# CmpE 593
# Multiagent Systems

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# Multiagent Negotiation

# Negotiation

Negotiation is central to adaptive, cooperative behavior

- Negotiation involves a small set of agents
- Actions are propose, counter-propose, support, accept, reject, dismiss, retract
- Negotiation requires a common language and common framework (an abstraction of the problem and its solution)

# Negotiation

- Price-based
  - The service is fixed
  - Agents negotiate on the price of the system
  - E.g.: Auctions
- Content-based
  - Need to negotiate and agree on the content of the service
  - E.g.: Which book is ideal for my request?
  - Price is important but not the focus of this work

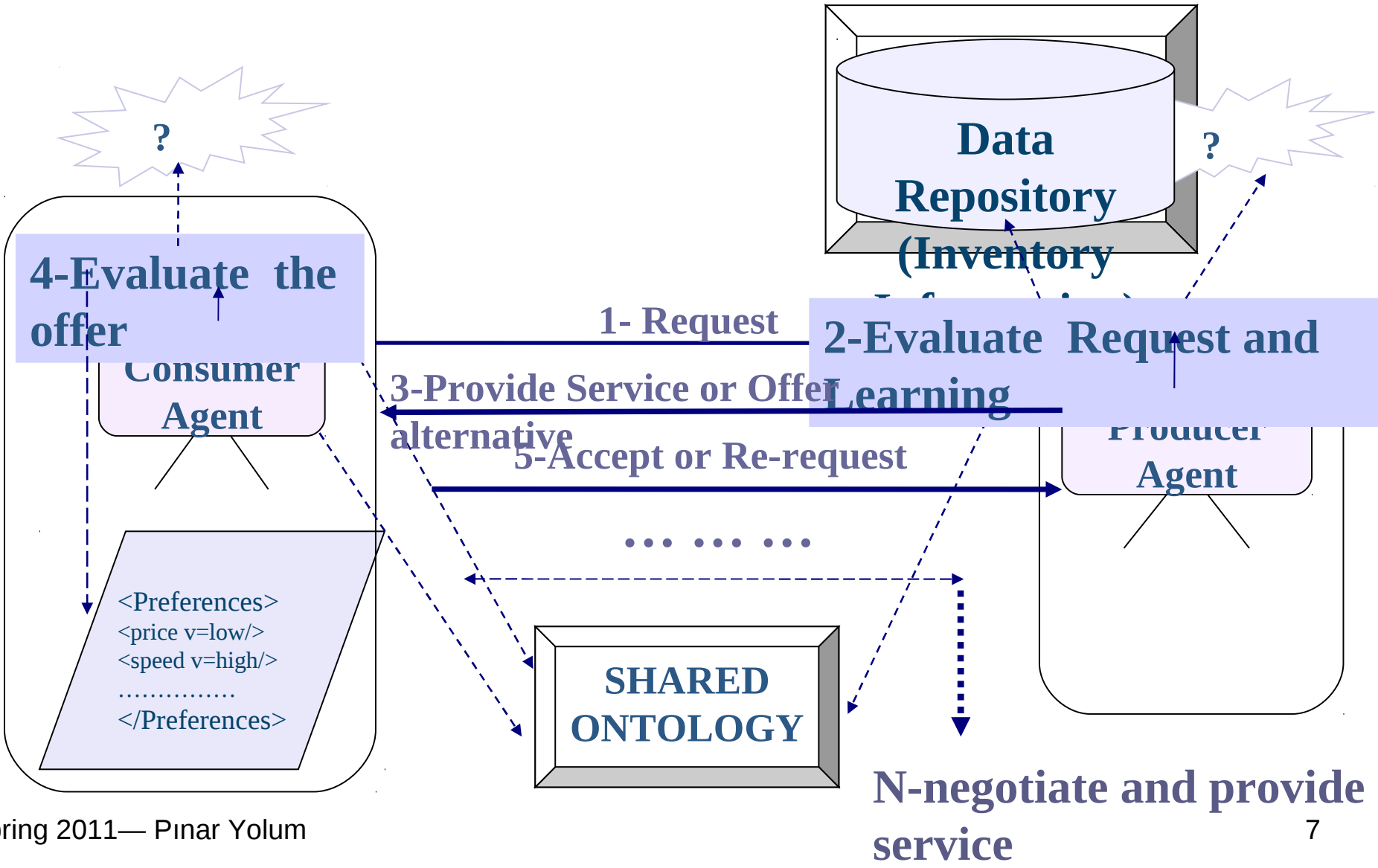
# Negotiation Example

- Consumer: Request a book on Web services with many examples and relevant literature
- Producer: Offer “Web services premier”. Has plenty of examples but no literature review
- Consumer: Reject. Request book with fewer examples yet some review of literature
- Producer: Offer “Web services unleashed”
- Consumer: Accept/Counter-offer/Stop

# Negotiation Challenges

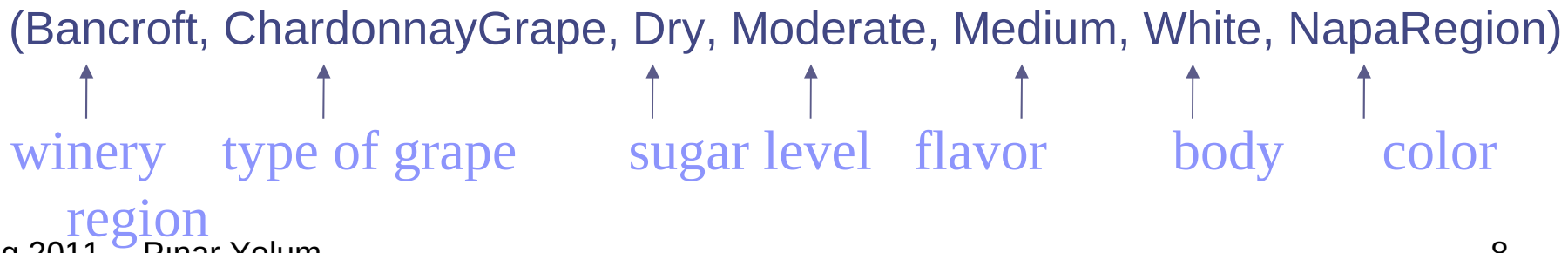
- Represent services unambiguously (so both the consumer and the producer know what they are talking about)
- Learn what the consumer wants (so that the producer can come up with a correct offer soon)
- Strategies so that all parties end up with desired outcomes

# Negotiation Architecture



# Representation

- The request of the consumer and the counter offer of the provider are represented as vectors.
- Example domain
  - Service: Wine
  - Service features: winery, type of grape, sugar level, flavor, body of the wine, color of the wine, region
  - Example request or offer vector:



# Preference Representation

- Preferences: Relative importance degree of features of the service
- Conjunctions and Disjunction
  - "I would like to buy red and dry wine."
    - Color (Red) **Λ** Sugar (Dry)
  - " The wine may be red and dry or it may be white and sweet"
    - [Color (Red) **Λ** Sugar (Dry)] **V** [Color (Rose) **Λ** Sugar (Sweet)]

- Represent a preference hypothesis via vectors
  - (?, ?, Dry, ?, ?, Red, ?)
    - **?** means that any value is valid

# Learning Preference

- As producer agent learns about consumer's preferences, it can provide better-targeted offers and thus enable faster negotiation.

- The information gained during the process:
  - Consumer's requests (Positive samples)
  - Producer's rejected counter offer (Negative samples)

- An incremental learning algorithm is needed.

**The aim is not to learn the exact model !**

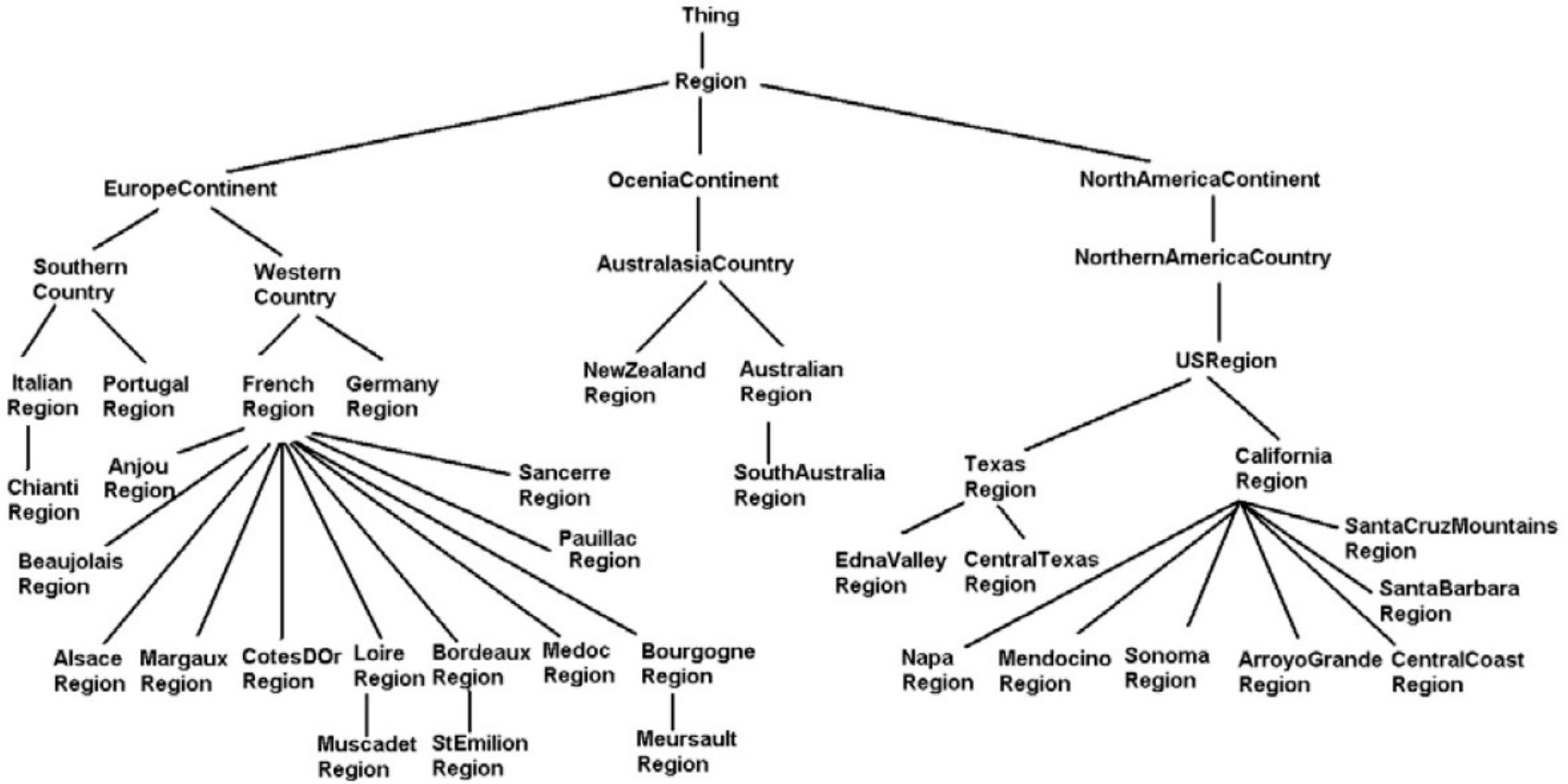
**To learn useful information for the negotiation process**

**Offer a service which is likely to be accepted by the consumer**

# Revisable Candidate Elimination Algorithm

- Based on Candidate Elimination Algorithm
- Support disjunctives and conjunctives
- Incorporates the idea of revision
- Enhanced with the use of ontology for revising the hypotheses

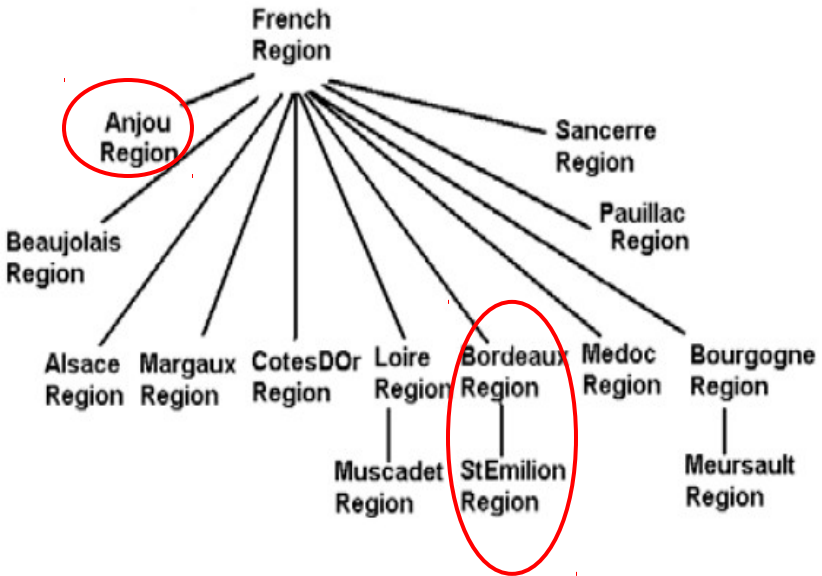
Integrate **ontology reasoning** into the **learning algorithm** so that **hierarchical information** can be learned from subsumption hierarchy object or subclass of relations.
Further, by using relationships among features, the producer can discover new knowledge from the existing knowledge.



# Generalization of attributes (1)

- If there is a hierarchical information
  - Generalization is performed according to a threshold value, Ω.
- Estimate proportion:

$$\frac{\#\text{ of values that the hypothesis involves}}{\#\text{ of values that the nearest common parent concept covers}}$$




E.g. If we have Anjou Region and Bordeaux Region values, this proportion for generalizing this attribute to French Region is equal to 3/15 (=0.2).

# Generalization of attributes (2)

- In the case of no hierarchy
  - If the attribute has more dissimilar values, we have more probability to generalize this feature to "**?**"

**Semantic Similarity for Body**

| Body 1 | Body 2 | Similarity |
|---|---|---|
| Light | Full | 0.3 |
| Medium | Light | 0.6 |
| Full | Medium | 0.6 |

If we have light and full,
we are more likely to generalize
to "**?**" than the case
when we have light and medium.

# When a positive example (x) comes

- Update S to cover x
  - Which specific hypothesis should cover this ?
    - Most similar one
  - Find the most similar specific hypothesis whose similarity is higher than a threshold value
  - Generalize this hypothesis minimally
    - If it covers any negatives in N, pass next most similar hypothesis, until finding a hypothesis covering x
      - If no hypothesis can be generalized, add x into S as a new hypothesis

# Example: Updating G when a negative example comes

- Initially, G={(?, ?, ?)}

- After the first negative sample (Chianti, Rose, Sweet)
  - The single specific hypothesis covered by (?, ?, ?)
    - (Chianti, Rose, OffDry)
  - Different values are
    - Sweet and OffDry

- After specializing the general hypothesis (?,?,?)
  - (?, ?, OffDry)

# Offering Alternatives - Producer

- Producer also has his own preferences as reflected with a utility value

- Producer
  - Uses the hypotheses in G to filter out its stock
  - From the filtered services, prefers the service having highest utility
  - Among these services, an average similarity value is estimated to S
  - Offer the most similar service to consumer

# Experiments

- Compare the performance of our learning algorithm in negotiation with other two alternatives:
  - Candidate Elimination Algorithm (CEA)
  - Disjunctive Candidate Elimination Algorithm (DCEA)
- The same consumer agent negotiates with these producers having the same service stock
- # of interactions between consumer and producer is the main factor

# Comparing RCEA, CEA and DCEA (2)

- Evaluation Criteria: **Performance-1**
  - Avg. # of interactions for a successful termination in the case that all producers have a success at the same run

**Avg. # of Interaction when all are successful**

| Preference | RCEA | CEA | DCEA |
|---|---|---|---|
| 1 | 5.14 | 3.12 | 11.63 |
| 2 | 7.95 | 4.07 | 19.63 |
| 3 | 6.72 | 2.52 | 9.98 |
| 4 | 3.33 | 2.23 | 5.15 |
| 5 | 1.59 | 1.43 | 1.68 |
| Average: | 4.946 | 2.674 | 9.614 |

# Comparing RCEA, CEA and DCEA (3)

- Evaluation Criteria: **Performance-2**
  - Avg. # of interactions needed to decide that a negotiation will not terminate successfully
    - because the producer stock does not have a useful service for the consumer.

**Avg. # of Interaction**
**when stocks do not have the desired service**

| Preference | RCEA | CEA | DCEA |
|---|---|---|---|
| 1 | 14.27 | 5.27 | 50.00 |
| 2 | 14.82 | 5.43 | 50.00 |
| 3 | 25.93 | 3.14 | 50.00 |
| 4 | 26.93 | 4.38 | 50.00 |
| Average: | 20.24 | 4.55 | 50.00 |