Business Rule Modality

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Business Rules determine what states and state transitions are possible or permitted for a given business domain, and may be of alethic or deontic modalities.

Alethic rules
- impose necessities (e.g. implied by physical laws)
- cannot be violated, even in principle
  e.g. Each Person was born on at most one Date.
  No Component includes itself.

Deontic rules
- impose obligations
- ought to be obeyed, but may be violated
  e.g. It is obligatory that each Person is husband of at most one Person.
  It is forbidden that any Person smokes in any Office.
Information modeling approaches such as ER, UML and ORM typically restrict their coverage of rules to alethic rules.

In practice, many business rules are deontic, and it is often important to know when they are violated so that actions can be taken to discourage future violations (whether or not support for this is automated).

In recognition of this need as well as for rule exchange etc., the OMG is finalizing the SBVR\textsuperscript{1} (Semantics of Business Vocabulary and Rules) proposal to specify a business semantics layer on top of its software-oriented layers.

\textsuperscript{1} Interim SBVR specification URL: www.omg.org/cgi-bin/doc?dtc/06-03-02.
This presentation is based on the author’s logical formalization work for SBVR, and work on NORMA\textsuperscript{1} an open-source tool for ORM 2 (2\textsuperscript{nd} generation ORM) which supports deontic and alethic rules.

The ideas discussed could be adapted for other approaches such as ER and UML.

In fact, the NORMA tool is currently being extended to support ER and UML notations as views of the underlying ORM model.

\textsuperscript{1} http://sourceforge.net/projects/orm
Modal Operators and Rule Verbalization

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Modal negation rules

\[ \sim □ p \equiv ◊\sim p \quad \sim O p \equiv P\sim p \]
\[ \sim ◊ p \equiv □\sim p \quad \sim P p \equiv O\sim p \equiv F p \]
\[ \sim F p \equiv P p \]

□ = true in all possible worlds
◊ = true in some possible world

For static constraints, a possible world is a state of the business domain.
NORMA displays alethic constraints in violet and verbalizes constraints in positive and negative forms.

The mandatory and uniqueness constraints in positive, combined form:

Each Person was born in exactly one Country.

(2 constraints: exactly one = some, and at most one).

This is read as a necessity. As an option, this may be made explicit:

It is necessary that each Person was born in exactly one Country.
In positive form, NORMA also verbalizes the lack of a uniqueness constraint on the right-hand role:

**It is possible that more than one** Person was born in **the same** Country.

Satisfying populations help illustrate constraints.
The mandatory and uniqueness constraints verbalized separately in **negative** form:

**For each** Person, **it is impossible that**

- **that** Person was born in **more than one** Country.

**It is impossible that any** Person was born in **no** Country.

NORMA is being extended to support counterexamples to illustrate constraint violation and generate test cases.
The uniqueness constraint might be alethic (shown above) or deontic.

Alethic +ve:

[It is necessary that] **For each** Room and HourSlot, **that** Room at **that** HourSlot is booked for **at most one** Activity.

Alethic –ve:

It is impossible that **the same** Room at **the same** HourSlot is booked for **more than one** Activity.
Deontic modality:

**+ve:** *It is obligatory that for each* Room *and* HourSlot, *that* Room at *that* HourSlot *is booked for* at most one Activity.

**-ve:** *It is forbidden that* the same Room at the same HourSlot *is booked for* more than one Activity.

NORMA display deontic rules in **blue**, typically with an “**o**” for “obligatory”.
Person was born in Country.
Each Person was born in exactly one Country.
It is possible that more than one Person was born in the same Country.

Person is a citizen of Country.
It is possible that more than one Person is a citizen of the same Country
and that the same Person is a citizen of more than one Country,
each Person, Country combination occurs at most once in the population of Person is a citizen of Country.
It is obligatory that each Person is a citizen of some Country.

Person is husband of Person.
It is obligatory that each Person₁ is husband of at most one Person₂.
It is obligatory that each Person₂ is wife of at most one Person₁.
It is possible that more than one Person₁ is husband of the same Person₂
and that more than one Person₂ is wife of the same Person₁.
each Person₁, Person₂ combination occurs at most once in the population of Person₁ is husband of Person₂.
NORMA currently allows modal operators only as the main operator of the rule expression.

Some allowed SBVR formulations that violate this restriction may be transformed into an equivalent NORMA expression by applying modal negation rules and the Barcan formulae and their converses, i.e.

\[ \forall x \square Fx \equiv \square \forall x Fx \]
\[ \exists x \lozenge Fx \equiv \lozenge \exists x Fx \]

e.g.

**For each** Person, **it is necessary that** that Person was born in **at most one** Country.

transforms to

**It is necessary that each** Person was born in **at most one** Country.
We also accept the following deontic variant of the Barcan formulae, allowing \( \forall \) and \( O \) to commute.

\[
\forall x \ O F x \equiv O \ \forall x \ F x
\]

This allows the following rule

**For each** Person,  
**it is obligatory that** that Person is a husband of **at most one** Person.  

to be transformed to

**It is obligatory that each** Person is a husband of **at most one** Person.
By normalizing rules to restrict modal operators to the main operator, the only impact on tagging a rule as a necessity or obligation is on rule enforcement.

For static rules, no commitment to a specific modal logic is required.

Enforcement of a necessity rule never allows violations.

Enforcement of an obligation rule allows violations, but takes some remedial action (e.g. display a message to a relevant authority indicating violation of the rule including verbalization of the rule).
Embedded, Static Rules

SBVR allows modal operators to be embedded anywhere in rule expressions. In rare cases, these rules cannot be transformed into rules where the only modal operator is the main operator.

To support such cases, we have two alternatives
  • adopt a specific modal logic\(^1\)
  • replace the embedded modal operators by domain-level predicates

For the first alternative, we prefer S4\(^2\).
For the second alternative, we proceed as for embedded deontics (see later).

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\(^1\) There are many normal modal logics (e.g. K, K4, KB, K5, DT, DB, D4, D5, T, Br, S4, S5) as well as non-normal modal logics (e.g. C2, ED2, E2, S0.5, S2, S3).

\(^2\) Schema evolution may seem to violate S4 (its accessibility relationship between possible worlds in transitive), but we resolve this by treating such evolution at the metametalevel.
Formally, we treat a model as an interpretation where each non-deontic formula evaluates to true.

A model is a permitted model if the $p$ in each deontic formula of the form $Op$ evaluates to true otherwise it is a forbidden model (though still a model).

This approach avoids the need to assign a truth value to expressions of the form $Op$. 
Various metarules apply between alethic and deontic rules, e.g. the argument (role set) of a deontic uniqueness constraint must be a proper subset of the argument of an alethic uniqueness constraint (explicit or implicit).

This example satisfies this metarule:

![Diagram] Person (name) is a husband of / is a wife of

However, if the marriage predicate were alethically 1:1, then no deontic uniqueness constraint may be added (if something is already necessary, it makes no sense to declare it obligatory).
Some SBVR formulae (e.g. $\text{OP}p$) are illegal in some deontic logics, and deontic logic itself is rife with controversies.

If a deontic model operator is embedded, we first try to normalize the formula using transformation rules such as $p \supset Oq \equiv O(p \supset q)$ or deontic counterparts to the Barcan formulae.

In rare cases, embedded deontics cannot be so normalized. Rather than choosing a specific modal logic (a risky option), where possible we transform such cases into first-order formulae with no modalities by replacing the modal operators by predicates at the business domain level.

Such predicates (e.g. “is forbidden”, “is permitted”) are reserved and given additional semantics (e.g. exclusion constraints between forbidden/permitted predicates).

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$^1$ In contrast to our approach, some versions of deontic logic reject this equivalence on the basis that agent control is restricted to the scope of modal operators.
As a simple example, consider the following SBVR rule.

*Car rentals ought not be issued to people who are barred drivers at the time the rental was issued.*

This deontic rule may be captured by the following ORM derivation rule for the partly derived domain fact type CarRental is forbidden:

CarRental is forbidden if
CarRental was issued at Time and
CarRental was issued to Person and
Person is a barred driver at Time.

The following slide shows the full ORM diagram for this case.
Person is a barred driver at Time₁ iff
Person was barred at a Time₂ <= Time₁ and
Person was not unbarred at a Time₃ between Time₂ and Time₁

CarRental is forbidden if
CarRental was issued at Time and
CarRental was issued to Person and
Person is a barred driver at Time
SBVR allows rules that embed possibly non-factual propositions. However, there does not appear to be any simple solution to providing explicit, formal semantics for such rules.

As a nasty example, consider the following business rule:

It is not permitted that some department adopts a rule that says it is obligatory that each employee of that department is male.

This example includes the mention (rather than use) of an open proposition in the scope of an embedded deontic operator. One possible, though weak, solution is to rely on reserved domain predicates to carry much of the semantics implicitly, as shown in the following ORM schema.
Some support for reification in the sense of propositional nominalization is being added by Pat Hayes and Chris Menzel to the IKL language, while retaining first-order. When available, this may offer other options for dealing with such cases.
Dynamic Rules

Dynamic rules restrict the possible transitions between business states.

The rule may simply compare one state to the next
(e.g. Salaries should never decrease)

or the rule may compare states separated by a given period
(e.g. Invoices ought to be paid within 30 days of being issued).

The invoice rule might be formally expressed thus,
assuming the relevant fact types exist in the conceptual schema:

For each Invoice, if that Invoice was issued on Date\(_1\)
then it is obligatory that
that Invoice is paid on Date\(_2\)
where Date\(_2\) \(\leq\) Date\(_1\) + 30 days.
This rule might now be normalized to the following formulation, moving the deontic operator to the front:

**It is obligatory that**

- each Invoice that was issued on Date$_1$
- is paid on Date$_2$
- where Date$_2$ $\leq$ Date$_1$ + 30 days.

This transformation requires an equivalence rule such as

$$p \supset Oq \equiv O(p \supset q).$$

While this formula is actually illegal in some deontic logics, it does seem intuitively acceptable.

In principle, such formal transformation issues might be ignored, so long as the domain expert confirms that the normalized formulation agrees with his/her intended semantics.
While it is obvious how to implement this rule in a database system, capturing the formal semantics in an appropriate logic (e.g. a temporal or dynamic logic) is a harder task.

One possibility is to provide a temporal package that may be imported into a domain model, in order to provide a first-order logic solution.

Another possibility is to adopt a temporal modal logic (e.g. treat a possible world as a sequence of accessible states).

We prefer a first-order solution where possible.
Conclusion

Many business rules are deontic rather than alethic.

This presentation discussed one way of modeling and verbalizing such rules in ORM 2, as supported by the open-source NORMA tool.

NORMA currently supports static rules where the only modal operator is the main operator.

Rules that cannot be transformed into such cases are challenging to adequately formalize and support, especially those involving embedded deontics or dynamic rules.

Some approaches were suggested to deal with such cases, but further research is needed to adequately address these complexities.