IDEal: A Legal Development Environment

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Contents

Part I

Theory

A legal matter processed in IDEal traverses four states:

- *Generation* ($\mathcal{G}$).
- *Representation* ($\mathcal{R}$).
- *Transformation* ($\mathcal{T}$).
- *Presentation* ($\mathcal{P}$).

We can understand IDEal as a system of *plug-ins* which either generate, or commonly access and transform a unified representation of a legal matter into derivative states. Consequently, the system is a series of machines mapping $[\ \alpha_i \in \mathcal{G} \cup \mathcal{T} \cup \mathcal{P}\ ] \rightarrow \mathcal{R}$, or $\mathcal{R} \rightarrow [\ \beta_i \in \mathcal{G} \cup \mathcal{T} \cup \mathcal{P}\ ]$. We denote $\langle \alpha_i \rangle$ as a *generator* state which can generate $\mathcal{R}$, and β_i as a *producible* state, which can be produced by some action on $\mathcal{R}$.

$$\begin{tikzcd}
 & & \mathcal{P} \arrow[dl, bend right] \\
\mathcal{G} \arrow[r, bend right] & \mathcal{R} \arrow[l, bend right] \arrow[ur, bend right] \arrow[dr, bend right] & \\
 & & \mathcal{T} \arrow[ul, bend right]
\end{tikzcd}$$

Figure 1: Visualising the interactions between the states.

1 Defining the Representation

Our goal is to define a mathematical structure for $\mathcal{R}$ which encodes legal information and maximises the number of producible states. Given that the representation is driven by the encoded legal information, we begin with the idea that a lawyer is a mechanism for analysing the *existence* or *non-existence* of a legal relationship between *objects*.

Facts, Nodes and the NodeState. We describe a legal object as a `Node`, and define the admissible *factual* actions, attributes or character of the `Node` as the `NodeState`. The $\texttt{NodeState}_n$ is an unordered set of n `Fact` objects which are generated and edited by an oracle, $\mathcal{F}$, in combination with a `SourceOfLaw`:

$$\mathcal{F} : (\texttt{SourceOfLaw},\ \{\ \texttt{Fact}_0, .., \ \texttt{Fact}_n\ \}) \rightarrow \texttt{NodeState}_n \tag{1.1}$$

$$\mathcal{F} : (\texttt{Fact},\ \texttt{NodeState}_n) \rightarrow \texttt{NodeState}_{n'} \tag{1.2}$$

$$\mathcal{F} : \texttt{NodeState}_n \rightarrow \texttt{NodeState}_{n''} \tag{1.3}$$

Sources of Law. A `SourceOfLaw` defines the conditions, attributes or characteristics which are required for the oracle to generate both a `NodeState`, as well as the `Role` (1.1) associated with a `NodeState`. Concretely, these are objects such as legislation or common law which have the inherent capacity to generate legal rights or obligations relevant to an object.

1.1 The Role Object

A `Role` defines the *legal personality* of a `Node` by capturing the attributes, actions, or characterstics attributable under law. A `Node` can be subject to multiple `Role` objects of arbitrary complexity, provided they are distinct under (1.6). The `Role` associated with a `Node` is generated by a pair `(NodeState, SourceOfLaw)` under the oracle function, $\mathcal{F}$, and is transformable under the `Consequence` of a `Link` (1.2):

$$\mathcal{F} : [\ (\texttt{NodeState, SourceOfLaw}) \rightarrow \texttt{Role}\ ] \tag{1.4}$$

$$\texttt{Consequence} : [\ \texttt{Role} \rightarrow \texttt{Role'}\ ] \tag{1.5}$$

Equivalence of Roles. We define an equivalence relation on a pair $(\texttt{Role}_i,\ \texttt{Role}_j)$ by comparing their generating states, such that they are only pairwise distinct where the generative facts and law diverge:

$$[\ \texttt{Role}_i = \texttt{Role}_j\ ] \iff [\ (\texttt{NodeState}_i \iff \texttt{NodeState}_j) \wedge (\texttt{SourceOfLaw}_i \iff \texttt{SourceOfLaw}_j)\ ] \tag{1.6}$$

Role Extension. The `NodeState` of a `Node` can generate multiple `Role` objects *iff* the `(NodeState, SourceOfLaw)` pair are distinct under (1.6). A `Role` is *reducible* when a subset of the generative `NodeState` can produce another distinct `Role`:

$$[\ N := \{\texttt{Fact}_0, .., \texttt{Fact}_n\}\ ] \wedge [\ M := \{\texttt{Fact}_0, .., \texttt{Fact}_m\}\ ] : [\ M \subset N\ ] \tag{1.7}$$

$$[\ \texttt{NodeState}_i = \mathcal{F}(N, \texttt{SourceOfLaw}_i)\ ] : \ [\ \texttt{Role}_i = \mathcal{F}(\texttt{NodeState}_i,\ , \texttt{SourceOfLaw}_{i'})\ ] \tag{1.8}$$

$$[\ \texttt{NodeState}_j = \mathcal{F}(M, , \texttt{SourceOfLaw}_j)\ ] : \ [\ \texttt{Role}_j = \mathcal{F}(\texttt{NodeState}_j, , \texttt{SourceOfLaw}_{j'})\ ] \tag{1.9}$$

$$\implies [\ N \texttt{ is } \textit{\texttt{reducible}}\ ] \tag{1.10}$$

A `Role` which is reducible is an *extension* of another `Role`, and the `Role` objects which are extended are called the *components of the extension.* The extended `Role` will automatically import any components of the extension objects into its own definition. We denote an extension using subset notation, such that the following indicates $\texttt{Role}_i$ is an extension of $\texttt{Role}_j$:

$$\texttt{Role}_j \subset \texttt{Role}_i \tag{1.11}$$

$$[\ \texttt{Role}_j \subset \texttt{Role}_i\ ] : [\ \texttt{Role}_i \implies \texttt{Role}_j\ ] \tag{1.12}$$

Given that an extension implies any components of the extension, a `Node` with multiple `Role` objects *may* replace any `Role` with an extension. We distinguish a `Role` extension from a `Role` *composition*, which is a set of distinct `Role` objects where there there does not exist a `Role` in the composition which is an extension of any other `Role`:

$$[\ N :=\ \{\ \texttt{Role}_0, .., \texttt{Role}_n\ \}\ ] : [\ \nexists(\texttt{Role}_i, \texttt{Role}_j) \in N : \texttt{Role}_i \subset \texttt{Role}_j\ ] \tag{1.13}$$

1.2 Links

A `Link` is a directed, pairwise relationship between a source ($\texttt{Role}_i$) and a destination ($\texttt{Role}_j$), which has been generated with the assistance of a `SourceOfLaw`. Given a pair ($\texttt{Role}_i, \texttt{Role}_j$) and an associated `SourceOfLaw`, the oracle may draw a $\texttt{Link}_{i \to j}$:

$$\mathcal{F} : (\texttt{SourceOfLaw},\ \texttt{Role}_i,\ \texttt{Role}_j) \to \texttt{Link}_{i \to j} \tag{1.14}$$

Hooking a Link. The `Hook` and `Anchor` objects are a specialisation of the `Role` object which represent the directed, relational requirements of a `Link`, and are generated under a (`SourceOfLaw, Role`) pairing. The oracle defines a `Link` by consuming a (`SourceOfLaw`, `Hook`, `Anchor`) triple:

$$[\ \mathcal{F}(\texttt{SourceOfLaw},\ \texttt{Role}_i) = \texttt{Hook}\ ]\ \wedge\ [\ \mathcal{F}(\texttt{SourceOfLaw},\ \texttt{Role}_j) = \texttt{Anchor}\ ] \tag{1.15}$$

$$\implies \mathcal{F} : (\texttt{SourceOfLaw},\ \texttt{Role}_i,\ \texttt{Role}_j) \to (\texttt{Hook, Anchor}) \tag{1.16}$$

$$\mathcal{F} : (\texttt{SourceOfLaw, Hook, Anchor}) \to \texttt{Link}_{i \to j} \tag{1.17}$$

1.3 Consequence

Given a `Link` to a relationship, the oracle, $\mathcal{F}$, generates a `Consequence` from a `SourceOfLaw`:

$$\texttt{Link}_{i \to j} \implies [\ \mathcal{F} : \texttt{SourceOfLaw} \to \texttt{Consequence}\ ] \tag{1.18}$$

A `Node` may be modified under the `Consequence` of a `Link`, changing the `NodeState` or associated `Role`:

$$[\ \mathcal{F}(\texttt{Consequence, Node}) = \texttt{Node'}\ ] \implies \{\ [\ \texttt{NodeState} \to \texttt{NodeState'}\ ] \vee [\ \texttt{Role}_i \to \texttt{Role}'_i\ ]\ \} \tag{1.19}$$

The oracle subsequently *walks the consequence forward* to generate or decouple any `Hook` or `Anchor` objects which have been invalidated by a disturbance of the `Conditions` required by the `SourceOfLaw`.

1.4 Sources of Law

Given a `SourceOfLaw`, there exists a related set of `Conditions` which must be satisfied before the oracle function, $\mathcal{F}$, can evaluate any expression:

$$\texttt{SourceOfLaw} \implies \texttt{Conditions} \tag{1.20}$$

$$\mathcal{F} : \texttt{Conditions} \rightarrow \{\ T, F\ \} \tag{1.21}$$

Application to Links. The `Hook` or `Anchor` required to draw a `Link` will have `Conditions` containing evaluations related to the `NodeState` of an object. The oracle, $\mathcal{F}$, will only generate a `Link` where the `Conditions` imposed by the `SourceOfLaw` are satisfied. Consequently, a `Link` will 'decouple' where a `Consequence` modifies the `NodeState` such that the evaluation of the `Conditions` of the relevant `SourceOfLaw` fail.

1.5 The Stage Controller

Time is encoded in $\mathcal{R}$ as an ordered set of n distinct `Interval` objects related by a `Transition`:

$$\texttt{IntervalSet} := \ \{\ \texttt{Interval}_0, .., \texttt{Interval}_n\ \} \tag{1.22}$$

$$\texttt{ForwardTransition} : \texttt{Interval}_i \rightarrow \texttt{Interval}_{i+1} \tag{1.23}$$

$$\texttt{BackwardTransition} : \texttt{Interval}_i \rightarrow \texttt{Interval}_{i-1} \tag{1.24}$$

The `BackwardTransition` and `ForwardTransition` are a specialisation of a `Transition` that form an identity map under function composition:

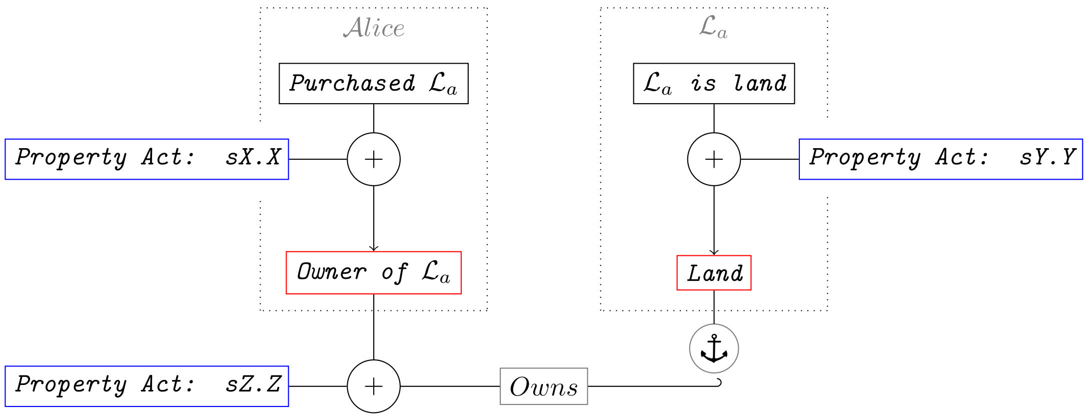
$$\texttt{BackwardTransition} \circ \texttt{ForwardTransition} : a \rightarrow a \tag{1.25}$$

The `TransitionSet` of an `Interval` is the minimum set of `ForwardTransition` and `BackwardTransition` objects required to reconstruct the `IntervalSet` under the oracle function, F:

$$\mathcal{F} : (\texttt{TransitionSet}, \texttt{Interval}) \rightarrow \texttt{IntervalSet} \tag{1.26}$$

Example.
Consider a boundary dispute between $\mathcal{A}lice$ and $\mathcal{B}ob$ on two adjacent plots of land: $\mathcal{L}_a$ and $\mathcal{L}_b$. In this case, $\mathcal{A}lice$ is the owner of $\mathcal{L}_a$, and $\mathcal{B}ob$ is the owner of $\mathcal{L}_b$. We are attempting to define whether it is permissible for $\mathcal{A}lice$ to build a structure by defining a boundary line delineating the properties, called `Bound`. The graphs below represents the information encoded in $\texttt{Interval}_0$.

Diagram 1.1 *Alice owns a parcel of land.*



The above diagram (**1.1**) reflects the following:

1. *Alice* and $\mathcal{L}_a$ are both a `Node`.
2. [*Purchased* $\mathcal{L}_a$] and [$\mathcal{L}_a$ *is land*] are both instances of a `Fact`.
3. (*Property Act* : *sX.X*, *Purchased* $\mathcal{L}_a$) generates the `Role` [*Owner of* $\mathcal{L}_a$].
4. (*Property Act* : *sY.Y*, $\mathcal{L}_a$ *is land*) generates the `Role` [*Real Property*].
5. The (`Hook`, `Anchor`) pairing below generates a `Link` [*Owns*]:
   (a) (*Property Act* : *sZ.Z*, *Owner of* $\mathcal{L}_a$) generates a `Hook`.
   (b) [*Real Property*] generates an `Anchor`.

The `Consequence` of the `Link` [*Owns*] requires that any other `Anchor` on $\mathcal{L}_a$ satisfies the additional `Condition` of having either a superior 'property' claim in relation to $\mathcal{L}_a$, or *Alice*'s consent.

Diagram 1.2 *Can Eve walk on* $\mathcal{L}_a$*?*

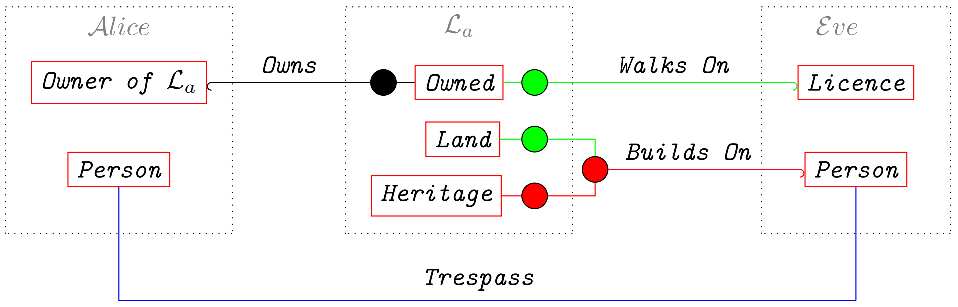


Diagram (**1.2**) reflects that:

1. $\mathcal{L}_a$ has the `NodeState` [*Owned*].
2. The `NodeState` [*Owned*] is a `Consequence` under the `Link` [*Owns*].
3. The `Condition` of [*Owns*] requires that any other `Anchor` on $\mathcal{L}_a$ has the `Role` [*Licence*]:
   (a) *Eve* may walk on $\mathcal{L}_a$ because:

   i. The [$Licence$] is a `Hook` which satisfies the `Conditions` for [$Walks\ On$].
   ii. [$Owned$] is an `Anchor` which satisfies the `Conditions` for `Link` [$Walks\ On$].

(b) $\mathcal{E}ve$ may **not** build on $\mathcal{L}_a$ because:

   i. [$Person$] is a `Hook` which **does not** satisfy the `Conditions` for [$Builds\ On$].
   ii. [$Land$] is an `Anchor` which satisfies the `Conditions` for [$Builds\ On$].
   iii. [$Heritage$] is an `Anchor` which **does not** satisfy the `Conditions` for [$Builds\ On$].

Compliance and Deviation. A lawyer constructs a `Link(Consequence)` by analysing the `Role` of an object relative to a set of legal conditions. We define both compliance and deviation as:

$$[\ \exists\ \texttt{Link(Existence, Consequence)}\ ] \wedge \begin{cases} [\ \texttt{Role} \implies \texttt{Link(..)}\ ], & \text{Compliance} \\ [\ \texttt{Role} \not\Rightarrow \texttt{Link(..)}\ ], & \text{Deviation} \end{cases} \tag{1.27}$$

Example. Continuing the previous example, we define compliance as Bob enforcing the terms of C against Alice, because Alice fulfils the relevant `Role`. Bob could not, however, enforce C against a third party, unless they also fulfilled a role which generated a `Link` to C.