eFLINT - An action-based language for reasoning about norms

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Context & Motivation

- NWO-funded projects:
  - DL4DL, Data Logistics (UvA, TNO, TKI Dinalog, ...)
  - SSPDDP, Data Processing (UvA, CWI, VU, ING, ABN AMRO, AirFrance KLM)
  - EPI, Personalize Interventions (UvA, CWI, VU, St. Antonius, UMC Utrecht, ...)

- Calculemus-FLINT project – Trust in the digital government
(UvA, TNO, ICTU, CWI, Ministry of Justice and e Security, Ministry of Finance, Immigration and Naturalisation Service (IND), ...)

Central questions

- How do we formalize the norms embedded in regulations, policies and contracts?
- Once formalized, how do we query the norms? What questions do we want to ask?

Norms - Philosophy/Sociology

Normative sentences are "ought-to" types of statements

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Examples: legal norms - social norms

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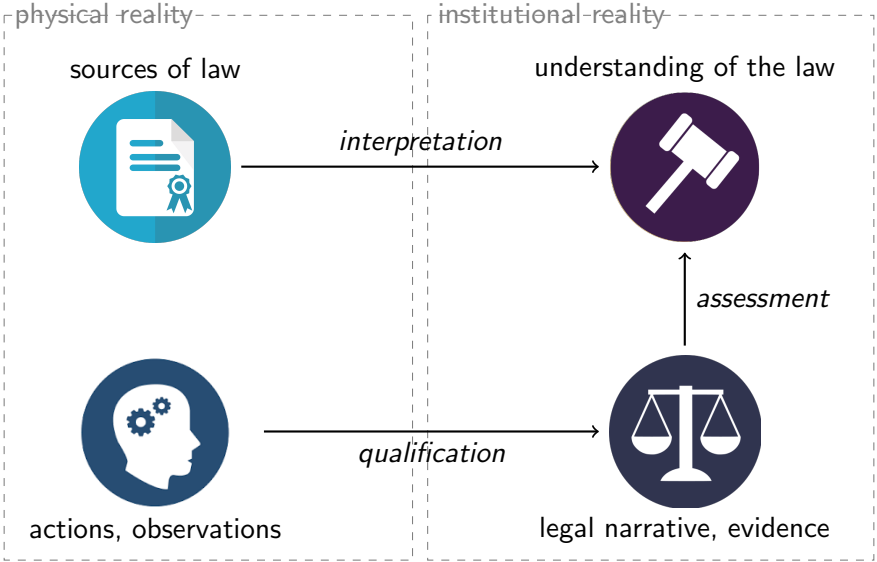
A player cannot score from an offside position

Deontic	**Potestative**
duties, obligations	powers, actions
permissions	liabilities

A normative framework derived from law



Interpreting normative sources

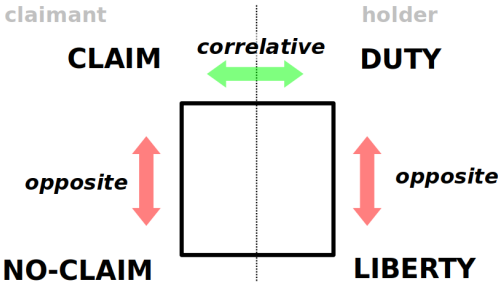
What does the result of interpretation look like?

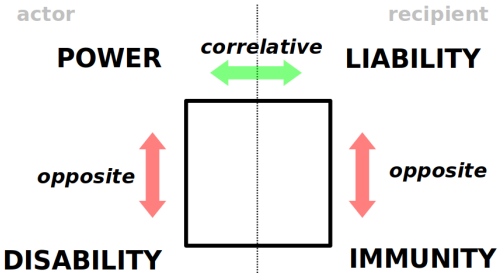
Interpreting normative sources

What does the result of interpretation look like?

How do we write down an interpretation formally?

Hohfeld's fundamental legal conceptions





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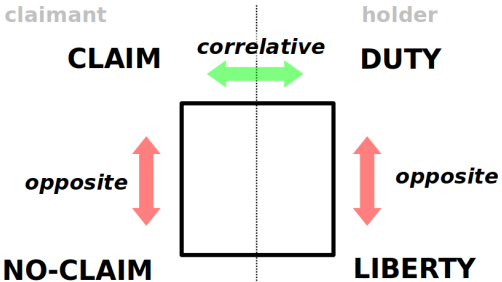

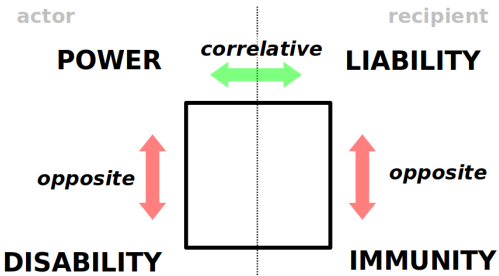

fundamental relation: **duty-claim**
between *duty holder* and *claimant*

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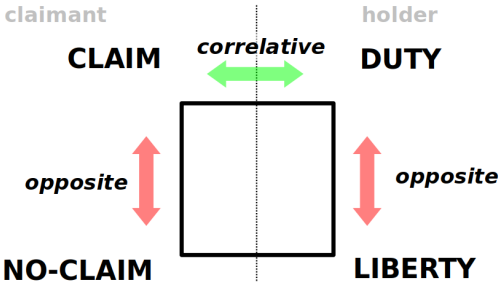

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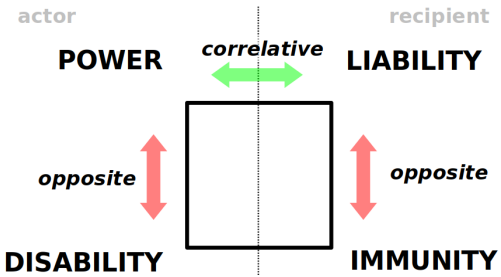

fundamental relation: **power-liability**
between *actor* and *recipient*

What does the result of interpretation look like?

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Acts

- An act-declaration specifies an *actor*, a *recipient* and pre- and post-conditions
- X is in a **power-liability** relation with Y – *at a particular moment in time* – if X is the actor of an act with recipient Y and the pre-conditions of the act are satisfied

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Duties

- A duty-declaration specifies a *holder*, a *claimant* and a violation-condition
- X is in a **duty-claim** relation with Y – *at a particular moment in time* – if X is the holder of a duty with claimant Y and Y has a valid claim if the duty is violated

What does the result of interpretation look like?

Knowledge representation

- A set of *facts* represents the world at a particular moment in time
- Actions terminate and/or create facts as determined by their post-conditions
- Some facts are derived, i.e. computed by some derivation rules

Facts – knowledge representation

How do we write down an interpretation formally (in eFLINT)?

```
1  Fact citizen
2  Fact official
3
4  Fact application Identified by weeknr * citizen * permit-type * location
5  Fact permit      Identified by weeknr * citizen * permit-type * location
6  Fact permit-type Identified by "solar panels", "new construction"
7  Fact location
8
9  Fact nitrogen-level         Identified by 1..10
10 Fact nitrogen-threshold     Identified by 1..10
11 Fact nitrogen-level-of      Identified by location * nitrogen-level
12 Fact too-much-nitrogen-at   Identified by location
13   Holds when nitrogen-level-of(location, nitrogen-level) &&
14              nitrogen-threshold &&
15              nitrogen-level > nitrogen-threshold
```

Duties – duty-claim

How do we write down an interpretation formally (in eFLINT)?

```
1 Duty consider-application
2   Holder official
3   Claimant citizen
4   Related to permit-type, location, weeknr
5   Violated when current-weeknr
6              && current-weeknr > weeknr + 2 // two weeks have passed
```

Acts – power-liability

How do we write down an interpretation formally (in eFLINT)?

```
1 Act apply
2   Actor citizen
3   Recipient official
4   Related to permit-type, location
5   Conditioned by (Forall weeknr : !application(weeknr = weeknr))
6   Creates application(weeknr = current-weeknr) When current-weeknr
7          ,consider-application(weeknr = current-weeknr) When current-weeknr
```

Acts – power-liability

How do we write down an interpretation formally (in eFLINT)?

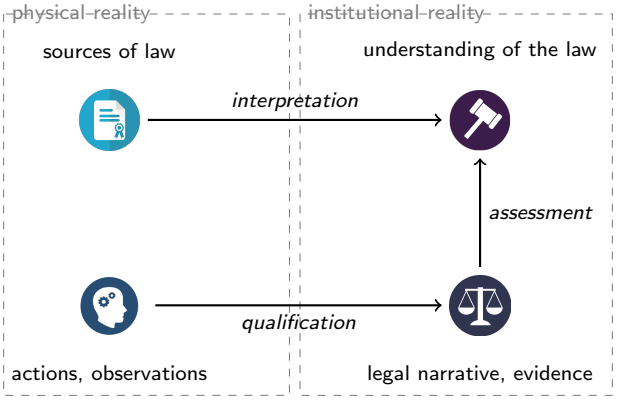
```
Act apply
  Actor citizen
  Recipient official
  Related to permit-type, location
  Conditioned by (Forall weeknr : !application(weeknr = weeknr))
  Creates application(weeknr = current-weeknr) When current-weeknr
         ,consider-application(weeknr = current-weeknr) When current-weeknr
```

```
Act deny-application
  Actor official
  Recipient citizen
  Related to permit-type, location
  Conditioned by (Exists weeknr : application(weeknr = weeknr))
               && permit-type == "new construction"
               && too-much-nitrogen-at(location)
  Terminates  application()
             ,consider-application()
```

Novelties

- eFLINT is based on Hohfeldian normative principles
- eFLINT is action-based, so we can apply familiar definitions of compliance
- eFLINT has a domain-specific design (although the domain is quite general)

Transitions and compliance



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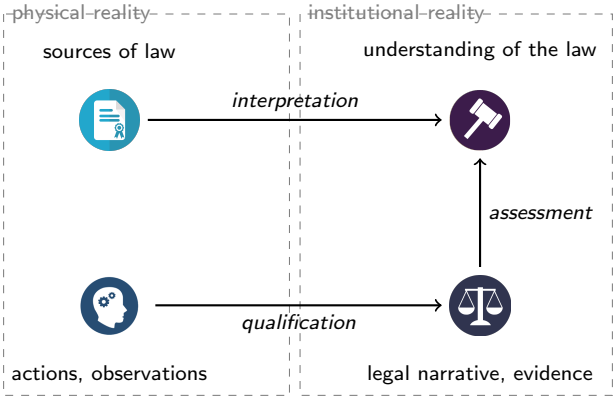
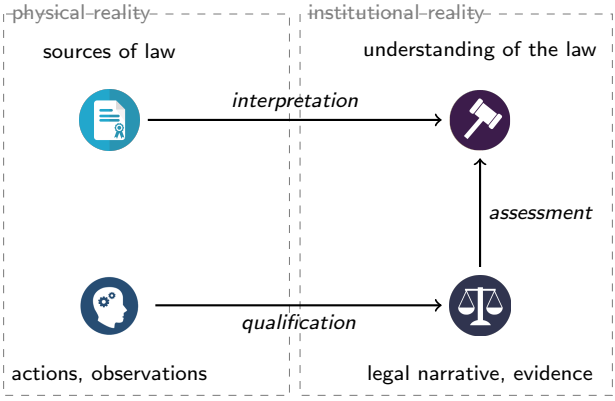


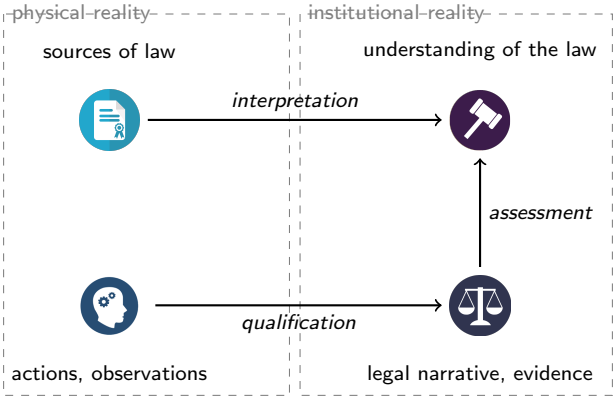
- An interpretation is written formally as act-, duty-, and fact-declarations

Transitions and compliance



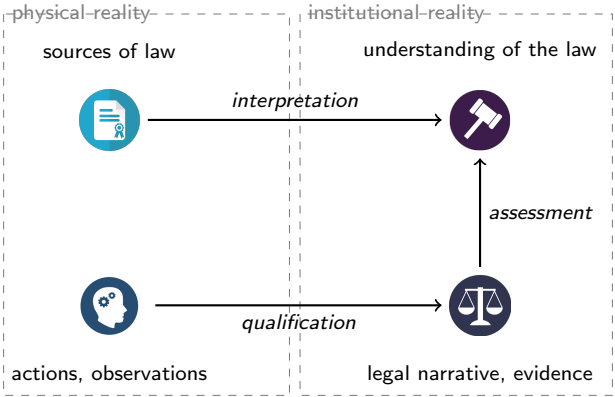
- The act-, duty-, and fact-declarations specify a transition system

Transitions and compliance



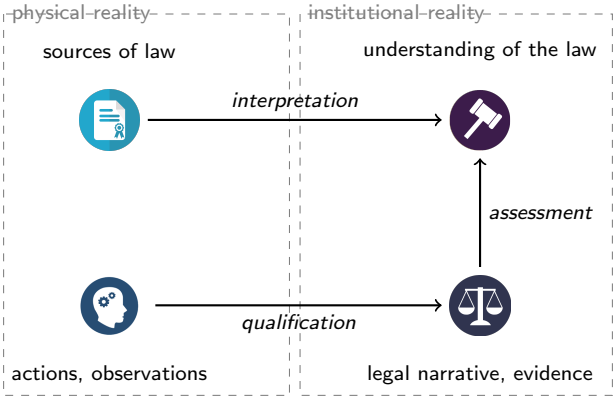
- Each path/trace in the transition system is an institutional narrative
- Powers, liabilities, duties and claims can be identified in each state on a path

Transitions and compliance



- Assessment is determining whether any powers or duties have been violated
- The eFLINT interpreter automates assessment

Transitions and compliance



How do we write down a narrative, the result of quantification?

How do we write down a narrative, the result of quantification?

scenario

```
+nitrogen-level-of(Amsterdam, 10).
+nitrogen-threshold(5).

!apply(Chloe, Official, "solar panels", Amsterdam).
?consider-application(Official, Chloe, "solar panels", Amsterdam, 0).
!approve-application().

!apply(Chloe, official, "new construction", Amsterdam).
!approve-application(). // non-compliant
```

Run | Reset | Save | model name

response

```
Non-compliant action at step 7
```

How do we write down a narrative, the result of quantification?

Step 0: initial state

Step 1: ("Amsterdam":location,10:nitrogen-level):nitrogen-level-of

+("Amsterdam":location,10:nitrogen-level):nitrogen-level-of

Step 2: 5:nitrogen-threshold

+5:nitrogen-threshold

Step 3: ("Chloe":citizen,"Official":official,"solar panels":permit-type,"Amsterdam":location):apply

+("Official":official,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location,0:weeknr):consider-application

+(0:weeknr,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location):application

Step 4: successful query

Step 5: ("Official":official,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location):approve-application

+(0:weeknr,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location):permit

-("Official":official,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location,0:weeknr):consider-application

-(0:weeknr,"Chloe":citizen,"solar panels":permit-type,"Amsterdam":location):application

Step 6: ("Chloe":citizen,"Official":official,"new construction":permit-type,"Amsterdam":location):apply

+("Official":official,"Chloe":citizen,"new construction":permit-type,"Amsterdam":location,0:weeknr):consider-application

+(0:weeknr,"Chloe":citizen,"new construction":permit-type,"Amsterdam":location):application

Ongoing research

• The NWO-funded project Secure Scalable Policy-enforced Distributed Data Processing (SSPDDP) is investigating ways to ensure the policy-compliance of software

In addition to the presented material, this requires at least:

- Qualification rules for constructing institutional narratives from observed behaviour
- Rules for translating traces of behaviour between models
- Applying such rules ‘on the fly’, blocking or reporting non-compliant actions

Ongoing research

• The Calculemus-FLINT project is building software to support governmental services and decision-making based on policies – *presented at 17:00 in the AI track*

Tools currently being developed as part of this project are to:

- Extract interpretations from sources of law (semi-automatic interpretation)
- View and edit act- and duty-declarations (manual interpretation)
- Apply the norms encoded in sets of act- and duty-declarations (assessment)
- Publish interpretations and assessments on a ledger (documentation)

We are looking for partners; please find our stand for more information!

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