit agents" to monitor collectability.
Footnote Disclosure is Sufficient	Client has implemented additional controls to deal with the change in credit policy.	The credential of new debtors has decreased since they are smaller companies with lower credit ratings. Thus, risk of unrecoverability increases correspondingly.

TABLE III
NET PERSUASIVE EVIDENCE.

V. JUSTIFYING WORKING PAPERS

After performing the technical audit, the auditor should prepare the working papers. The information within represents the main record of the work of the auditor has done, the conclusions that he has reached, and their justifications (SAS 41). These justifications should be sufficient and appropriate to support a documented conclusion (SAS 96).

The doubtful debts scenario is adapted from [2], in which a business agent requests an increasing of its credit line to its partner bank. Consider that the fish processing business entity has been the client of the audit firm for the past five years. Aiming at meeting its sales target, during the second quarter of the past year, the company has adopted a more liberal credit policy. Two experienced "credit agents" have been hired in order to manage the newly introduced risk. The financial representative of the company considers that no additional allowance for doubtful debts is needed and that a detailed footnote on the above matter suffices in case of need. By requesting additional financing to meet its operational needs, the bank performs an audit of the financial statements to decide between allowing a footnote disclosure or asking for additional allowance. An audit manager reviews the memos produced by the auditors.

The 3 specific forms of justifications (net persuasive evidence, breadth of issues, and framing evidence) are formalised in DJL. When net persuasive evidence is chosen, arguments both supporting and attacking the possible decisions are enumerated (table III). The corresponding theory in distributed justification logic is illustrated in figure 9, where the only agent, the auditor, is no longer figured. The formula 4 here says that because the *smaller_companies* implies *lower_credit_ratings* and new debtors are indeed small companies, by applied the application operator, this is an argument for the decreasing of credential of new debtors, which in turn, further justifies the increased risk. The increased risk term is an acceptable rebutting defeater against the decision of footnote disclosure.

In the breadth of issues justification strategy, arguments from different areas are aggregated to support a specific consequent (table IV). The accrual operator is exploited

1 $(debts\_2010 > debts\_2009) : additional\_allowance$
2 $(two\_experienced\_credit\_agents) : \neg additional\_allowance$
3 $(additional\_intern\_control) : footnote\_disclosure$
4 $[(smaller\_companies \Rightarrow lower\_credit\_ratings) \wedge$
$new\_debtors\_are\_small\_companies)] :$
$credential\_of\_new\_debtors\_decreased :$
$risk\_of\_unrecoverability\_increases : \neg footnote\_disclosure$

Fig. 9. Net Persuasive Evidence in Justification Logic

Internal control	Company hired two experienced "credit agents" whose task is to monitor accounts receivable collections
Financial statement analysis	Company's ageing accounts receivable for 91-120 days and greater than 120 days has decreased (2%)
Materiality	Sales made to new customers were not material to the total sales for the year
GAAP	Based on the principle of prudence, suggest additional allowance
Client-related factors	Historically a good client for the last 5 years, hence, may have comfort with management representation
Industry-related factors	Volatile nature of the industry.

TABLE IV
BREADTH OF ISSUES.

to formalise this, as figure 10 bears out.

In case of framing evidence approach, the justifications are composed differently in order to stronger support one decision or the other, exemplified in table V. The corresponding formalisation is depicted in figure 11.

VI. DISCUSSION AND RELATED WORK

Recent work in Multi-Agent Systems concerns different communication protocols and strategies that enable agents to negotiate and argue. Research, such as that presented in [9] and [10], uses argumentation as a form of negotiation for reaching the desired outcome, while [11] introduces value-based argumentation for justifying compliance to specific regulated norms. Norms are seen as a form of constraining agent behaviour in [12], where argumentation is used to reason about the norms one should or one may not comply with.

One common approach is inspection using HACCP (Hazard Analysis and Critical Control Points) plans [13], which addresses different potential hazards during production which may include physical, chemical, or biological

Preparers' Conclusion	Framing evidence
Require Additional Allowance for Doubtful Debts	The company is very confident about its new strategy and feels that no additional accrual is necessary and merely a footnote is enough. However, based on the principle of prudence suggest additional allowance.
Footnote Disclosure is Sufficient	Although management adopted a more liberal credit policy by selling to smaller companies with lower credit ratings, management hired experienced credit agents to monitor accounts receivable collections, and as such, no additional provision is required

TABLE V
FRAMING EVIDENCE TO BE CONSISTENT WITH THE CONCLUSION.

$[two\_credit\_agents + aging\_account\_decreasing + (\neg material\_sales) + (prudence \Rightarrow additional\_allowance) + (credible\_client \Rightarrow confort\_with\_management \bullet credible\_client)] : additional\_allowance$

Fig. 10. Breath of Issues in Justification Logic.

$(principle\_of\_prudence : additional\_allowance) : \neg(company\_confidence \wedge \neg additional\_accrual \wedge \neg footnote\_enough) : footnote\_disclosure[(two\_credit\_agents \Rightarrow \neg additional) \bullet two\_credit\_agents] : \neg[(smaller\_company \Rightarrow lower\_credit\_rating) \bullet smaller\_company \bullet (lower\_credit\_rating \Rightarrow liberal\_credit\_policy)] : \neg footnote\_disclosure$

Fig. 11. Framing Evidence in Justification Logic.

hazards. The approach presented in this paper is similar to a HACCP audit: business processes are, at their critical points, comprised of sets of rules that verify whether or not different norms at different stages of the process are being complied with. Each decision in an HACCP plan should be justified. Similarly, the auditors should include in their workpapers adequate justifications supporting the conclusion.

Since in justification logic, an agent is able to justify evidence for its own, it is quite obvious that collaborating evidence translates to "no need for justification from the other side". That is not the case when the external auditor receives inconsistent evidence though: he needs a justification of why he should believe the evidence provided by the internal audit.

Another issue that occurs during an argumentative dispute is that of standards of proof. Considering the nature of our application, which entails a legal dispute, both agents have the same standard of proof. That is because they both have to subscribe to an external standard (both being auditors), provided as a benchmark by legal entities [14]. Distribute justification logic allows to model different standard of proofs for each agent: $t :_i F \wedge \neg t_j : F$. Here, the same evidence t is accepted by the agent i to justify F, but it not strong enough for the agent j viewpoint to accept F.

Business processes are a collection of tasks that produce a specific service or product. They ensure that each business entity knows what they have to do, and what inputs and outputs they work with. Business processes are modeled as flowcharts, which makes them suitable for computer-based representation. The most common approaches include the BPMN (Business Process Modeling Notation) standard [15], process ontologies [16], Petri nets [17] and even UML activity diagrams [18]. In this study, the Drools tool was used for checking the norm compliance.

VII. Conclusion

Given the short history of justification logic and its theoretically roots, there is a lack of running scenarios modeled using justification logic. Our study presents such a practical scenario in the auditing domain, advocating that the expressivity of justification logic [19], [20] is adequate for modelling types of justification occurring in a common audit processes, such as net persuasive evidence, breath of issues, or framing evidence.

Acknowledgment

We are grateful to the anonymous reviewers for their useful comments. This work was supported by the grant ID 160/672 from the National Research Council of Romanian Ministry of Education and Research: ARGNET - Support System for Structured Argumentation in the Web Context, and POSDRU/89/1.5/S/62557/EXCEL.

References

[1] A. I. of Certified Public Accountants. Auditing Standards Executive Committee, "Analytical review procedures," 1978.

[2] P. G. Shankar and H.-T. Tan, "Determinants of audit preparers' workpaper justifications," Nanyang Technological University, Tech. Rep., 2005.

[3] J. S. Rich, I. Solomon, and K. T. Trotman, "The audit review process: A characterization from the persuasion perspective," *Accounting, Organizations and Society*, vol. 22, no. 5, pp. 481–505, July 1997.

[4] G. M. Lisa Koonce, Urton Anderson, "Justification of decisions in auditing," *Journal of Accounting Research*, vol. 33, pp. 369–384, 1995.

[5] S. N. Artëmov, "Justification logic," in *JELIA*, 2008, pp. 1–4.

[6] D. Walton and D. M. Godden, "Redefining knowledge in a way suitable for argumentation theory," in *Dissensus and the Search for Common Ground*, H. Hansen, Ed., 2007, pp. 1–13.

[7] I. A. Letia and A. Groza, "Arguing with justifications between collaborating agents," in *Argumentation in Multi-Agent Systems*, Taipei, Taiwan, 2011.

[8] P. Browne, *JBoss Drools Business Rules*. Packt Publishing, 2009.

[9] T. Skylogiannis, G. Antoniou, N. Bassiliades, and G. Governatori, "Dr-negotiate - a system for automated agent negotiation with defeasible logic-based strategies," in *Proceedings of the 2005 IEEE International Conference on e-Technology, e-Commerce and e-Service (EEE'05) on e-Technology, e-Commerce and e-Service*, ser. EEE '05. Washington, DC, USA: IEEE Computer Society, 2005, pp. 44–49. [Online]. Available: http://dx.doi.org/10.1109/EEE.2005.61

[10] S.-L. Huang and C.-Y. Lin, "The search for potentially interesting products in an e-marketplace: An agent-to-agent argumentation approach," *Expert Syst. Appl.*, vol. 37, pp. 4468–4478, June 2010. [Online]. Available: http://dx.doi.org/10.1016/j.eswa.2009.12.064

[11] B. Burgemeestre, J. Hulstijn, and Y.-H. Tan, "Value-based argumentation for justifying compliance," in *Proceedings of the 10th international conference on Deontic logic in computer science*, ser. DEON'10. Berlin, Heidelberg: Springer-Verlag, 2010, pp. 214–228. [Online]. Available: http://portal.acm.org/citation.cfm?id=1876014.1876030

[12] F. Lopez y Lopez, M. Luck, and M. d'Inverno, "Normative agent reasoning in dynamic societies," in *Proceedings of the Third International Joint Conference on Autonomous Agents and Multiagent Systems - Volume 2*, ser. AAMAS '04. Washington, DC, USA: IEEE Computer Society, 2004, pp. 732–739. [Online]. Available: http://dx.doi.org/10.1109/AAMAS.2004.197

[13] W. H. Sperber, "Auditing and verification of food safety and haccp," *Food Control*, vol. 9, no. 2-3, pp. 157 – 162, 1998, first International Food Safety and HACCP Conferrence. [Online]. Available: http://www.sciencedirect.com/science/article/B6T6S-3TGN8TF-K/2/2ee1830d21bd4ede390400c97e56b7f2

[14] R. Schwartz, "Auditors' liability, vague due care, and auditing standards," *Review of Quantitative Finance and Accounting*, vol. 11, pp. 183–207, 1998, 10.1023/A:1008220317852. [Online]. Available: http://dx.doi.org/10.1023/A:1008220317852

[15] P. Wohed, W. M. P. van der Aalst, M. Dumas, A. H. M. ter Hofstede, and N. Russell, "On the suitability of bpmn for business process modelling," in *Business Process Management*, 2006, pp. 161–176.

[16] M. Hepp and D. Roman, "An ontology framework for semantic business process management," in *Wirtschaftsinformatik (1)*, 2007, pp. 423–440.

[17] N. Lohmann, E. Verbeek, and R. M. Dijkman, "Petri net transformations for business processes - a survey," *T. Petri Nets and Other Models of Concurrency*, vol. 2, pp. 46–63, 2009.

[18] K. B. Akhlaki, J. L. Garrido, M. Noguera, M. V. Hurtado, and L. Chung, "Extending and formalizing uml 2.0 activity diagrams for the specification of time-constrained business processes," in *RCIS*, 2010, pp. 93–100.

[19] M. Fitting, "Reasoning with justifications," in *Towards Mathematical Philosophy, Papers from the Studia Logica conference Trends in Logic IV*, ser. Trends in Logic, D. Makinson, J. Malinowski, and H. Wansing, Eds. Springer, 2009, vol. 28, ch. 6, pp. 107–123, published online November 2008.

[20] M. Horridge, B. Parsia, and U. Sattler, "Justification oriented proofs in OWL," in *International Semantic Web Conference*, 2010.