A Programming Language for Estates and Future Interests

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In this talk

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Publications


• *A Programming Language for Estates and Future Interests*, Yale Journal of Law and Technology (forthcoming)
Motivation
Pop Quiz

What interests does the following conveyance create?

“To Sulu for life, then to Uhura and her heirs, but if she marries, then to McCoy and his heirs.”

(Peter T. Wendel, A Possessory Estates and Future Interests Primer 116 (3d ed. 2007))
Answer

- Sulu has a life estate
- Uhura has a vested remainder in fee simple subject to divestment
- McCoy has a shifting executory interest in fee simple
Estates in Land and Future Interests

• Division of land among multiple owners over time

• Doctrines developed over the past millennium

• Highly formalistic, and extremely rigid
Future interests in legal education

- Future interests were the traditional core of the first-year law-school course in Property
  - Students might spend several months on them
  - Today, a week or two is more common
- Notoriously dry, notoriously incomprehensible
  - There are study aids just for this part of the course!
  - Frequent target of student complaints
Quotes

• “The law is supposed to be a learned profession. Would not that supposition have to be revised if lawyers could no longer talk intelligently about fee tails after possibility of issue extinct, or distinguish a destructible contingent remainder from an executory interest in the nature of a shifting use?” — A. James Casner

• The formulas that govern future interests are similar to those of chemistry. They seem to be more of the law of nature than law of men except for one crucial difference: The rules of future interests occasionally make no sense.” — Daniel B. Bogart
Inspiration
Conveyances are a *programming language*

- Future interests feel different from other parts of law because ambiguity and discretion have been wrung out.
- Centuries of judicial rigidity turned future interests into a highly formalized system mostly following consistent rules:
  - “to X for life” —> X’s interest terminates at X’s death.
  - “Y, but if C to X” —> X’s interest cuts off Y if C occurs.
- These rules have the modular recursive generative structure of a programming language.
Our project

• Formalize the language of conveyances (Orlando)
  • Syntax
  • Semantics
• Create an interpreter for that language (Littleton)
  • OCaml back-end
  • Command-line and Bootstrap+JS front-ends
Formalization
Moving parts

1. Concrete syntax of *conveyances*
   Represents the actual language used by a lawyer

2. Abstract data type of *title trees*
   Represents the legal interests in a piece of property

3. Syntax-directed *translation function* from (1) to (2)
   Captures the speech-act effects of legal language

4. **Semantics** to update (2) in response to events
   Implements the doctrines of property law
(1) Conveyance syntax is a context-free grammar

\[
\text{conveyance} \Rightarrow \underbrace{\text{Owner conveys}}_{\text{grant}} \to \underbrace{\text{to Alice}}_{\text{person}}
\]

\[
\text{grant} \Rightarrow \underbrace{\text{to Alice for life}}_{\text{grant}} \text{ then to Bob}
\]

\[
\text{grant} \Rightarrow \underbrace{\text{to Alice}}_{\text{grant}} \text{ for life}
\]
Conveyance syntax grammar

\[
\begin{align*}
\text{conveyance} & \Rightarrow \text{owner } \text{conveys } \text{grant} \\
\text{grant} & \Rightarrow \text{to } \text{person } \text{quantum} \\
\text{grant} & \Rightarrow \text{grant } \text{limitation} \\
\text{grant} & \Rightarrow \text{if condition } \text{grant} \\
\text{grant} & \Rightarrow \text{if condition } \text{grant otherwise } \text{grant} \\
\text{grant} & \Rightarrow \text{grant } \text{but } \text{if condition } \text{grant} \\
\text{grant} & \Rightarrow \text{grant } \text{but } \text{if condition } \ldots \text{reenter} \\
\text{grant} & \Rightarrow \text{grant then } \text{grant} \\
\text{grant} & \Rightarrow (\text{grant}) \\
\text{quantum} & \Rightarrow \varepsilon \\
\text{quantum} & \Rightarrow \text{and } \text{pronoun } \text{heirs} \\
\text{quantum} & \Rightarrow \text{and the heirs of } \text{pronoun } \text{body} \\
\text{quantum} & \Rightarrow \text{for life} \\
\text{quantum} & \Rightarrow \text{for the life of } \text{person} \\
\text{quantum} & \Rightarrow \text{for } n \text{ years} \\
\text{limitation} & \Rightarrow \text{while } \text{condition} \\
\text{limitation} & \Rightarrow \text{until } \text{condition} \\
\text{person} & \Rightarrow 0|A|B|C| \ldots |\text{Alice}|\text{Bob}| \ldots \\
\text{pronoun} & \Rightarrow \text{her}|\text{his}|\text{hir}|\text{their}|\text{zir}| \ldots
\end{align*}
\]
Parsing

\[
\text{conveyance}
\]

\[
\Rightarrow \text{person conveys grant}
\]

\[
\Rightarrow \text{Owner conveys grant}
\]

\[
\Rightarrow \text{Owner conveys grant then grant}
\]

\[
\Rightarrow \text{Owner conveys to person quantum then grant}
\]

\[
\Rightarrow \text{Owner conveys to Alice quantum then grant}
\]

\[
\Rightarrow \text{Owner conveys to Alice for life then grant}
\]

\[
\Rightarrow \text{Owner conveys to Alice for life then to person quantum}
\]

\[
\Rightarrow \text{Owner conveys to Alice for life then to Bob quantum}
\]

\[
\Rightarrow \text{Owner conveys to Alice for life then to Bob and his heirs}
\]
(2) Title trees

\[
\begin{align*}
t & \Rightarrow \text{ to } p \\
t & \Rightarrow \bot \\
t & \Rightarrow t_1 \text{ while } c \\
t & \Rightarrow \text{ if } c \text{ then } t_1 \text{ else } t_2 \\
t & \Rightarrow t_1 \rightarrow t_2
\end{align*}
\]
Graphical representation of title trees

(a) to $p$  (b) $\perp$  (c) $t_1$ while $c$  (d) $t_1 \rightarrow t_2$  (e) if $c$ then $t_1$ else $t_2$

while $A$ is alive $\rightarrow$ to $B$

(to $A$ while $A$ is alive) $\rightarrow$ to $B$
(3) Translation function

\[
\begin{align*}
\lbrack owner \ conveys \ grant \rbrack(t) &= t[\lbrack grant \rbrack_{owner} \rightarrow \text{to owner}] / \text{to owner} \\
\lbrack \text{to person true} \rbrack_o &= \text{to person} \\
\lbrack \text{to person quantum} \rbrack_o &= \text{to person while} \ \lbrack \text{quantum} \rbrack_{person} \\
\lbrack \text{grant limitation} \rbrack_o &= \lbrack \text{grant} \rbrack_o \ \text{while} \ \lbrack \text{limitation} \rbrack \\
\lbrack \text{if condition grant} \rbrack_o &= \text{if} \ \lbrack \text{condition} \rbrack \ \text{then} \ \lbrack \text{grant} \rbrack_o \ \text{else} \bot \\
\lbrack \text{if condition grant}_1 \ \text{otherwise grant}_2 \rbrack_o &= \text{if} \ \lbrack \text{condition} \rbrack \ \text{then} \ \lbrack \text{grant}_1 \rbrack_o \ \text{else} \ \lbrack \text{grant}_2 \rbrack_o \\
\lbrack \text{grant}_1 \ \text{but if condition grant}_2 \rbrack_o &= \left(\left(\lbrack \text{grant}_1 \rbrack_o \rightarrow \text{to } p\right) \ \text{while} \ \lbrack \text{condition} \rbrack\right) \rightarrow \lbrack \text{grant}_2 \rbrack_o \\
\lbrack \text{grant but if condition ... reenter} \rbrack_o &= \left(\lbrack \text{grant}_1 \rbrack_o \ \text{while} \ \lbrack \text{condition} \rbrack \ \text{and} \ \text{o does not reenter}\right) \rightarrow \text{to } o \\
\lbrack \text{grant then grant}_2 \rbrack_o &= \lbrack \text{grant}_1 \rbrack_o \rightarrow \lbrack \text{grant}_2 \rbrack_o \\
\lbrack (\text{grant}) \rbrack_o &= \lbrack \text{grant} \rbrack_o \\
\lbrack \epsilon \rbrack_p &= \text{true} \\
\lbrack \text{and ... heirs} \rbrack_p &= \text{true} \\
\lbrack \text{and the heirs ... body} \rbrack_p &= p \ \text{has issue} \\
\lbrack \text{for life} \rbrack_p &= p \ \text{is alive} \\
\lbrack \text{for the life of } q \rbrack_p &= q \ \text{is alive} \\
\lbrack \text{for n years} \rbrack_p &= n \ \text{years have not yet passed} \\
\lbrack \text{while condition} \rbrack &= \lbrack \text{condition} \rbrack \\
\lbrack \text{until condition} \rbrack &= \neg \lbrack \text{condition} \rbrack
\end{align*}
\]
Translation

\[
\begin{align*}
& \llbracket \text{to A for life, then to B and her heirs} \rrbracket_O \\
= & \llbracket \text{to A for life} \rrbracket_O \rightarrow \llbracket \text{to B and her heirs} \rrbracket_O \\
= & \llbracket \text{to A while A is alive} \rrbracket_O \rightarrow \llbracket \text{to B and her heirs} \rrbracket_O \\
= & (\text{to A while A is alive}) \rightarrow \llbracket \text{to B and her heirs} \rrbracket_O \\
= & (\text{to A while A is alive}) \rightarrow \llbracket \text{to B true} \rrbracket_O \\
= & (\text{to A while A is alive}) \rightarrow \text{to B}
\end{align*}
\]
(4) Title tree semantics

\[ \delta(\text{to } p) = \text{to } p \]

\[ \delta(\perp) = \perp \]

\[ \delta(t \; \text{while } c) = \begin{cases} 
\delta(t) \; \text{while } c & \text{if } \vdash c \text{ and } \delta(t) \neq \perp \\
\perp & \text{if } \not\vdash c \\
\perp & \text{if } \delta(t) = \perp 
\end{cases} \]

\[ \delta(\text{if } c \; \text{then } t_1 \; \text{else } t_2) = \begin{cases} 
\delta(t_1) & \text{if } \vdash c \\
\delta(t_2) & \text{if } \not\vdash c 
\end{cases} \]

\[ \delta(t_1 \rightarrow t_2) = \begin{cases} 
\delta(t_1) \rightarrow t_2 & \text{if } \delta(t_1) \neq \perp \\
\delta(t_2) & \text{if } \delta(t_1) = \perp 
\end{cases} \]
A conveyance and subsequent events

0 conveys to A for life, then if B is married to B for life, then to C.
B marries.
A dies.
B dies.

(to A while A is alive) \rightarrow
(if B is married then (to B while B is alive) else ⊥) \rightarrow
to C

while A is alive \rightarrow if B is married \rightarrow
no \rightarrow ⊥ \rightarrow to C

while B is alive \rightarrow to B
B marries. (1)
A dies.

While A is alive → if B is married

- Yes → While B is alive
  - to B
- No → ⊥
  - to C

⊥ → if B is married

- Yes → While B is alive
  - to B
- No → ⊥
  - to C
\( \bot \rightarrow \text{if B is married} \xrightarrow{\text{no}} \bot \rightarrow \text{to C} \)

\( \text{while B is alive} \)

\( \text{to B} \)

\( \text{if B is married} \xrightarrow{\text{no}} \bot \rightarrow \text{to C} \)

\( \text{while B is alive} \)

\( \text{to B} \)
if B is married

\[ \begin{align*} 
\text{no} & \quad \Downarrow \quad \text{yes} \\
\text{while B is alive} \\
\text{to B} \\
\text{while B is alive} \\
\text{to C} \\
\end{align*} \]
B dies. (5)
Implementation
Littleton back-end

• ~6000 lines of OCaml
• ~3000 lines of framework
• ~1000 lines of legal semantics
• ~1000 lines of symbolic AI to reason about events
• ~1000 lines of parsing code
Littleton front end

- Command-line “interpreter” for Orlando
- Interactive web app
  - Compiled to JS that runs in-browser
  - Bootstrap interface
- Available at https://conveyanc.es
Demonstration
Reflection
Advantages of formalization

• Captures the existing rules law students learn

• Recovers the underlying logic that has been obscured by generations of rote learning

• Reveals broader patterns hidden by the proliferation of names and details

• Provides a principled basis for critique and reform
Legal variation = different formal rules

\[
\begin{align*}
\llbracket \text{and...heirs} \rrbracket_p &= \text{true} \\
\llbracket \epsilon \rrbracket_p &= \text{p is alive} \\
\llbracket \text{for life} \rrbracket_p &= \text{p is alive} \\
\llbracket \text{for the life of q} \rrbracket_p &= \text{q is alive}
\end{align*}
\]

(a) Default quantum (older rule)

\[
\begin{align*}
\llbracket \text{and...heirs} \rrbracket_p &= \text{true} \\
\llbracket \epsilon \rrbracket_p &= \text{true} \\
\llbracket \text{for life} \rrbracket_p &= \text{p is alive} \\
\llbracket \text{for the life of q} \rrbracket_p &= \text{q is alive}
\end{align*}
\]

(b) Default quantum (modern rule)
Syntactic ambiguity

(a) (to A for life, then to B), but if C marries to C

(b) to A for life, then (to B, but if C marries to C)
Unnecessary complexity

(a) to A until B graduates college, then to O gives A a fee simple determinable

(b) to A until B graduates college, then to B gives A a fee simple with executory limitation

(c) to A, but if B graduates college to B gives A a fee simple subject to executory limitation
Advantages of implementation

• Visualization for education

• Interactivity for experimentation
A programming-language approach to law

- Treating future interests as a programming language captures the *linguistic structure* of conveyances
- Fits legal areas with rule-driven linguistic structure
- Other suitable bodies of law: property, contracts, tax
Questions