Lecture III
Social Dependency Models in RE

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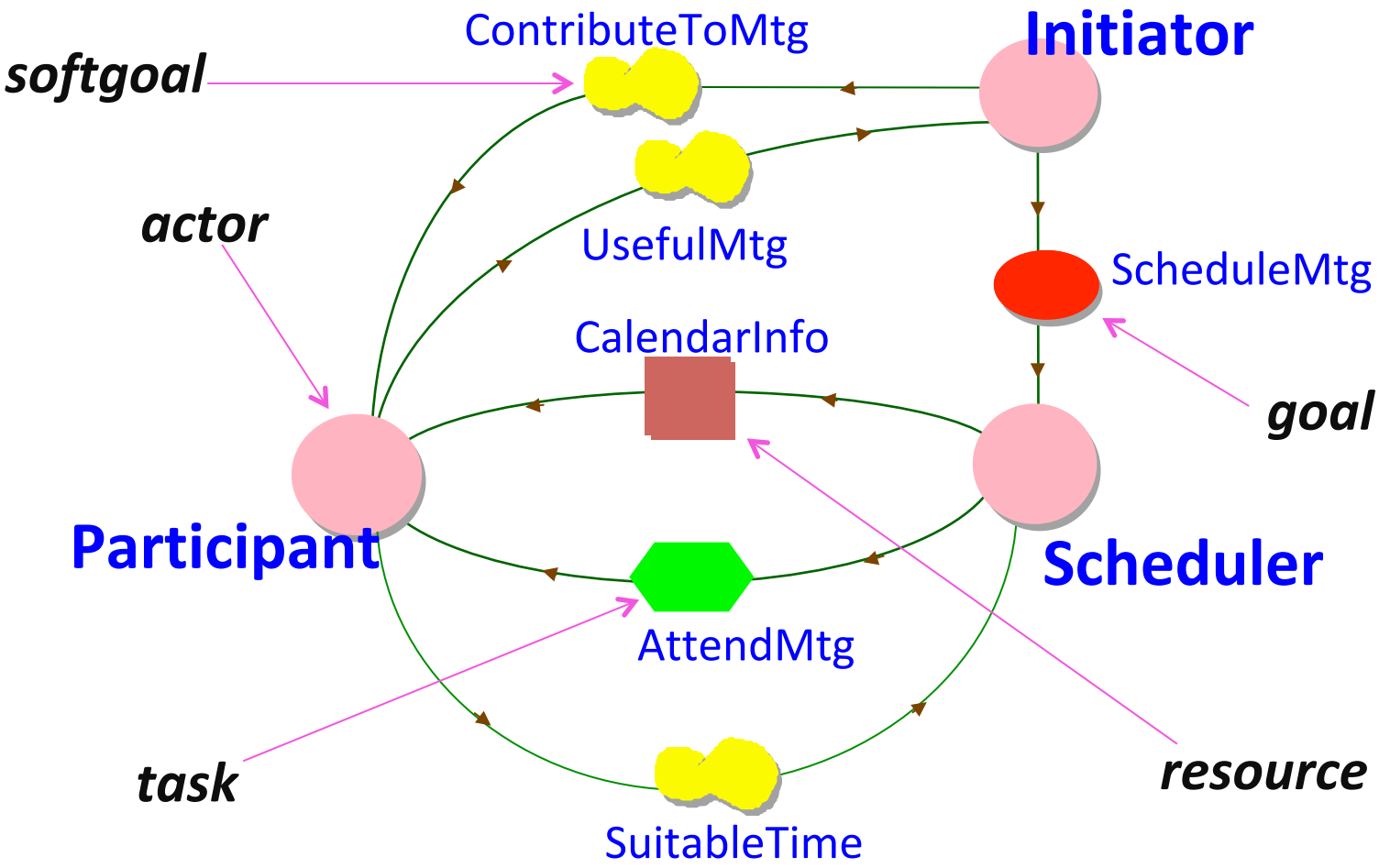
Social dependency models

- Social dependence models assume an ontology of actors (agents, roles) and social dependencies among them.
- *i** pioneered such models with its actor dependency diagrams [Yu95].
- But there were other proposals in the same period: Munindar Singh proposed ***social commitments*** as fundamental concepts for multi-agent systems [Singh91], [Singh99], while in Law, ***rights*** and ***obligations*** have been acknowledged as foundational legal (and therefore social) concepts [Hohfeld13].
- We review such concepts and how they have been adopted and used in RE.

Social dependencies in *i**

- Actor dependence models consist of actors (roles, agents), and dependencies (goal, softgoal, task, resource) among them.



Formalizing social dependencies

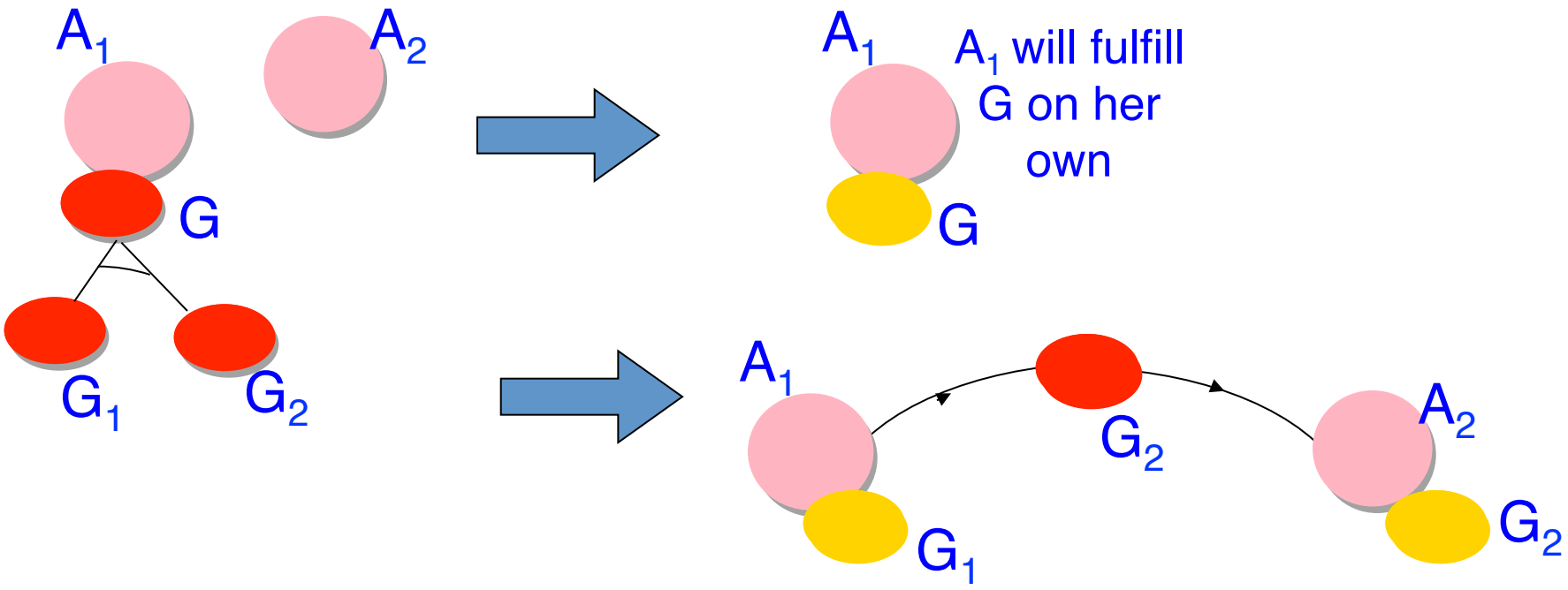
- Actor dependencies are formalized in Eric Yu's PhD thesis using intentional concepts, such as ***beliefs***, ***goals*** and ***commitments***.
- For example, here are the axioms for ***committed goal*** dependency:

$$CW(a, b, \phi) \equiv CW(a, \phi) \wedge B(a, CA(b, \phi))$$
$$CW(a, \phi) \Rightarrow B(a, \exists p, \exists \phi_0(\neg \phi \Rightarrow fail(a, p, \phi_0)))$$
$$CA(a, \phi) \Rightarrow B(a, \exists p(result(p, \phi) \wedge allDepOK(a, p)))$$

- AllDepOK includes all the constraints that need to apply for actor a to execute plan p.
- The formalization of CW (Committed Want), CA (Committed Able) were adopted from Yves Lesperance's PhD thesis.

The delegation problem

- The delegation problem takes as input a collection of actors and their goals, and selects a suitable network of dependencies for fulfilling all actor goals, given constraints on what dependencies are allowed.



Solving the delegation problem

- The delegation problem can be solved with an AI planner.
- But we need to specify more details for any one problem:
  - ✓ Type(g : goal; gt : gtype) – goals can have a type
  - ✓ Order(g1 : goal; g2 : goal) – fulfill g1, then g2
  - ✓ CanSat(a : actor; g : goal) – a can solve g
  - ✓ CanSatT(a : actor; gt : gtype) – a can solve gt goals
  - ✓ Wants(a : actor; g : goal) – a wants g
  - ✓ CanDep(a1 : actor; a2 : actor) – a1 can depend on a2
  - ✓ CanDep4gt(a1: actor; a2 : actor; gt : gtype) – a1 can depend on a2 for goals of type gt
  - ✓ CanDep4g(a1: actor; a2: actor; g: goal) -- a1 can depend on a2 for g.

Experimental evaluation

- Bryl used three criteria for selecting the best plan:
  - ✓ Number of actions in a plan
  - ✓ Overall plan cost
  - ✓ Degree of satisfaction of quality requirements
- The LPG-td planner was used in her experiments [LPG].
- The planner can solve problems involving <10 actors and up to 25 goal graphs of modest size.

Social commitments

- A commitment **C(debtor, creditor, antecedent, consequent)** is a promise from a ***debtor*** to a ***creditor*** to achieve the ***consequent*** if the ***antecedent*** holds.
- The debtor and creditor are actors, antecedent, consequent are propositions describing states-of-affairs.
- Examples:
  - ✓ C(Ebook, Alice, $12payment, BraveNewWorld)
  - ✓ C(Amit, John, vacation, lecture-on-commitments)
  - ✓ C(Alice, Barbara, goodWeather, goOnTrip)
  - ✓ C(UniTN, Fabiano, passExams, getDegree)

[Credits for these notes on commitments: Amit Chopra]

Commitments are everywhere …

- Examples:
  - ✓ A book loan
  - ✓ An airline ticket
  - ✓ A flier announcing a concert
  - ✓ Discount flier at the supermarket
  - ✓ All-you-can-eat ad
  - ✓ Money-back warranty
  - ✓ Contracts!
- Why? Because they make the world more predictable by imposing minimal constraints on actors' behaviour, while respecting their autonomy.

Reasoning with commitments

- Detach: makes a conditional commitment unconditional

  $C(\text{EBook}, \text{Alice}, \$12\text{payment}, \text{BNW}) \wedge \$12\text{payment} \Longrightarrow$

  $C(\text{EBook}, \text{Alice}, \top, \text{BNW})$

- Discharge: $u \Longrightarrow \neg C(x, y, r, u)$
- For example,

  $\text{BNW} \Longrightarrow \neg C(\text{EBook}, \text{Alice}, \$12\text{payment}, \text{BNW})$

  $\text{BNW} \Longrightarrow \neg C(\text{EBook}, \text{Alice}, \top, \text{BNW})$

Operations on commitments

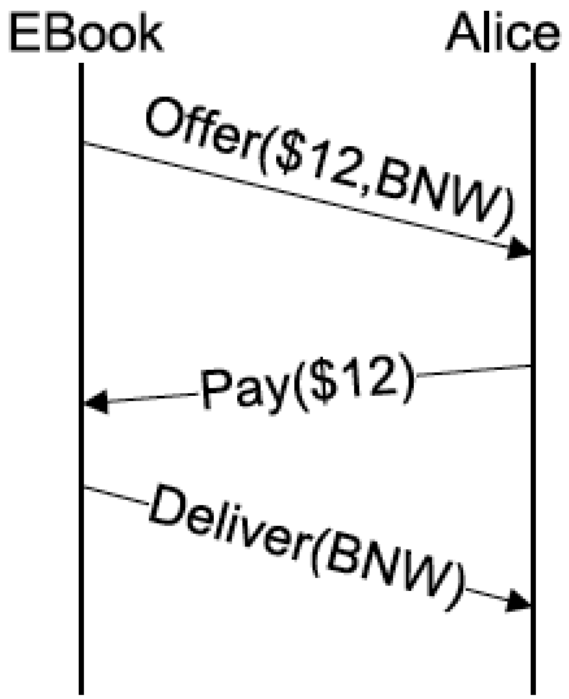
- CREATE(C(x, y, r, u)): performer x, effect C(x, y, r, u)
- CANCEL(C(x, y, r, u)): performer x, effect ¬C(x, y, r, u)
- RELEASE(C(x, y, r, u)): performer y, effect ¬C(x, y, r, u)
- ASSIGN(C(x, y, r, u), z): performer x, effect
  ¬C(x, y, r, u) ⋀ C(x, z, r, u)
- DELEGATE(C(x, y, r, u), z): performer x, effect
  ¬C(x, y, r, u) ⋀ C(z, y, r, u)
- For example,

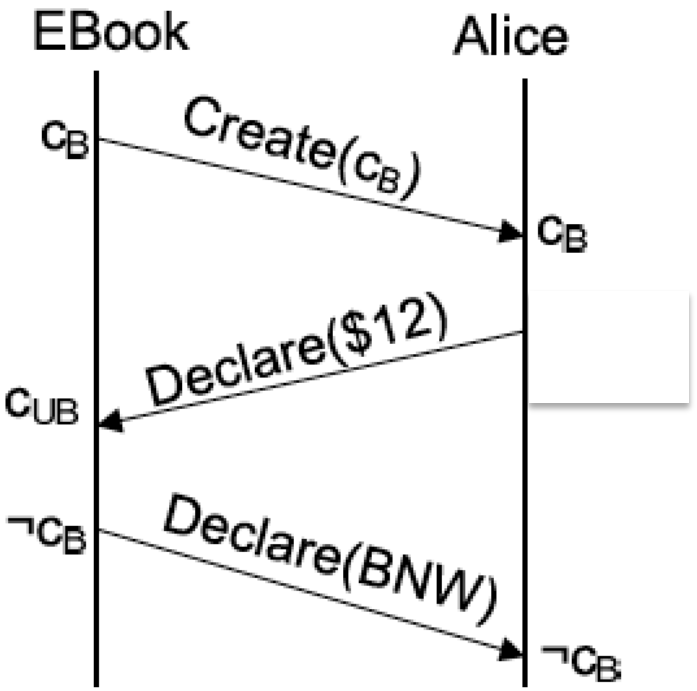
  DELEGATE**(**C**(**EBook**,**Alice**, $**12payment**,**BNW**),**Charlie**)** ⇒
  C**(**Charlie**,**Alice**, $**12payment**,**BNW**)**

  ASSIGN**(**C**(**EBook**,** Alice**, $**12payment**,**BNW**),**Bob**)** ⇒
  C**(**EBook**,**Bob**, $**12payment**,**BNW**)**

Commitments come and go via events

- C_B := C(EBook, Alice, $12payment, BNW))
- C_{UB} := C(EBook, Alice, $\top$, BNW))

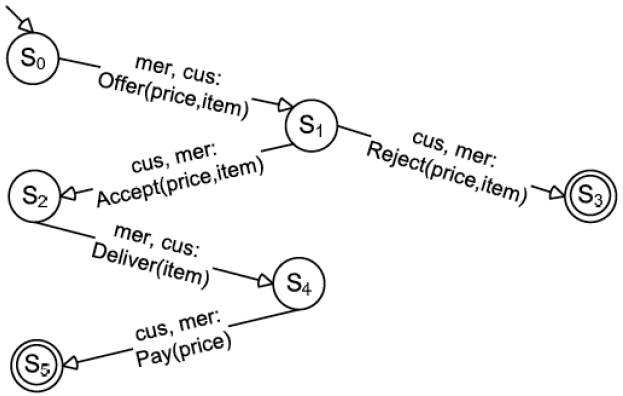




Events ***Meaning***

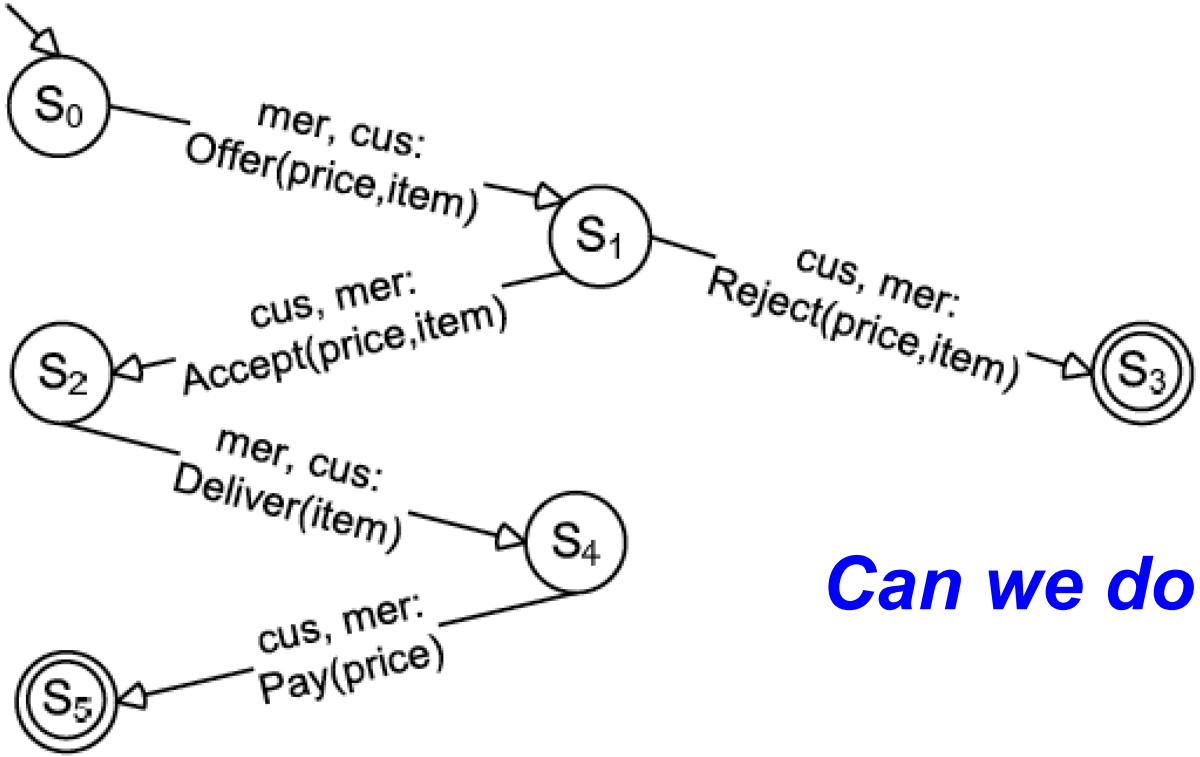
Protocols

- A protocol consists of a sequence of events that create/ discharge commitments among roles.
- For example, a buyer-seller protocol creates a 'sell' commitment upon an offer, which becomes unconditional when a payment is made, and then is discharged when the book is delivered.
- Protocols have been traditionally modelled as state machines/Petri nets, etc.



Challenge: flexible protocols/processes

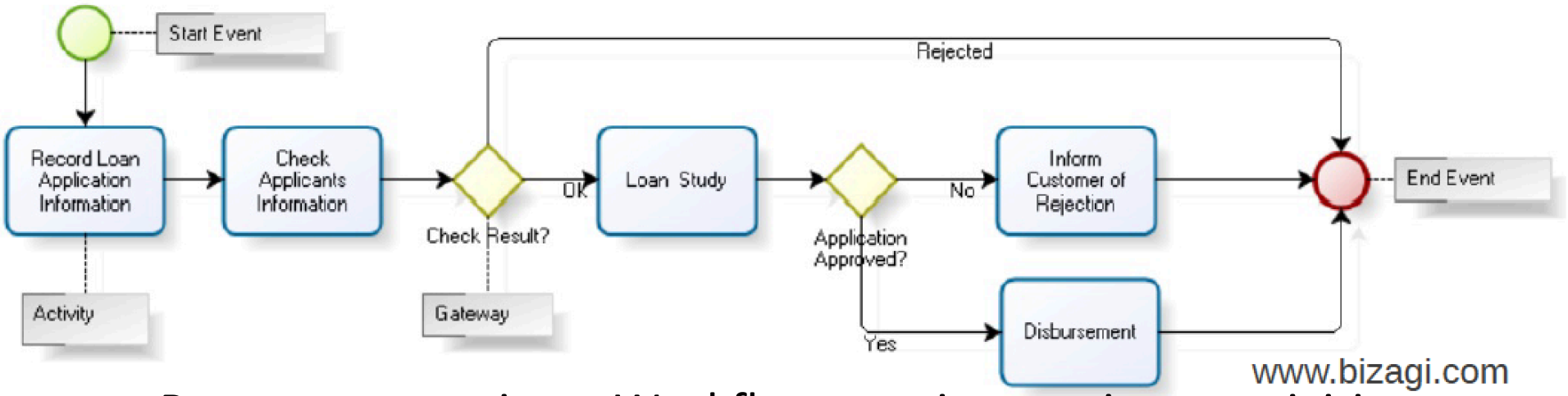
- It is well-known that Petri net/state machine models were intended for ***system*** processes not ***business*** processes as they are not flexible enough and are often violated.



Can we do better?

How to model business processes?

- Right now they modelled as activities and control flows, see BPMN.



- Process execution: Workflow engine assigns activities to performers
- Exception handling by changing assignments, follow alternative flow paths.

Can we do better?

A specification language for business processes (Azzurra)

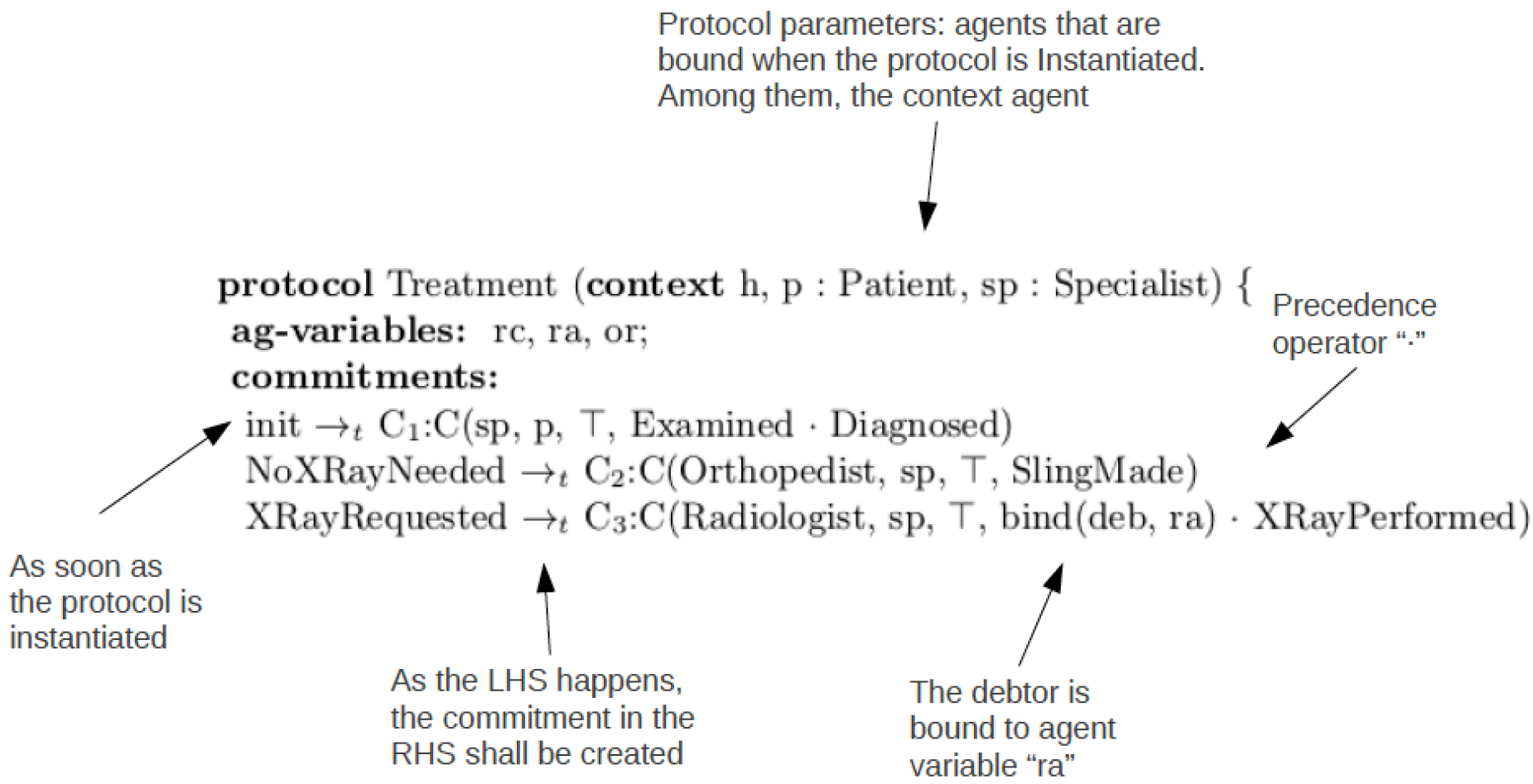
- A business process is specified as a collection of commitments [Dalpiaz15].
- Consider doctor Maria and her commitments:
  - ✓ C1 to head clinician: “Make the daily rounds”
  - ✓ C2 to nurse Zena: “Visit patient Tom by noon”
  - ✓ C3 to secretary Jane: “Fill weekly report by 4pm”
- Here, there are no activities to be performed only outcomes that have to become true, because that’s what commitments are all about!

Azzurra concepts

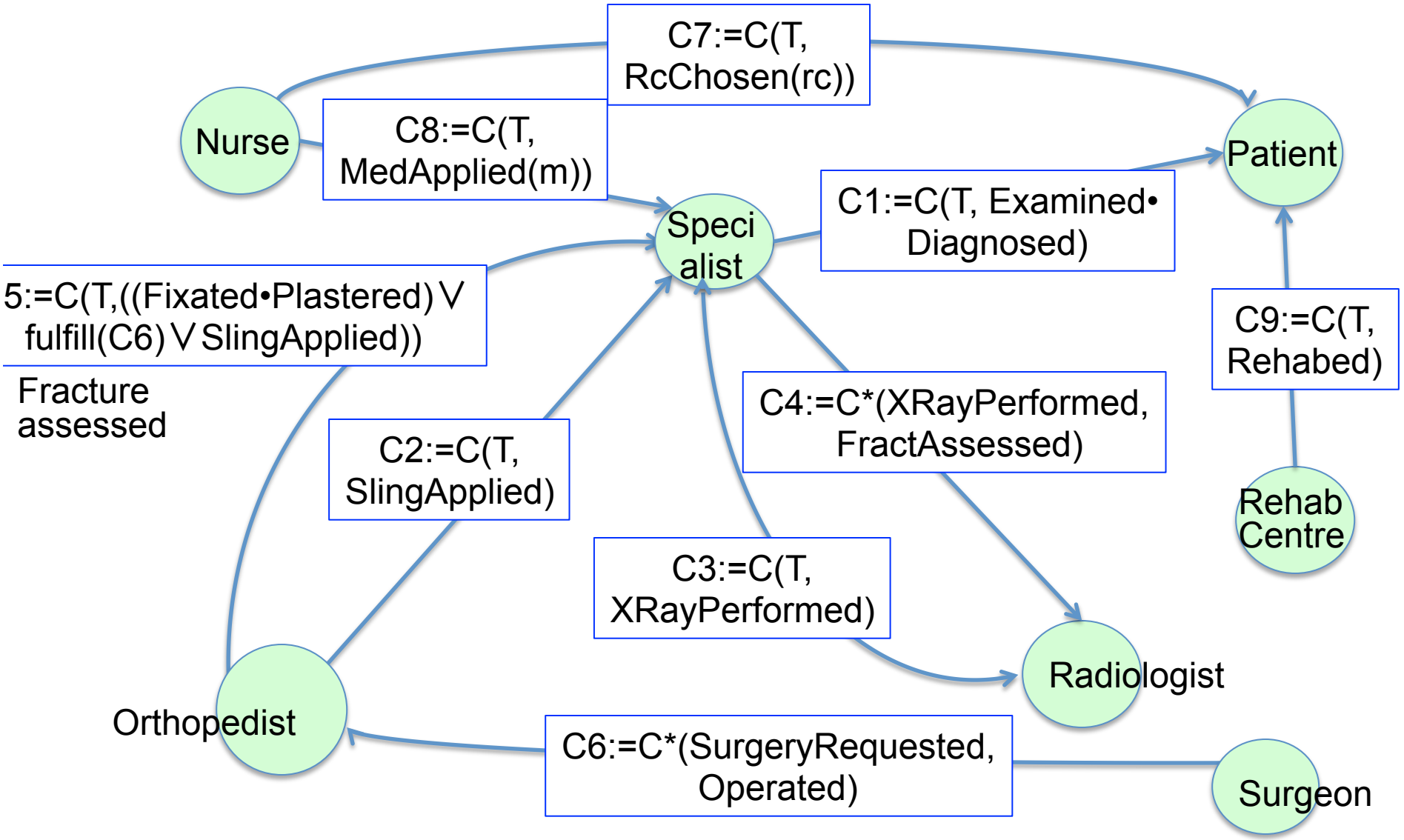
- Agents: Paolo, Vitor
- Roles: Professor, PhDStudent, Postdoc
- Commitment C(x,y,r,u): promise by debtor x to creditor y to make consequent u true if antecedent r becomes true.
- Strong commitment C*(x,y,r,u): promise by debtor x to creditor y to make consequent u true ***after*** antecedent r becomes true.
- Conditional commitment is a commitment that becomes true when a condition holds COND → C(x,y,r,u)
- A protocol declares commitments between roles, as in

C(SeminarOrg, Presenter, TalkDetailsSent, TalkAnnounced)

Example: Fracture treatment protocol



Graphical syntax by example



Reasoning with Azzurra specifications

- Given a sequence of input events such as

  instantiated(Treatment(RGH, John, Maria)),

  instantiated(C1(⋯), Examined(Maria, John),

  Diagnosed(John), noXRayNeeded, ⋯

determine if this is compliant with the specification, and if so, what is the final state of the protocol execution.

Smart contracts

• These are software IoT systems that monitor executions of a contract to ensure that terms are complied with, detect violations and assign blame.

• You can think of them as legal processes, where contract participants are legally bound to do as the contract says.

• Example: Importing meat from Brazil, a contract between a Canadian supermarket chain, a Brazilian meat producer, trucking companies in Brazil and Canada respectively, and a shipping company.

• Here the focus of smart contract software is on ***compliance*** and ***control***.

Smart contract for meat importing

- Receives event logs when meat has been transferred from the producer to the truck company (Brazil), truck company to shipping company etc.
- Receives log when the quality of the meat has been checked, e.g., “should be AAA”, either through sensors or by relying on a human agent.
- Receives logs sent by temperature sensors to ensure that the meat remains refrigerated throughout the trip, except for <2hr periods.
- Checks that no parts of the shipment are substituted with inferior or harmful alternatives.

Smart contracts and blockchains

- For a smart contract to have legal status, the integrity of its data must be guaranteed.
- That's where blockchain technology comes in! This technology ensures that the logs of events recorded in the blockchain ledger (and checked for compliance by smart contract) can't be tampered with.
- Many software companies are selling smart contract systems to supermarket chains, banks, governments, etc.
- What they are actually selling is IoT programs implemented on a blockchain platform.

(SE) Research questions

- Traditionally, software requirements were about ***functions*** and ***quality constraints*** for a system-to-be; but smart contracts are about ***obligations*** and ***powers*** on social agents (aka ***parties)*** and constraints thereof.
- A (formal) specification for a smart contract consists of bilateral obligations and powers with constraints, very different from a specification for vanilla software.
- How do we generate semi-automatically blockchain code from formal specifications?
- Analyzing smart contract specifications using model checkers, SMT solvers, etc.
- How to generate semi-automatically smart contract specifications from natural language?

Symbolaio: Specifications for contracts

- Defined a formal contract specification language
  - ✓ Primitive concepts include ***obligation***, ***power, role, time point/interval***;
  - ✓ Lifetime semantics for obligations, powers;
  - ✓ Limited expressively to Propositional Logic+;
- Working on an analyzer for contract specifications that takes as input a tagged sequence of events

  e1, e2, ⋯, en compliant

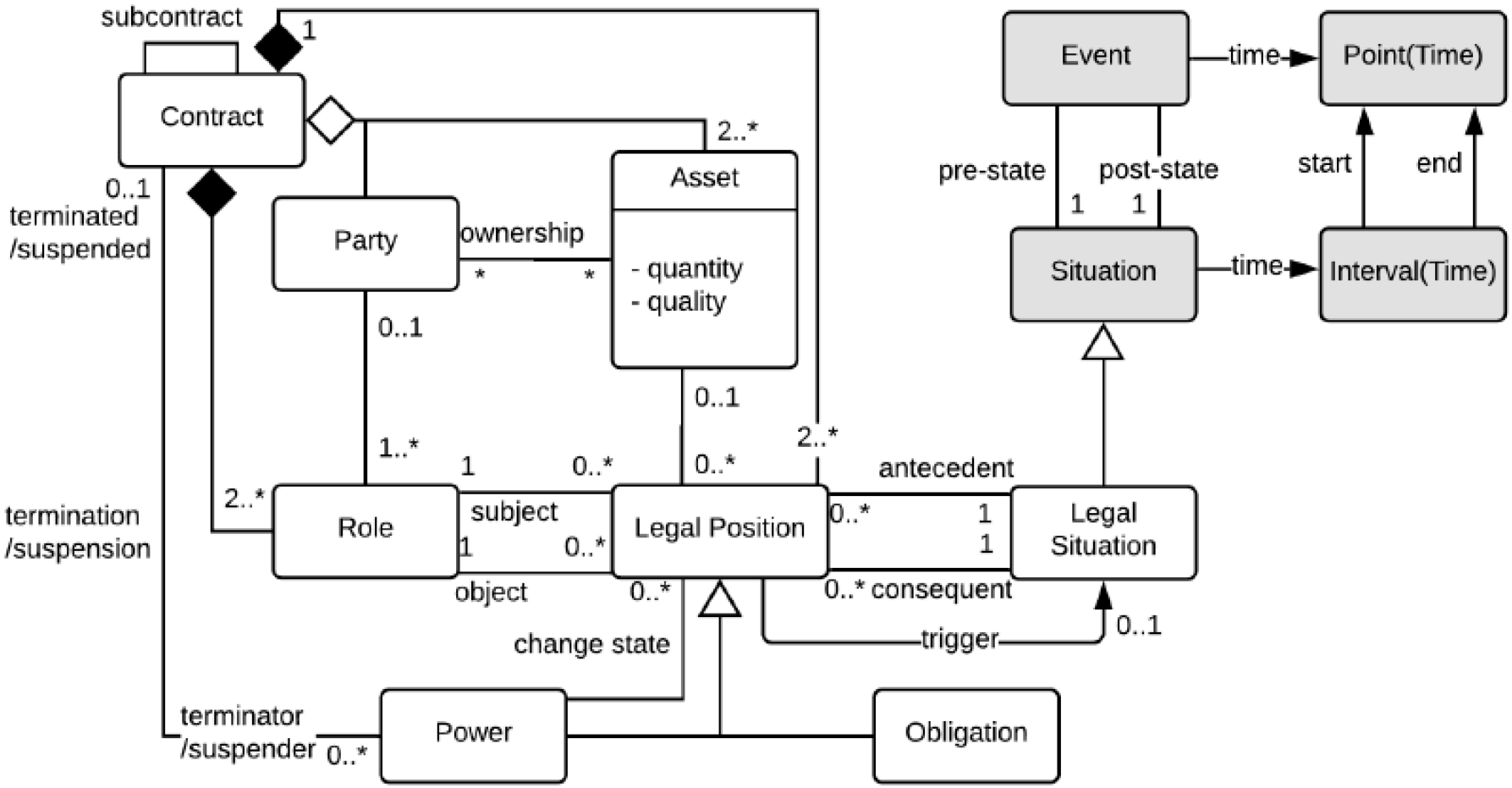
  e1', e2', ⋯, em' non-compliant

and returns CORRECT/INCORRECT, depending on whether the tag is correct or not.

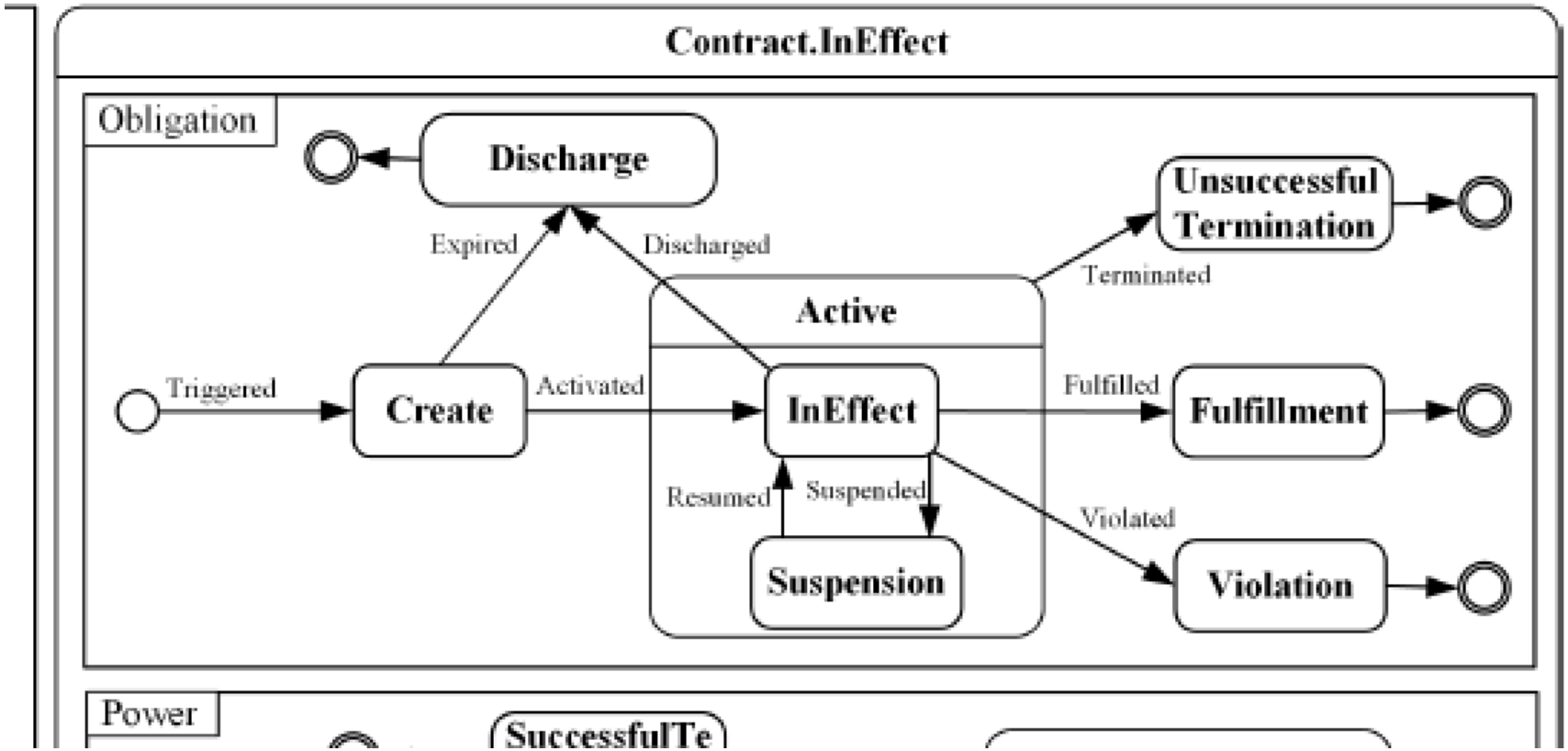
Interesting features

- ***Powers***: these are rights that parties have to change other obligations and powers.
- For example,
  - ✓ "Seller has the power to charge 1.10% the sales price if Buyer is late in paying"
  - ✓ "Money back warranty": "Buyer has the right to get money back if not happy with the purchased goods"
- ***Surviving obligations*** continue to apply after contract execution terminates.
- ***Sub-contracting***, can be done at contract execution time.

Ontology for contracts

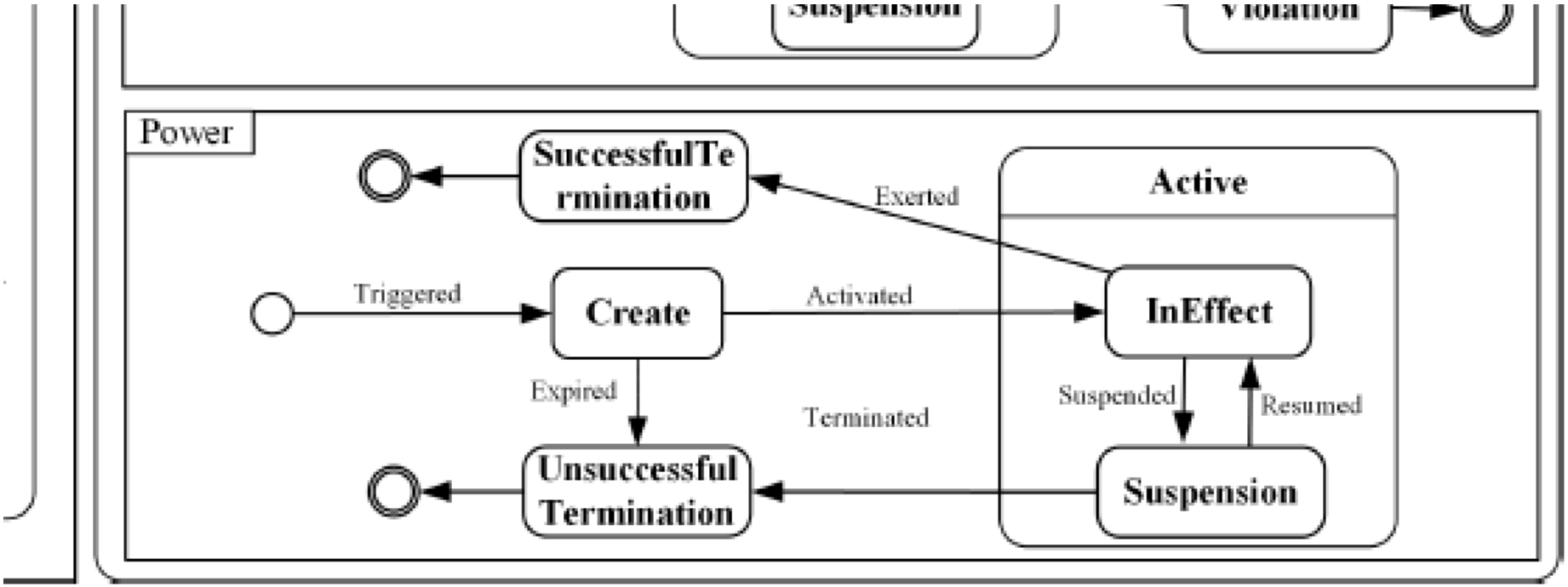


Semantics for obligations



- Semantics consists of defining axioms that specify when do transition events occur; for example "'activated' occurs when the antecedent of an obligation becomes true"

Semantics for powers



Meat purchase and sale agreement

Between Seller and Buyer: This agreement is entered into as of the date **<eDate>**, between **<party1>** as Seller with the address **<retAdd>**, and **<party2>** as Buyer with the address **<delAdd>**.

Terms and Conditions

1. **Payment & Delivery:** (a) Seller shall sell an amount of **<qnt>** meat with **<qlt>** quality (“goods") to the Buyer; (b) Title in the goods shall not pass on to the Buyer until payment of the price has been made in full; (c o The Seller shall deliver the order in one delivery within **<delDueDateDays>** days to the Buyer at its warehouse; (d) The Buyer shall pay **<amt>** (\price") in **<curr>** to the Seller before **<payDueDate>**; (e) In the event of late payment of price due, the Buyer shall pay interests equal to **<intRate>**% of the price.

2. **Assignment:** The rights and obligations are not assignable by Buyer.

3. **Termination:** (a) Any delay in delivery of the goods will entitle the Buyer to terminate the Contract if it exceeds 10 Business Days.

4. **Confidentiality:** (a) Both Seller and Buyer must keep the contents of this contract confidential during the execution of the contract and for six months after the termination of the contract.

Contract domain

- ✓ Seller ***isA*** Role ***with*** returnAddress : String;
- ✓ Buyer ***isA*** Role ***with*** warehouse : String;
- ✓ Meat ***isA*** PerishableGood isA Asset ***with*** quantity : Integer,
  quality : MeatQuality;
- ✓ Delivered ***isA*** Event ***with*** item: Meat, deliveryAddress :
  String, delDueDate : Date;
- ✓ Paid ***isA*** Event ***with*** amount : Integer, currency : Currency,
  from : Buyer, to: Seller, payDueDate: Date;
- ✓ Currency ***isA*** Enumeration(`CAD', `USD', `EUR');
- ✓ MeatQuality ***isA*** Enumeration(`PRIME', `AAA', `AA', `A');
- ✓ …

Contract declarations and conditions

Contract meatSaleC(buyer: Buyer, seller: Seller, qnt: Int, qlt: MeatQuality, amt: Int, cur: Currency, payDueDate: Date, delAdd: String, eDate: Date, del#Days: Int, intRate : Int)

Declarations

goods: Meat ***with*** quantity := qnt, quality := qlt;

delivered: Delivered ***with*** item : goods, deliveryAddress := delAdd, delDueDate := eDate + delDueDatedays;

paid : Paid with amount := amt, currency := curr, from := buyer, to := seller, dueD := payDueDate;

paidLate: Paid with amount := (1 + intRate)*amt, currency := curr, from := buyer, to := seller;

Precondition isOwner(goods, seller);

Postcondition

isOwner(goods, buyer) AND not(isOwner(goods, seller));

Contract obligations

Obligations

o1 : O(seller, buyer, true, happenBefore(delivered,
delivered.delDueDate));

o2 : O(buyer, seller, true, happensBefore(paid,
paid.payDueDate));

o3 : violates(o2) → O(buyer, seller, true,
happens(paidLate,));

SurvivingObligations

so1: SO(seller, buyer, true, keepConfidential);

so2: SO(buyer, seller, true, keepConfidential);

- keepConfidential is defined as “There is no third party that knows the terms of this contract during the execution of the contract and 6mo after”.

Contract powers

Powers

p1: P(seller, buyer, violates(o2 OR o3), suspends(o1));
p2: P(buyer, seller, happensWithin(paidLate, suspension(o1)), resumes(o1));
p3: P(buyer, seller, not(happensBefore(delivered(goods), delivered.delDueDate + 10days), discharges(o2 AND o3) AND terminates(meatSaleC));

Constraints

not(buyer = seller);
∀ o(CannotBeAssigned(o: Obligation);
∀ p(CannotBeAssigned(p: Power);

- Powers are rights that parties have to change another obligation/power, i.e., cancel it, suspend it, etc.

Summary

- Social dependency models are useful not only for specifying requirements assignments in RE, but also for specifying business and legal processes.
- ***Commitments*** constitute a better-developed and formalized variant of *i** ***actor dependencies***.
- Legal ***Obligations/Rights*** are variants of commitments that are legally binding, and therefore have consequences if not complied with.
- The notion of ***power*** is perhaps the most interesting variant among social dependencies in that it allows for a legal process to change completely, depending on what happens with the compliance of initial obligations.

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