Achievements

- **Formal Language Game**

  1) Applies deduction, abduction and nonmonotonic logic.
  2) *Fairness Semantics*. Foundation in moral philosophy and jurisprudence.
  3) The implementation can monitor pleading, ensuring that certain discourse norms are not violated.

- **A Dialogue Logic for *Synthetic* Problems**

  1) Premises, facts and claims are subject to debate.
  2) Backing of proposed rules may be challenged.
  3) Theory of the case and applicable law is *constructed* during argumentation.

- **Defeasible Reasoning**

  1) Extension of Geffner & Pearl's logic of conditional entailment
  2) Rule language for explicit exceptions.
  3) Reification of rules allows discussion about their *backing*, *applicability* and relative *priority.*

Other Applications?

Collaborative Design.

AAAI Workshop this year.

Design Rationale.

Issue of journal on Human-Computer Interaction. (HCI).
Relation to IBIS?

The Implementation

Formula Table.

Each first-order formula used is indexed and stored in a table represented using a balanced (2-3-4) tree.

Argument Manager.

Operations on sets of formulas implemented so as to preserve indexing of "clauses", to enable fast retrieval.

Theorem Prover for Clausal Intuitionistic Logic (CIL).

CIL extends Horn clause logic with (intuitionistic) negation and embedded implications. (Negation required for counterarguments.) Speed: about 700 LIPS on a Sparc 1.

Minimal Reason Maintenance System.

A tractable "assumption-based" reason maintenance system. Implements my theory of tractable abduction.

Theorem Prover for Conditional Entailment.

Based on Geffner & Pearl's algorithm. (Complete for the "known" consequence relation.)

Programming Language: Standard ML of New Jersey
Source Size: 224 KB, about 140 DIN A4 pages.

Tractable Abduction

Minimal Supporting Arguments.

Given a set of supporting arguments A (each of the form $<\Delta,\psi>$), an argument Γ is a *minimal supporting argument* for ϕ if and only if:

1. known (Γ,ϕ),

2. not known $(\Gamma, \perp)$, and

3. there is no $<\Psi,\phi> \in A$ such that $\Psi \subset \Gamma$.

Minimality here is relative to arguments actually made, not some consequence relation.

Known Relation.

Given a set of supporting arguments A, a formula ϕ is *known* to be a consequence of an argument Γ, if and only if:

1. $\phi \in \Gamma$,

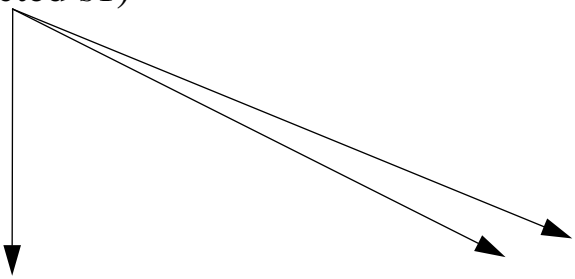
2. there exists an argument $<\Psi,\phi> \in A$, such that, for every formula $\psi \in \Psi$, it is known that ψ is a consequence of Γ, or

3. known $(\Gamma,\perp)$.

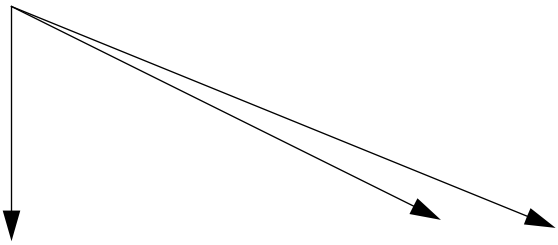
The known relation is isomorphic to propositional definite Horn clauses. Membership in the relation is decidable in linear time. [Dowling and Gallier, 1984].

Dialectical Structure and Issues

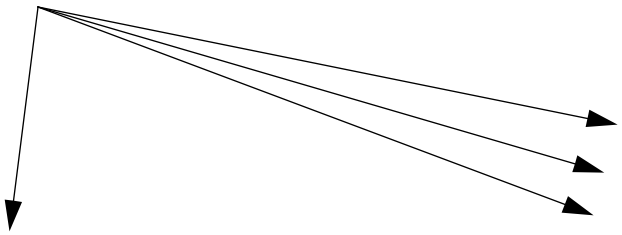
main claim: (perfected s1)



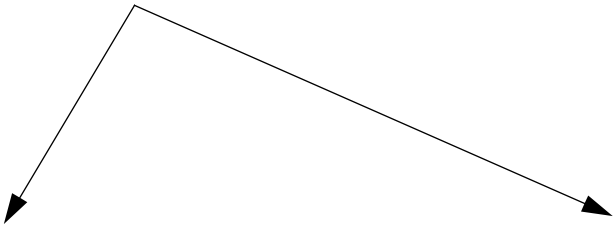
minimal supports: {(goods ship1),(possession smith ship1)}



minimal rebuttals: {(backing sma-1), (not (filed s1))}

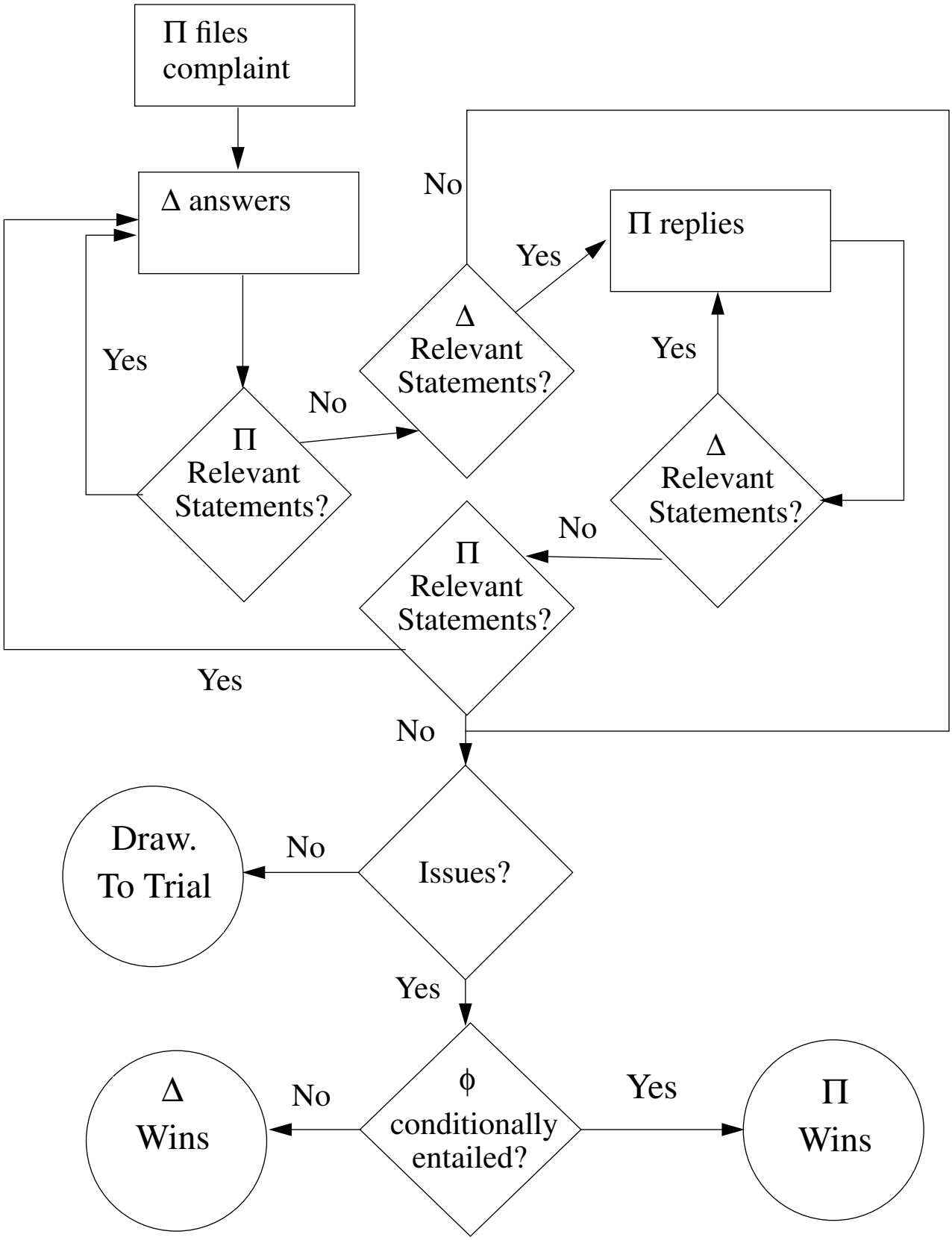


minimal defeaters: {(later ucc sma-1), (backing lex-posterior)}



minimal rebuttals: {(higher sma-1 ucc), (backing lex-superior)}

Control and Termination



Control and Termination

- A statement is *relevant* if and only if it concerns an *issue*.
- A party must continue making assertions until his opponent has no further relevant open statements.
- The game is over when neither party has relevant open statements.

Determining the "winner".

The plaintiff is entitled to a *summary judgment* if

1) There are no issues, and
2) The main claim, ϕ, is *conditionally entailed* by the default theory constructed by the parties during pleading.

The defendant is entitled to a summary judgment if

1) There are no issues, and
2) The main claim is not conditionally entailed.

Otherwise, the Pleadings Game ends in a draw.

Two Further *Language Games*:

1) Discovery (of evidence)
2) Trial ---- where the court decides the issues.

Transcript of Pleadings
in Smith vs. Jones

…

```
p: (complaint (perfected s1) bg)

d: (deny (claim (perfected s1)))

p: (rule (ucc-9-305 (p s g)
     if (and (secured-party s P)
             (collateral s g)
             (goods g)
             (possession g p))
     then (perfected s))

p: (argument a1 (apply ucc-9-305
                       (smith s1 ship1)))

p: (defend (denial (claim (perfected s1)))
           a1))
```

…

```
d: (concede (claim (collateral s1 ship1)))
d: (rule sma-1 (s g)
     if (and (collateral s g)
             (ship g)
             (not (filed s))
             (perfected s))
     then false)

d: (argument r1 (difference
                       (apply sma-1 (s1 ship1))
                       (set (perfected s1))))
d: (defend (argument a1 (perfected s1)) r1)
```

…

Assertions

These are the *moves* of the Pleadings Game.

1. (concede <statement>)

```
(concede (claim (ship s1)))
(concede (claim (backing ucc-9-305)))
```

2. (deny <statement>)

```
(deny (claim (applicable ucc-9-305
                         (ship1))))
(deny (denial (claim (not (filed s1)))))
```

3. (declare <rule>)

```
(rule ucc-9-105-h(x)
          if (movable x)
          then (goods x)
          unless (money x))
```

4. (defend <statement> <set of formulas>)

```
(defend (denial (claim (perfected s1)))
     (apply ucc-9-305 (smith s1 ship1)))

(defend (argument arg1 (perfected s1))
     (apply sma-1 (s1 ship1)))
```

There are no other kinds of assertions.

Statements

1. (claim <formula>)

```
(claim (perfected s1))
```

2. (denial <statement>)

```
(denial (claim (perfected s1)))
```

3. (argument <set of formulas> <formula>)

```
(argument (set (if (moves ship1)
                   (goods ship1))
               (moves ship1))
          (goods ship1))

(argument (apply ucc-9-305
                 (smith s1 ship1))
          (perfected s1))
```

4. (rebuttal <set of formulas> <formula> <set of formulas>)

```
(rebuttal arg1 (perfected s1) arg2)
```

There are no other kinds of statement.

The Record

The *record* is the playing board of the Pleadings Game. It consists of:

a) the *main claim* of the case: ϕ

b) a set of formulas, *L*, representing the *nondefeasible background knowledge* accepted by both parties. (May be empty.)

c) a set of defeasible *rules*.

d) the *open*, *denied* and *conceded statements* of each party.

Arguments

Argument. A set of formulas.

Supporting Argument. $\frac{\Gamma}{\phi}$

Counterarguments. $\frac{\Gamma \cup \Delta}{\bot}$

Defeating Argument. A counterargument Δ *defeats* Γ if and only if *every* assumption of Δ is preferred to *some* assumption of Γ. (*Specificity.*)

Protected Argument. A counterargument Δ is *protected from* Γ if and only if it contains a subargument which defeats Γ.

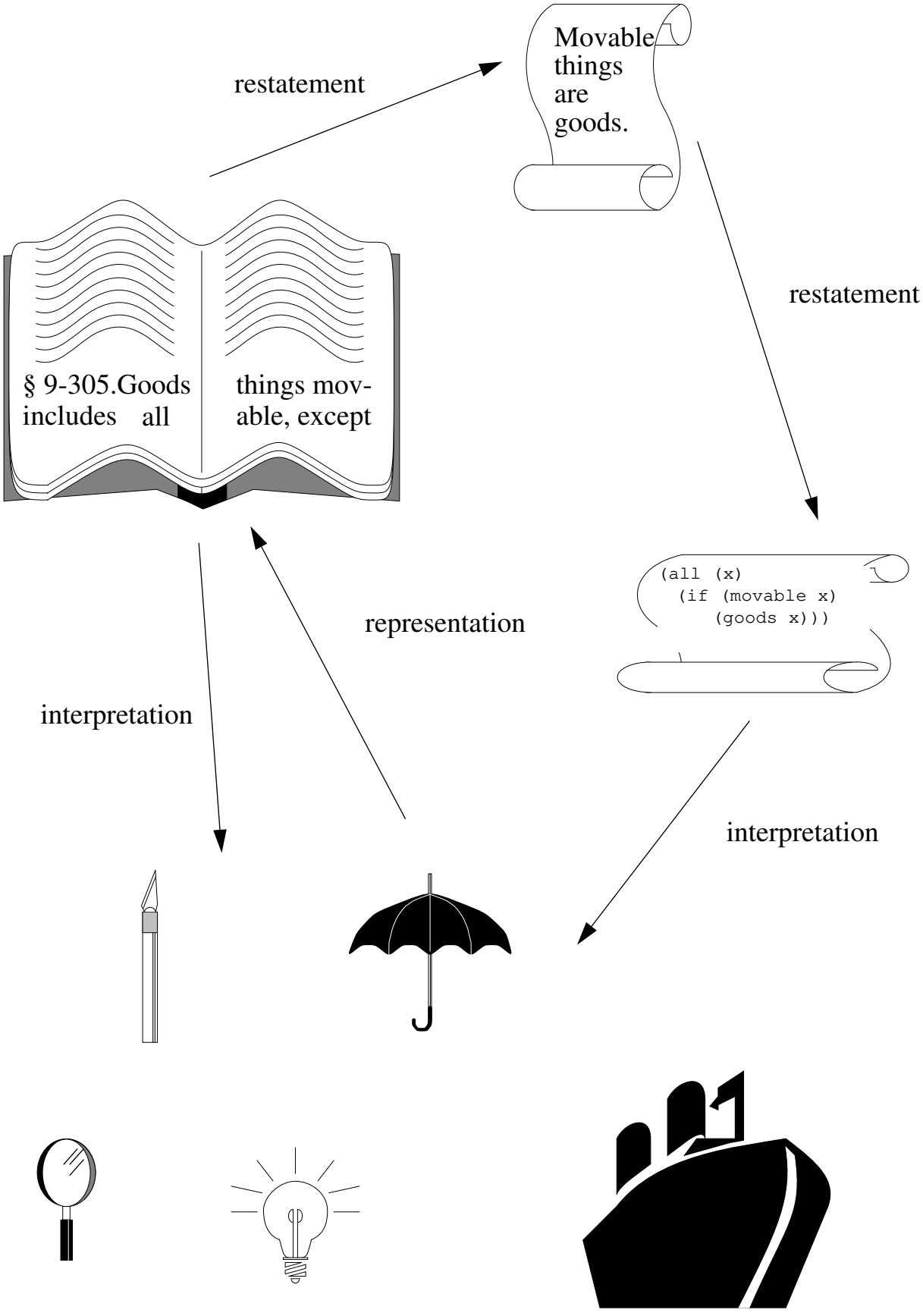
Rebuttal. A counterargument Δ *rebuts* Γ if and only if Γ is not protected from Δ.

Basic Idea: A rebuttal is *at least as good* as its counterargument, but defeaters and protected arguments are *better.*

Some Discourse Norms

- No speaker may contradict himself.
- A speaker shall be held to believe the necessary consequences of his claims.
- Like things shall be treated alike (*Universalizability*).
- An argument supporting a claim may only be made when the claim is denied.
- Only relevant statements may be made.
- An argument may be rebutted by a counterargument which is at least as strong.
- A rebuttal may be defeated by a better counterargument

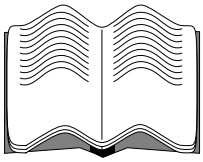
Hermeneutic Interpretation



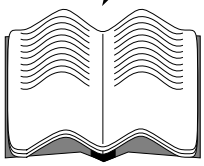
Division of Powers

Legislature

Judiciary

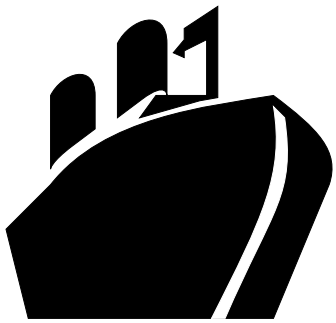


Statutes



Cases

Good?



Kinds of Issues

First Order

Factual

Possession?
Financing Statement Filed?

Legal

Are ships goods?

Shall a financing statement be file

Second Order

Lex Posterior (later > earlier)
Lex Superior (higher > lower)

Third Order

Lex Superior > *Lex Posterior*

Pleading

Smith: My security interest is perfected.

Jones: No it isn't.

Smith: Goods may be protected by taking possession (UCC 9-505).

Jones: Ships aren't goods. And you don't have possession.

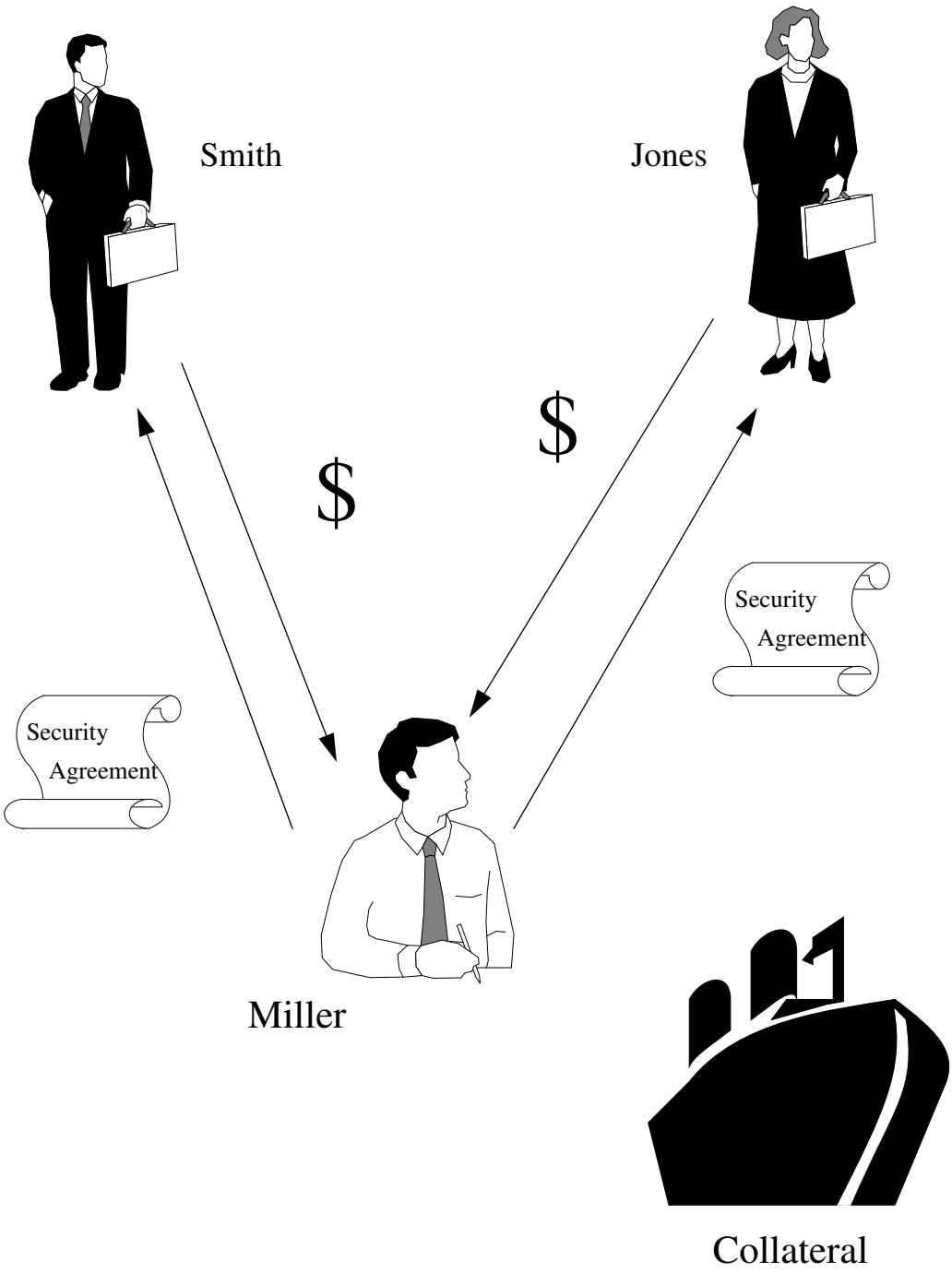
Smith: Except for money, movable things are goods (UCC 9-105-h).

Jones: Sure, ships are movable, but that's not enough under the UCC. And the Ship Mortgage Act requires a financing statement to be filed.

Smith: I have filed, but I don't agree that the Ship Mortgage Act requires this. Anyway, the UCC was enacted after the Ship Mortgage Act.

Jones: But the Ship Mortgage Act is Federal Law.

Smith vs. Jones



The Pleadings Game

Formalizing Procedural Justice

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1. Features of Legal Reasoning and Argumentation
2. Formalization
3. Implementation
4. Other Applications?
5. Achievements