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A Generic Ontology of Rational Negotiation

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The Outlook

- **Focus**: modeling aspects, minimal technical details (the rest – in the paper)
- **Why** to model negotiation? In a generic way?
 - **YU.Inc** scenario – the example (quite a generic case)
 - Negotiations on Who is (becomes) Who in **Yu.Inc**
- **Framework** to model negotiations illustrated by **Yu.Inc**
- Outline of the **usage** (engineering design, no politics)
- **Conclusions** and future work

Why to Model Negotiation?

- Walton and Krabbe's typology – six dialogue types which differ by their pragmatic content:
 - persuasion, negotiation, inquiry, information seeking, deliberation, eristic
- We are interested in rational encounters ...
 - Resulting in pragmatic actions
 - To be effectively and efficiently coordinated using rational motives
- **Negotiation** – the most fundamental and powerful means (e.g., Jennings)
 - **Generic** enough to model a wide range of settings
 - Auctions, contracting, bargaining, coalition formation, ...

Yu.Inc

The Adventure of Coalition Formation

Family Business has to be efficient!
Need the team of executives



Mr. Yu
The Founder
22% of shares

Coalition with control package, CEO, CFO, The Board of Trustees,



Mr. Yahoo
of Yahoo Corp
38% of shares

- I'm the most influential and efficient
- Was the CEO before
- Ready to collaborate
- Shall dominate the coalition
- Can guarantee 12-16% growth in sales
- My opposition will destabilize the Co

- Well, I'm loosing influence, indeed
- I'm still professional, employees like me and trust me



Mr. Santa
of Santa Corp
11% of shares

- Honesty is my dominant feature
- I can be the CEO if you support me
- I can be the CFO
- My 11% may become an important thing on the table

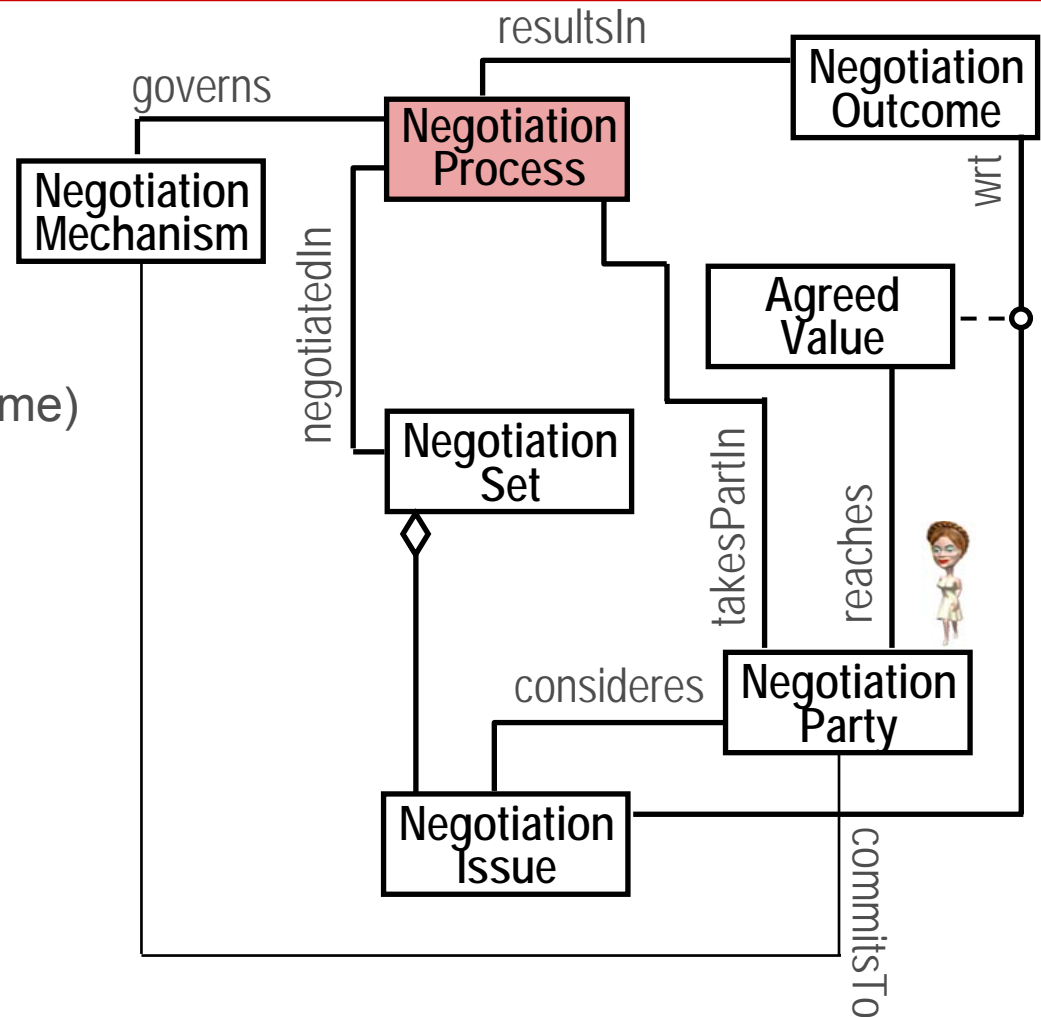
- Hey, dear, you promised me the CEO's chair
- He won't disturb us if we have Santa
- Shall we appoint Santa as CFO?
- Well, I was the CEO and want want want it again
- You know, I'll do whatever you say, ... effectively



Ms. Jolie
of Jolie Corp
28% of shares

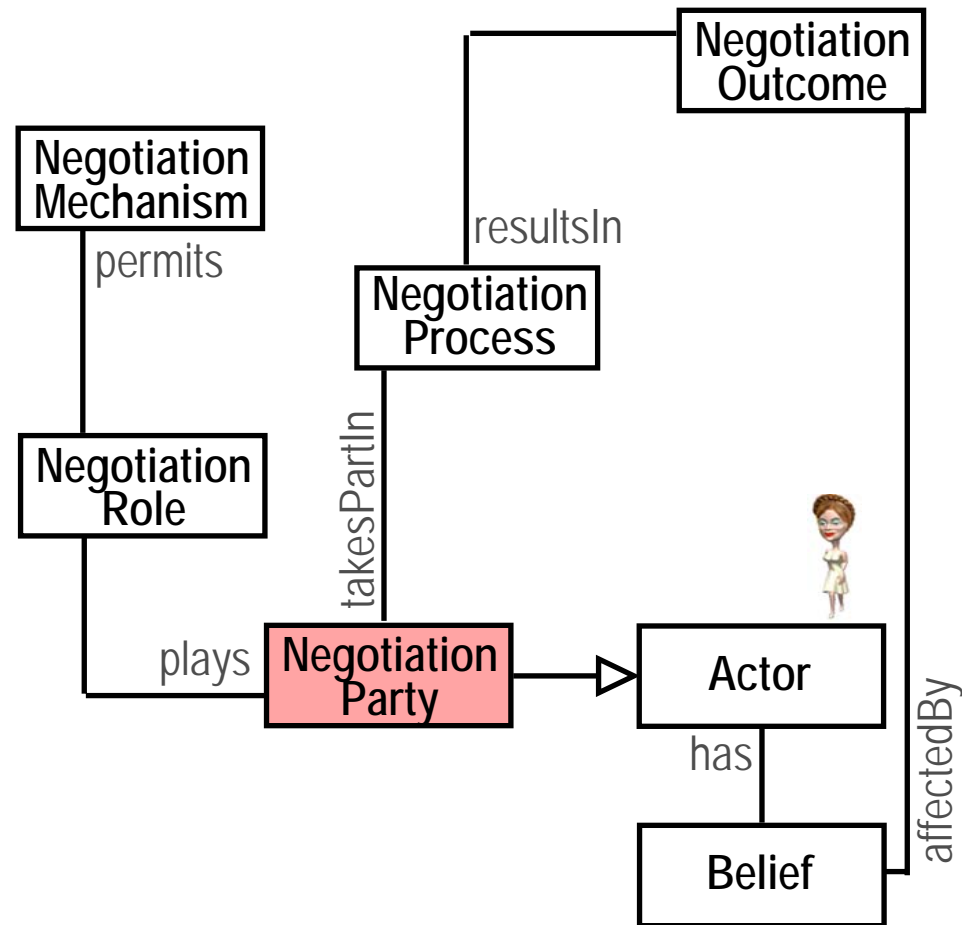
Negotiation Process

- Governed by a **Negotiation Mechanism**
- **Negotiation Parties** (aim to reach common **Agreement** on the **Negotiation Issues**)
 - commit to the **Negotiation Mechanism** (the rules of the game)
 - Apply their **private** rational behaviors
 - **Communicate**
 - Content: offers, counter-offers, arguments, counter-arguments
 - **Concede**
- **Negotiation Set**
- **Negotiation Setting** – the configuration of a **Negotiation Process**



Negotiation Party

- Participant of the **Negotiation Process**
- An **Actor**, representing him/herself or the group
 - Has **beliefs** about the other parties
 - Assumed to be **rational**:
 - Will not act in a way or agree upon an outcome which lowers own **Utility**
 - Even if this outcome may bring extra **Utility** to the other **Parties**
- Plays the Role in the **NP**
 - **Negotiation Roles** frame out the **Goals**, the **Commitments**, and the **Strategies** of the **Parties**



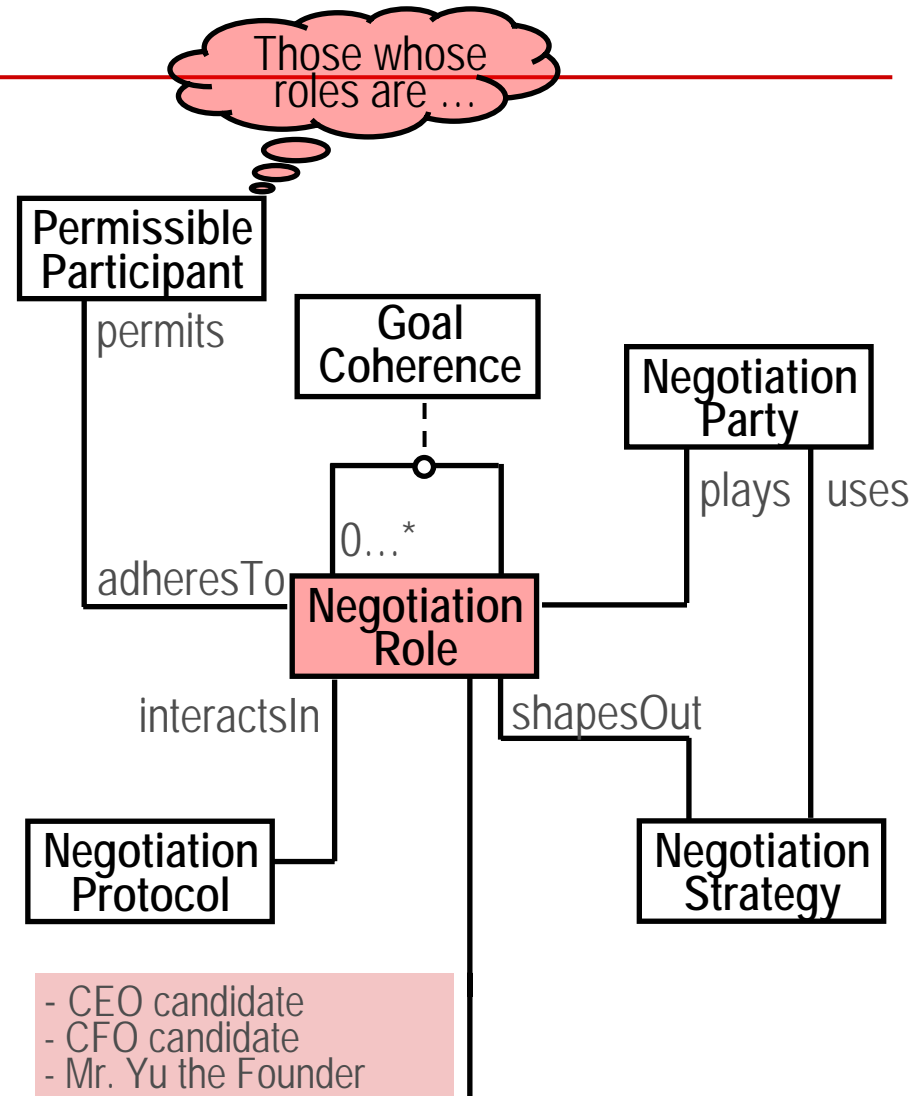
Utility

- Represents rational motivations of **Negotiation Parties**
- A **Utility Function** assigns a number for every possible **Negotiation Outcome**
 - The higher the number – the more preferred the outcome is
 - Ordinal UF – only the **relative rankings** are important, but no quantity is actually being measured
 - I'd prefer to become the CEO much (57.25%) more than to become the CFO
 - Cardinal UF – **quantities** are measured
 - My valuation of the CEO's chair is 3,000 **Utility Units** (UU)
- Are used in **Negotiation Strategies** to reason about possible **Negotiation Outcomes**
- Is not money, broader, a useful analogy
- Problem: all the **Parties** to use the same measure and units



Negotiation Role

- **Behavior pattern** of a **Permissible Participant** of a **Negotiation Process**
- Shapes out:
 - The configuration of the party's **Negotiation Strategy**
 - The attitudes to the other parties
 - Attitude – pre-disposition to collaboration with the other parties
- A **Party** (playing one **Role**) is eager to **collaborate** with another **Party** (playing another **Role**) if their goals are coherent

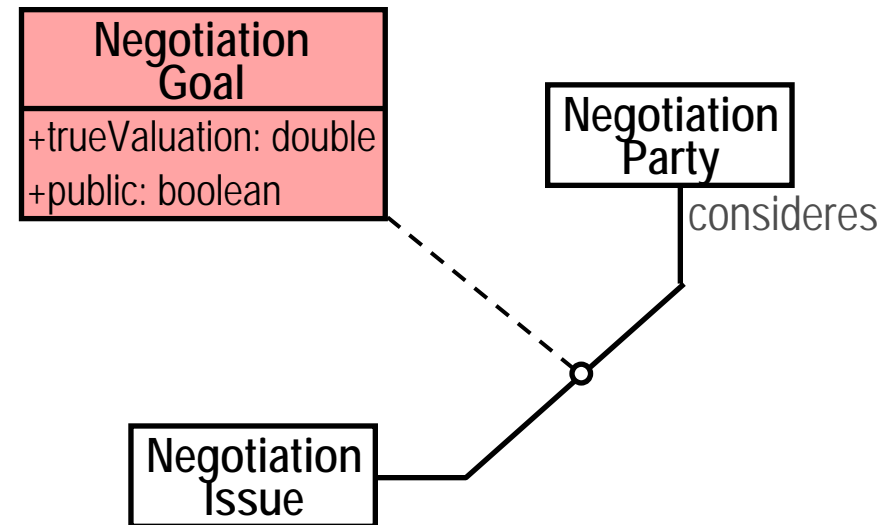
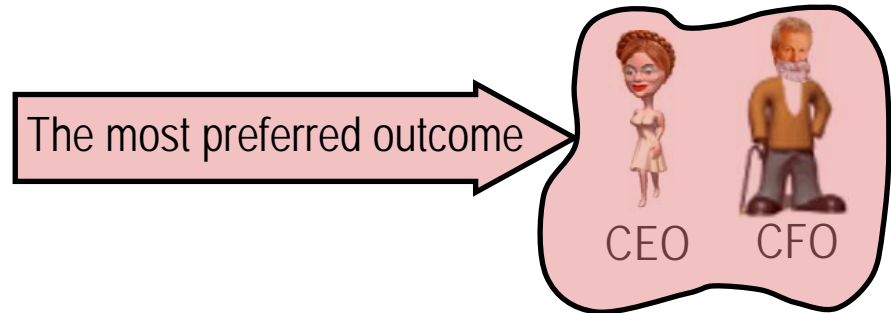


Negotiation Goal(s):

- I wanna be the CEO by all means
- I wouldn't object **Sa** becomes the CFO
- I'll better die (politically) than allow **Yh** to become the CEO



- The **goal** pursued by a **Negotiation Party** in the **Negotiation Process**
- The **state of affairs** which:
 - May be reached in the Negotiation Process
 - Is specified in the terms of the true valuations of the Negotiation Issues comprising the Negotiation Set
 - Is most preferred by the party among the other possible states of affairs (the highest **Utility**)
- The specification of the **goal** is framed by the **Negotiation Role**
 - Coherent, neutral, conflicting



Private vs Public Goals

- **Private**: the goals are not revealed to public (the other parties)
 - E.g., in Classical English auction
- **Public**: true valuations are:
 - Either explicitly exposed
 - Or may be implicitly revealed in communication
 - E.g., in Vickrey Auction

- Public
- valuations
- I wanna be the CEO by all means
 - I wouldn't object Sa becomes the CFO
 - I'll better die (politically) than allow Yh to become the CEO

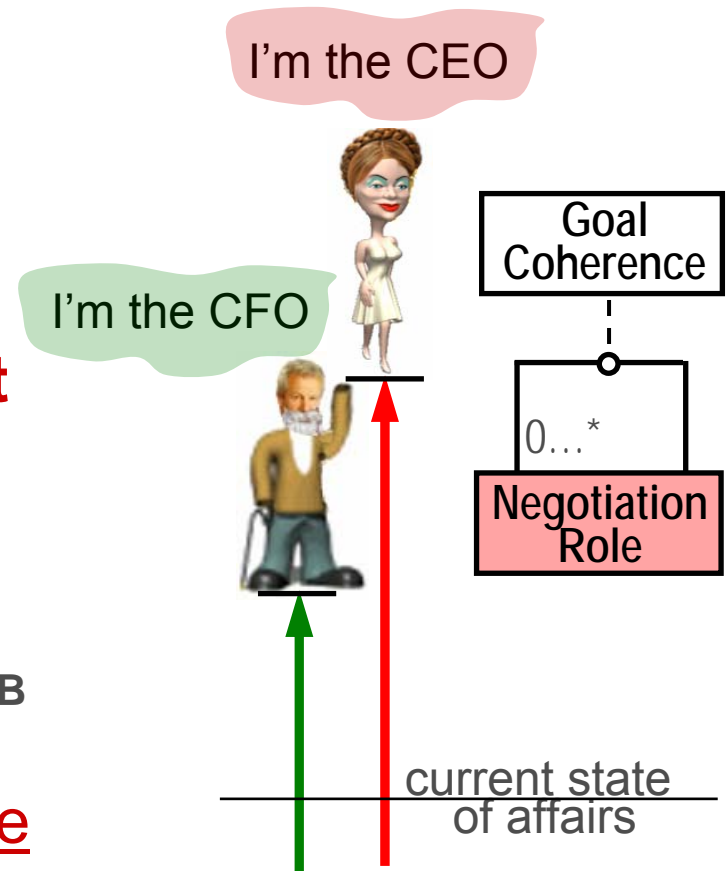


Private – nobody is informed about the VALUATION of such a death



Coherent, Neutral, Conflicting Goals

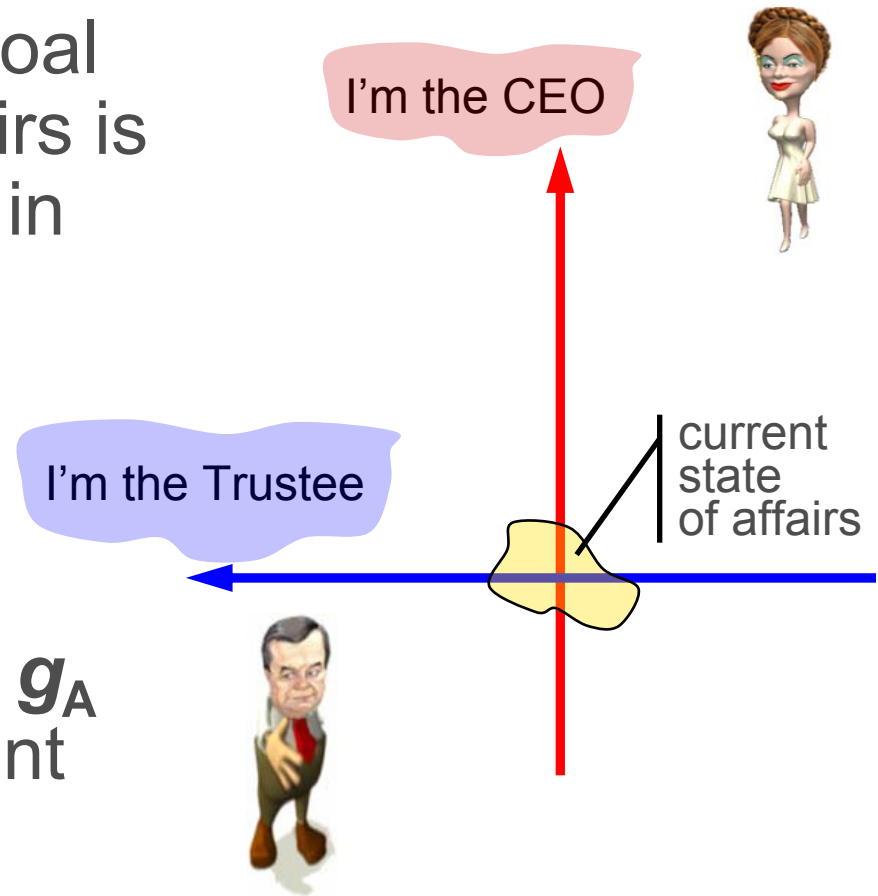
- The distance between the goal and the current state of affairs is measured by the difference in **Utility**
- A goal g_A of the party **A** is **coherent** to the goal g_B of the party **B** if they are mutually facilitating
 - **A** is **closer** to g_A → **B** is **closer** to g_B
 - **Negotiation Roles** are Cooperative



Coherent, Neutral, Conflicting Goals

- The distance between the goal and the current state of affairs is measured by the difference in **Utility**

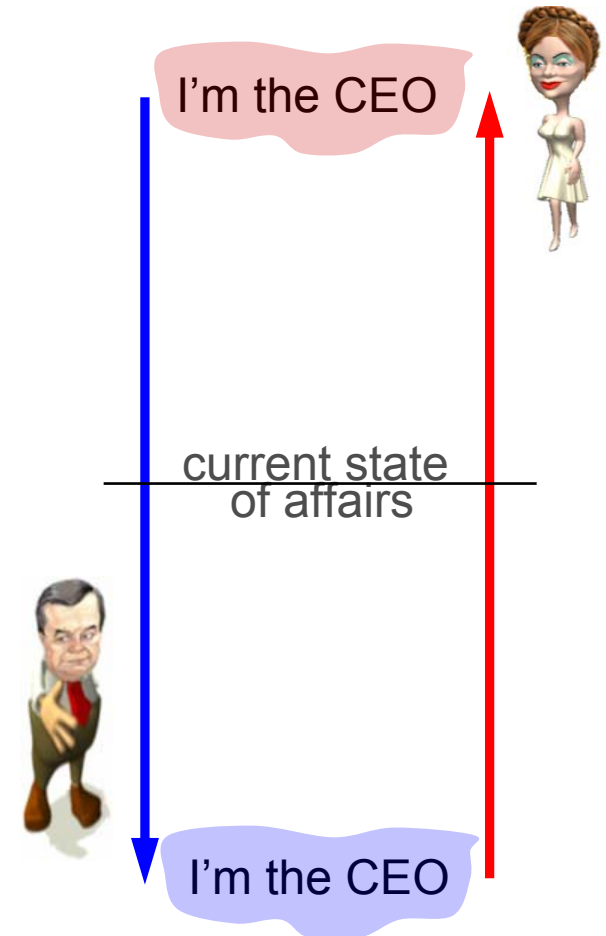
- A goal g_A of the party **A** is **neutral** to the goal g_B of the party **B** if the movement of **A** towards g_A does not affect the movement of **B** towards g_B



– Negotiation Roles are Cooperative

Coherent, Neutral, Conflicting Goals

- The distance between the goal and the current state of affairs is measured by the difference in **Utility**
- A goal g_A of the party **A** is **conflicting** to the goal g_B of the party **B** if:
 - **A** is **closer** to g_A → **B** is **farther** to g_B
 - And vice versa
- **Negotiation Roles** are Competitive



Negotiation Set

- The set of matters or **Issues** negotiated in the **Negotiation Process**

$$NS = \{NI, \dots, NI\}$$

- **Negotiation Parties** aim at reaching an agreement on the values of the **NI**
- Single-issue negotiation: $|NS| = 1$
- Multi-issue negotiation: $|NS| > 1$



NI: becomes the CEO

Valuation: 3,000 UU

Agreed value: 4,000 UU

Negotiation Setting: Symmetric vs Non-Symmetric

- **Symmetric** wrt the **Parties** involved:
 - **Roles** played by the **Parties** are similar
 - The parts of the **Beliefs** revealed to the other **Parties** are similar
 - How to find out?
 - **Parties** normally have Neutral or Coherent **Goals**
 - Their **Negotiation Roles** are Cooperative
- **Non-symmetric**:
 - Differences in the **Roles** of the **Parties**
 - Shared **Beliefs** differ
 - The **Goals** may be Conflicting
 - The **Roles** may be Competitive



Non-symmetric:
- Private Goals
- Conflicting Goals
- Competitive Roles

Negotiation Setting: Single-Issue vs Multi-Issue

- An NI_A is independent from the other NIs in the NS if the agreement on NI_A doesn't affect the agreement on the other
- If an NI is independent it can be negotiated separately:
 - Decomposition of a Multi-Issue Negotiation into the series of a simpler Single-Issue Negotiations
- An NI_A is dependent on the other NIs if the agreement on the latter affects the agreement on NI_A
 - If the NIs are dependent decomposition is impossible
- Dependencies among NIs may be formalized by SWRL rules



I'm the
Trustee



I'm the
CEO



I'm the
CFO



I'm the
CEO

Negotiation Setting: 1 - 1, 1 - m, m - m

- **1-to-1** negotiation: 1 **Party** negotiates with exactly 1 opponent



If you support my appointment as the CEO I shall help you to become the CFO



- **1-to-many**: 1 representative of a **Role** negotiates with the group(s) of the representatives of (an)other **Role(s)**



We have to appoint the CEO, the CFO, the Board of Trustees

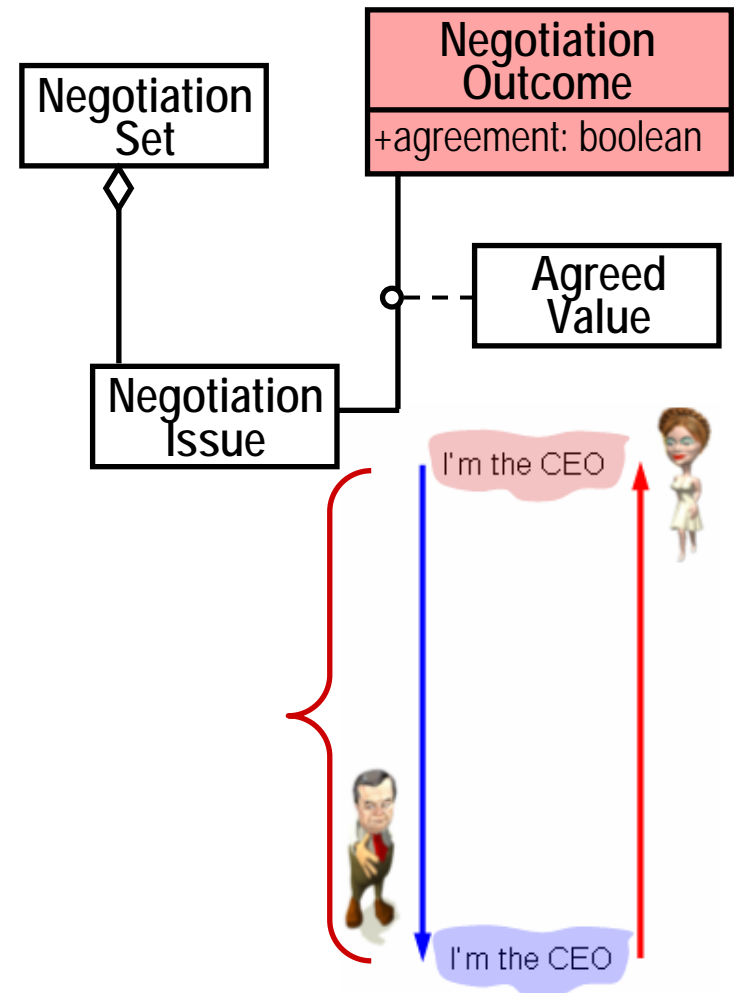


- **Many-to-many**: if there are 2 or more groups of **Parties** playing different Roles



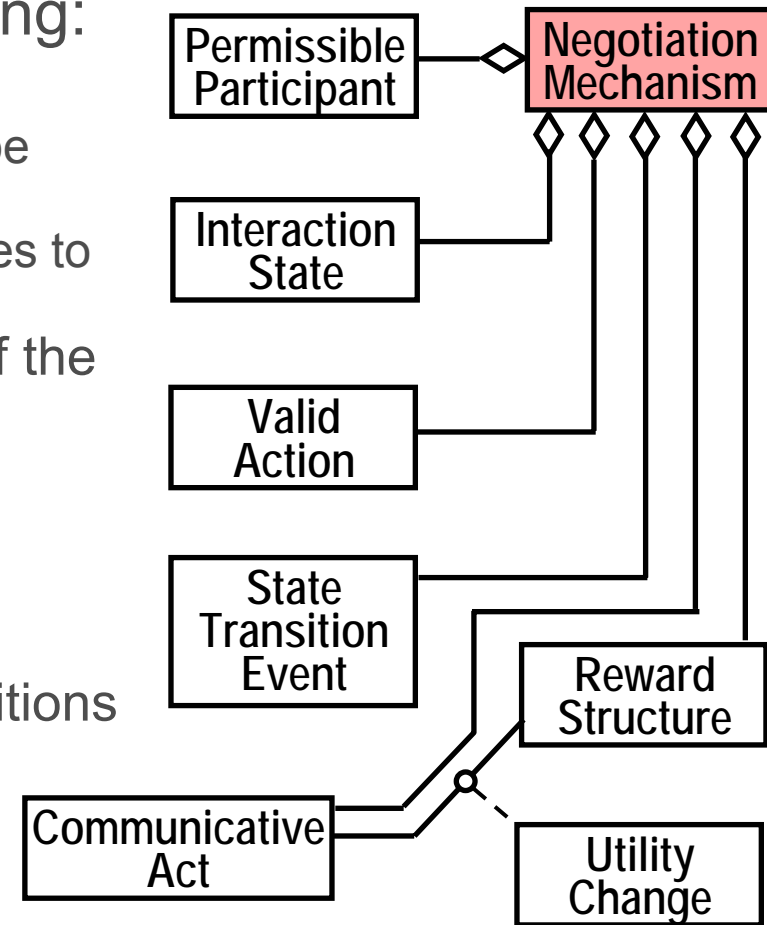
Negotiation Outcome

- **Result** of Negotiation Process
- If negotiation is successful:
 - The **agreed values** of the **NIs** comprising the **NS**
- If negotiation fails:
 - The outcome points to the **differences** in the valuations of the **NIs**
 - The **distance** not passed to reach the **goals**



Negotiation Mechanism

- The agreed rules of encounter covering:
 - **Permissible Participants** specify:
 - Which **Negotiation Roles** are allowed to be played
 - The permissions for the parties playing roles to undertake **Valid Actions**
 - **Interaction States** – the generic states of the parties, at least:
 - Initiate negotiation
 - Perform a Valid Action
 - Wait for a Communicative Act
 - Terminate negotiation
 - **State Transition Events** cause the transitions of **Interaction States**
 - Internal – produced by the **Valid Actions**
 - External, e.g., electric power breakdown



Negotiation Mechanism



- The agreed rules of encounter covering:
 - **Valid Actions** – allowed to be undertaken by the Permissible Participants
 - Followed by a **Communicative Act** to communicate the results to the other parties
 - The locus of the internal behavior of a **Negotiation Party**
 - Pro-active and flexible because of exploiting **Negotiation Strategies**
 - **Communicative Acts** – the means to construct the interaction
 - FIPA ACL
 - Communication of the required content
 - **Reward Structures** – the means to share and re-allocate the **Utility** among the parties

I have lowered my priority of the goal of having **Sa** as the CFO for the sake of becoming the CEO

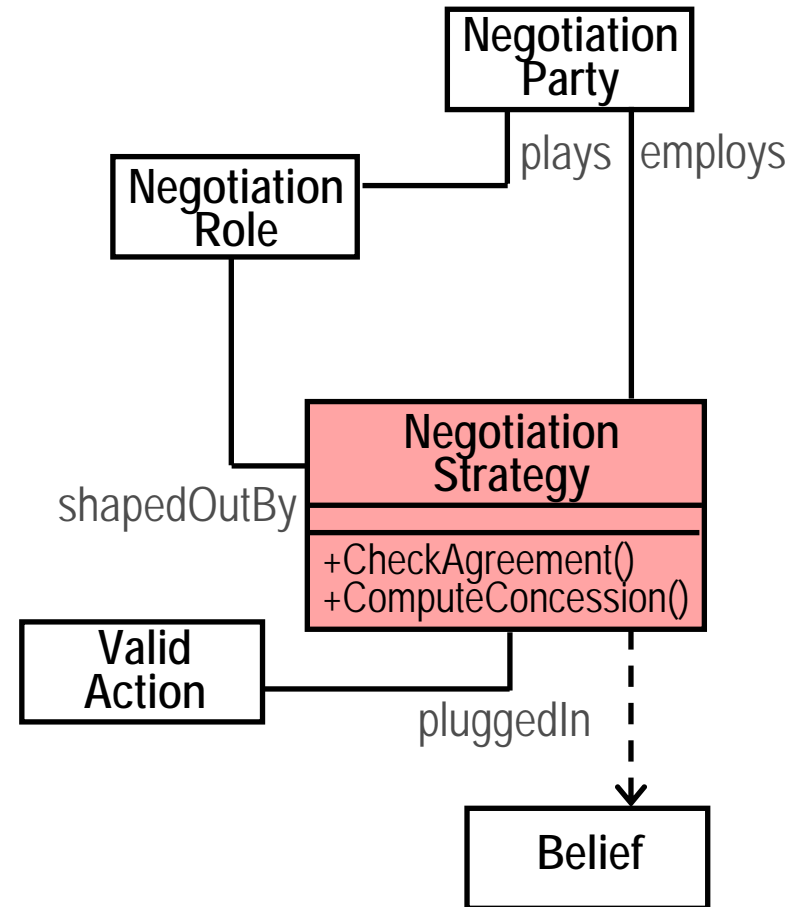
Yh may now require that **Sa** spends more utility to reach his goal

Negotiation Process: One-Shot vs Iterative

- **One-shot** – the **Outcome** is elaborated in one round
- This round normally comprises
 - A proposal by one **Party** (group)
 - The acceptance or rejection communicated by the Counterparty
- **Iterative** – the **Outcome** is reached iteratively in a series of rounds
- It is assumed that the **Parties concede** (NI valuations) towards the **Agreement** by turns in these iterations
 - The concessions are done in a rational way
 - Reasoning is undertaken in **Valid Actions**
 - **PROBLEM**: Who concedes **FIRST**???

Negotiation Strategy

- Specification of the **internal behavior** of a **Negotiation Party** playing a **Negotiation Role** in a **Negotiation Process**
- Employed to reason about the next move:
 - Compute how much to concede on the values of the Negotiation Issues
 - Check out if the Negotiation Goals are reached
 - Find out if it is rational to continue or terminate Negotiation



Outline of the Usage

Of course not in political settings, though ... if they pay ...

- Target Domain: **D**ynamic **E**ngineering **D**esign **P**rocesses
- **G**eneric **N**egotiation **O**ntology:
 - Implemented in OWL+SWRL
 - A Descriptive Framework
- Gruber's Minimal Ontological Commitment
- Refine to use:
 - Add rules
 - Add properties
 - Add instances
 - Add sub-classes
- **Tried** with Contracting negotiations on Tasks (paper)
- **In progress**: Meaning negotiation on Ontology Contexts (ISWC'05 paper)

Conclusions and Future Work

- We made our first steps on a 1,000 mile road ...
 - The **Description Framework** has been developed
 - **GNO** has been implemented (OWL+SWRL)
 - Some **refinements** were experimented with
- Adopted by **PSI Negotiation Framework**
- Anticipated to be used in the next version of **PSI DEDP-PMS Research Prototype**
- Looking forward to receiving **advice**
- Ready for **cooperation**

"... perhaps the most fundamental and powerful mechanism for managing inter-agent dependencies at run-time is **negotiation** — the process by which a group of agents comes to a mutually acceptable agreement on some matter."

- Nick Jennings

If a character has been recognized in a wrong way

- it happened by just a coincidence...

- Vadim & Natalya

Questions please ...

Off-line questions are accepted by vadim@ermolayev.com

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