# Agent Mediated Electronic Commerce

## Negotiating Agents bidding in Auctions

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# Purpose

- To provide an overview of Electronic Commerce (EC) today and its unexploited possibilities
- To provide basic auction theory
- To introduce Software Agent Technology
- To describe how software agents can advance current EC and online auctions.
- To demonstrate scenarios with agents participating in online auctions.

# Structure

- **PART I**: Electronic Commerce (EC)
- **PART II**: Auctions and Bidding
- **PART III**: Software Agents
- **PART IV**: Agents-Mediated EC

# PART I:
# Electronic Commerce

# Electronic Commerce (EC)

"electronic commerce covers any form of

- business or
- administrative transaction or
- information exchange

that is executed using any information and communications technology"

*(Electronic Commerce Association),* http://www.theeca.org

# What is EC?

- The previous definition is too broad and so we focus on commercial activities conducted on the Internet
  - Therefore, other forms of remote transactions (e.g. ordering an air ticket over the Internet or buying a computer by credit card) are not considered here.

# A more specific definition of EC

- Electronic Commerce involves making business transactions via telecommunications networks, primarily the Internet.
  - It is also sometimes referred to as **e-business (or e-biz)**
- Evolution of EC:
  - Electronic commerce applications began in the early 1970s.
  - Electronic data interchange (EDI) extended the types of participating companies.
  - EC applications expanded rapidly with the commercialization of the Internet in the early 1990s.

# Benefits to organisations

- EC allows vendors to **reach a large number of customers**, **anywhere around the globe**, at a very low operating cost.
- Companies can **procure materials and services** from other companies ***rapidly*** and ***less expensively***.
- **Marketing distribution *channels*** (e.g. retailers) can be ***drastically cut*** or eliminated.
- **Customer services** and relationships are facilitated by ***interactive, one-to-one* communication**, at a **low cost**.

# Benefits to consumers

- EC often provides customers with ***less expensive*** **products and services** by allowing them to **shop in many places**.
- EC provides customers with ***more choices***.
- EC enables customers to shop ***24 hours*** **a day**, year round, from almost any location.
- Customers can receive relevant and ***detailed information*** **and *other services* in seconds.**
- EC enables consumers to get ***customized products and services***.

# Limitations of EC

## Technical Limitations

- Lack of universally accepted standards
- Still-evolving software development tools
- Difficulties in integrating the Internet and EC software

## Non-Technical Limitations

- Trust and security
- Legal issues
- National and international government regulations
- No central administration
- Traditional Customer resistance
- Requires sellers to use certain methods of payment (e.g. PayPal, Credit card)
- You can’t feel the real item

# Transaction types

- B2B (business-to-business)
- B2C (business-to-consumer)
- C2B (consumer-to-business)
- C2C (consumer-to-consumer)
- Other:
  - Nonbusiness e-commerce
    - use of the Internet by nonbusiness organizations such as academic institutions or government agencies to reduce expenses or improve services
  - Intrabusiness commerce
  - Government-to-Citizens (G2C)
  - Mobile Commerce (m-commerce)

# EC Today


**Most current (1st Generation) EC applications:**

- Buyers: Generally Humans
  - Internet users
- Information discovery: Browsing through a catalog of well-defined commodities (e.g., flights, books, compact discs, computer components)
- Purchase: Usually at a Fixed Price using Credit Card
- Sellers: Do not interact with the customers

# New possibilities for EC

**Next (2nd) Generation:**

- Buyers : (Represented by) software agents
- Information discovery : Agents crawl all the available outlets to find the most suitable one for purchasing the chosen good (e.g. the one that sells cheapest)
- Purchase: Automatic. Specify time and place of delivery.
- Sellers: Agents that could vary their offering (terms of price, quality, warranty, and so on) depending on:
  - the customer they are dealing with (e.g., offering discounts or special offers to particular target groups),
  - what their competitors are doing (e.g., continuously monitoring their prices and making sure its own price is competitive),
  - current state of their business (e.g., if they have plenty of a particular item in stock, it may be appropriate to reduce the price in order to try and increase demand).

# PART II: Auctions and Bidding

# General info about auctions

- Auctions are the most widely-studied economic mechanism.
- Auctions refer to arbitrary resource allocation problems with self-motivated participants: Auctioneer and bidders
- Auction (selling item(s)): one buyer, multiple bidders

  e.g. selling a cd on eBay
- Reverse Auction (buying item(s)): one buyer, multiple sellers

  e.g. procurement

# Historical note

- Reports that auctions were held in Babylon in 500 B.C. According to Herodotus, auctions of women for marriage were held annually.

*(The Babylonian Marriage Market, 1875 by Edwin Longsden)*

- 193 A.D. After having assassinated Emperor Pertinax, Praetorian Guard sold the Roman Empire by means of an Auction

*Source: Canduci, Alexander (2010), Triumph & Tragedy: The Rise and Fall of Rome's Immortal Emperors, Pier 9, ISBN 978-1741965988*

# Where auctions are used nowadays?

- Treasury auctions (bill, notes, bonds, securities)
- Has been used to transfer assets from public to private sector
- Right to drill oil, off-shore oil lease
- Government and private corporations solicit delivery price offers of products
- Electricity market
- Private firms sell products (flowers, fish, tobacco, livestock, diamonds)
- Internet auctions

# Auction challenges


- **Seller's information problem**:
  - The seller has usually **incomplete information** about buyers' valuations (else, he just needs to set the price as the maximum valuation of the buyer)
  - What pricing scheme performs well even in incomplete information setting?
    - Is auction better suited for a given problem?
    - Does a type of auction yield greater revenue?
- For the **buyer**:
  - What are good bidding strategies?

# Terminology


- **Revenue**: expected selling price
- **Private Value**: no bidder knows with certainty the valuation of the other bidders, and knowledge of the other bidders' valuation would not affect the value of the particular bidder
- **Pure common value**: the actual value is the same for ever bidders but bidders have different private information about the what that value actually is.
- **Correlated value**: agent's value of an item depends partly on its own preferences and partly on others' values for it
- **Profit = Selling price – private value**
  - It has been proved that alternative definitions for profit lead to better agent performance in certain types of auctions

# Auction Parameters

- Opening and closing
- Type of Auction (ascending, descending, open, sealed)
- Number and identity of participants
- Bid Submission (timing, increment step)
- Number of offers permitted
- Allows withdraw?
- Information revelation policy
- Winner determination
- Amount to be paid

# Auction Types

- English
- Dutch
- First-price sealed-bid
- Vickrey (uniform second-price sealed bid)
- …

- **Winner's Curse:** The winner actually bids the furthest from the average bid, which is the best estimate of the item's actual worth (reasonable information).

# English (first-price open-cry = ascending)

- ***Protocol:*** Each bidder is free to raise his bid. When no bidder is willing to raise, the auction ends, and the highest bidder wins the item at the price of his bid
- ***Strategy:*** Series of bids as a function of agent's private value, his prior estimates of others' valuations, and past bids
- ***Best strategy:*** In private value auctions, bidder's dominant strategy is to always bid a small amount more than current highest bid, and stop when his private value price is reached
- ***Variations:***
  - In **correlated value auctions**, auctioneer often increases price at a constant rate or as he thinks is appropriate (Japanese auction)
  - Open-exit: Bidder has to openly declare exit without re-entering possibility => More info to other bidders about the agent's valuation

# First-price sealed-bid

- ***Protocol:*** Each bidder submits one bid without knowing others' bids. The highest bidder wins the item at the price of his bid
- Single round of bidding
- ***Strategy:*** Bid as a function of agent's private value and his prior estimates of others' valuations
- ***Best strategy:*** No dominant strategy in general. Can determine Nash equilibrium strategies via common knowledge assumptions about the probability distributions from which valuations are drawn
- ***Variant***: $k^{th}$ price

# Dutch (descending)

- ***Protocol***: Auctioneer continuously lowers the price until a bidder takes the item at the current price
- Strategically equivalent to first-price sealed-bid protocol in all auction settings
- ***Strategy***: Bid as a function of agent's private value and his prior estimates of others' valuations
- ***Best strategy***: No dominant strategy in general
- **Examples**: Dutch flower market, Ontario tobacco auction, Filene's basement, Waldenbooks

# Vickrey (= second-price sealed bid)

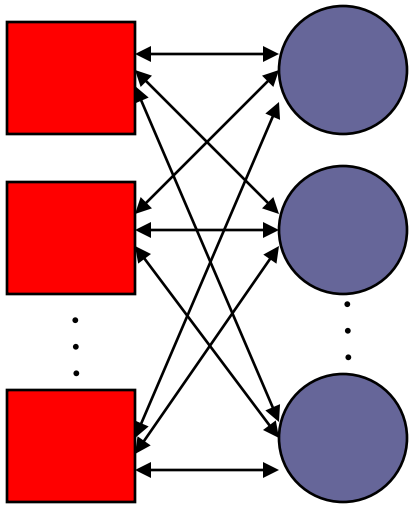
- ***Protocol***: Each bidder submits one bid without knowing others' bids. Highest bidder wins item at the 2nd highest price
- ***Strategy***: Bid as a function of agent's private value & his prior estimates of others' valuations
- ***Best strategy***: In a private value auction with risk neutral bidders, Vickrey is strategically equivalent to English. In such settings, dominant strategy is to bid one's true valuation
  - Independent of others' bidding plans, operating environments, capabilities...
  - Single round of bidding
- Widely advocated for computational multiagent systems
- Old [Vickrey 1961], but not widely used among humans

# The Continuous Double Auction

- A symmetric market mechanism that allows buyers and sellers to trade
- Market clears continuously whenever a transaction is possible
- Traders in the CDA must react in real time to maximise their utility
- Similar to stock market

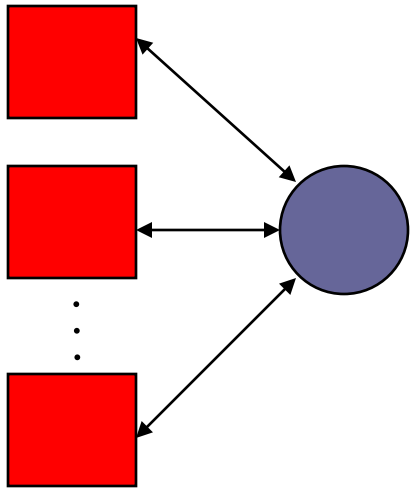
# Number of buyers and sellers

Continuous double



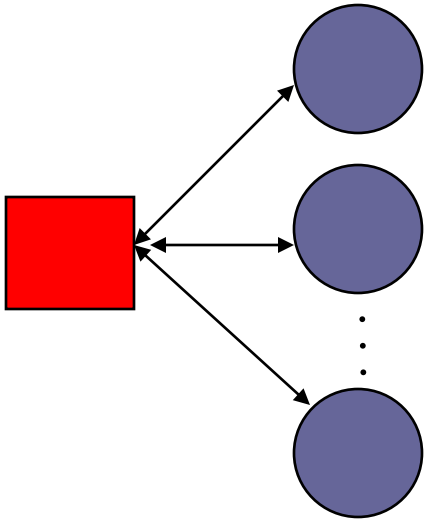
*N* buyers vs. *M* sellers

English



*N* buyers vs. 1 seller

First-price sealed



1 buyer vs. *M* sellers

# Auction types on the Internet

| Auction type | % | Websites |
|---|---|---|
| English | 85 | eBay, Amazon, egghead, eSellpia and most auction sites |
| First Price Sealed Bid | 7 | The Chicago Wine Company; Timeshare Resale International |
| Dutch | 4 | Klik-Klok Department Store; Bookbid |
| Vickrey | 1 | Antebellum Covers (www.antebellumcovers.com) |
| Continuous Double Auction | 1 | Auction Depot (www.auctiondepot.com) |
| Sealed Double Auction | 1 | Fastparts (www.fastparts.com) |

SOURCE: BEAM & SEGEV

# Bidding Strategy

$$S = \vec{b} = f(v_p, \hat{\vec{v}}, \vec{h})$$

| | |
|---|---|
| $\vec{b}$ | Vector of Bids |
| $v_p$ | Private valuation |
| $\hat{\vec{v}}$ | Estimates of opponents private valuations |
| $\vec{h}$ | History |

# Optimal strategy

- Nash equilibrium:

$S_A^* = \langle S_1^*, S_2^*, ..., S_{|A|}^* \rangle \quad \forall i \in A : S_i^*$ is the agent's $i$ best strategy

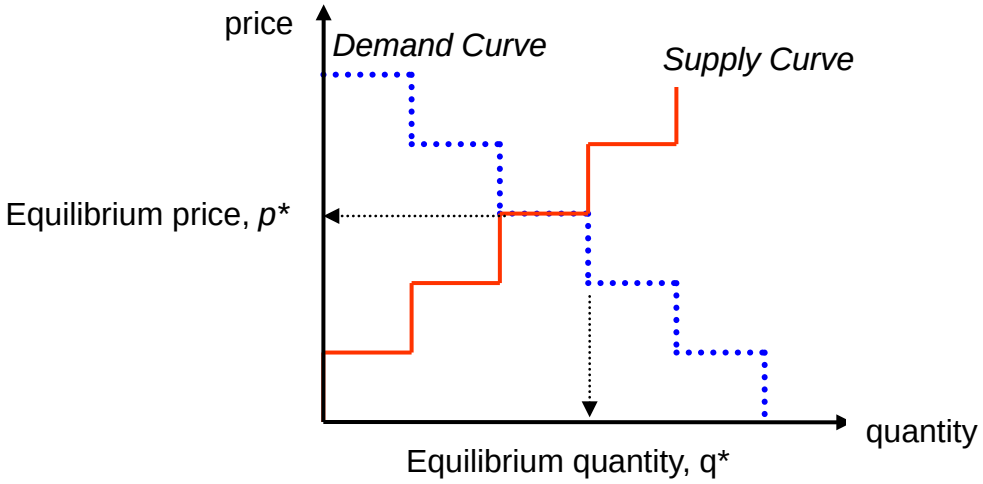
when the other agents choose strategies: $\langle S_1^*, S_2^*, ..., S_{i-1}^*, S_{i+1}^*, ..., S_{|A|}^* \rangle$

- **English Auction**
  - Bid current maximum bid + increment step as long as bid is less than or equals private valuation
- **Second Sealed-bid**
  - Bid private valuation

# Pareto Efficiency

- An allocation of resources is **Pareto Efficient** when there is no alteration of it that could make someone better off without making someone else worse off
- Vilfredo Pareto (1848-1923)
  - Economist and Sociologist

# Optimal Allocation in CDAs




- Optimal allocation occurs when total profit in the market is maximised, which is at the equilibrium (price and quantity).

# The optimal strategy cannot be always calculated

- First-price sealed & Dutch auctions
  - The opponents' private valuation needs to be estimated (through the corresponding probability distributions).
- Combinatorial auctions
  - Concurrent auction of different types
  - Different quantities – many goods

# PART III: Software Agents

# What is an agent?


- "Agent" is one of the more ubiquitous buzzwords in computer science today.
  - It's used for almost any piece of software
- "I know an agent when I see one"

# A definition about agents

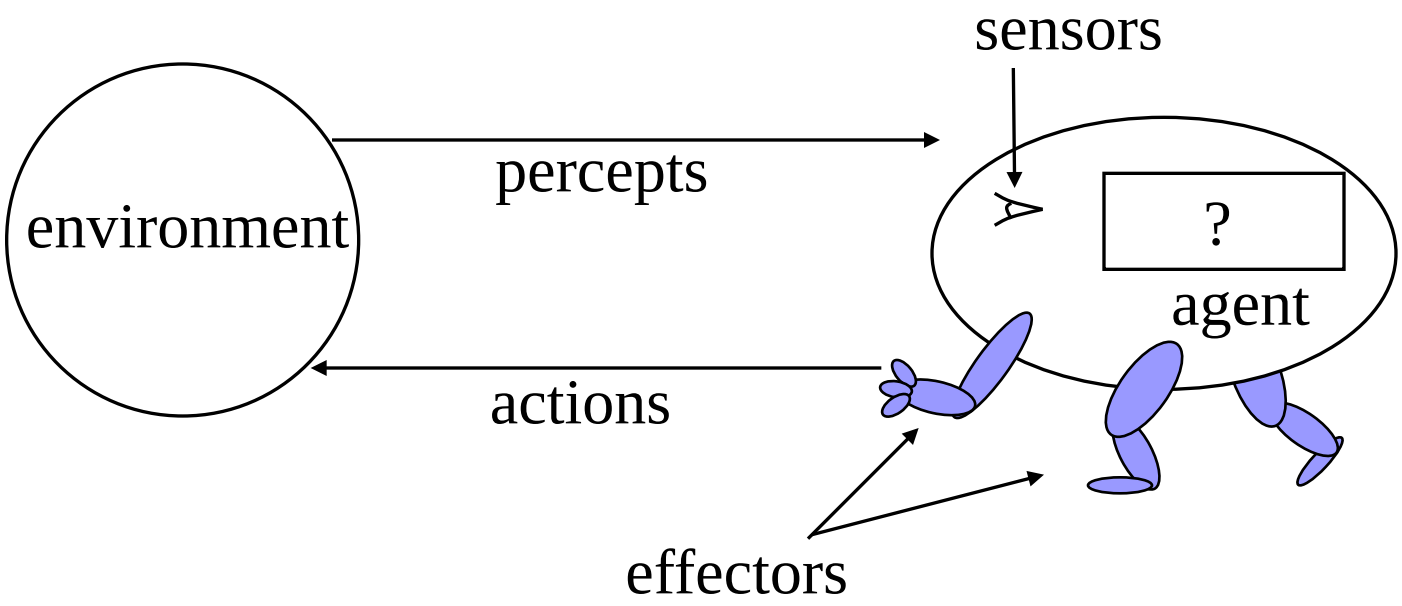
***Autonomous software entities*** *that constantly perform a set of tasks in a goal-oriented way, on behalf of a third-party entity, human or software.*

- In real life agents are humans that act **on behalf of someone else**.
- Software agents are computer programs that **act on behalf of a third-party entity** (human or software program) and employs a set of attributes.

# Examples

- News-filtering agents
- Shopbots/price comparison agents
- Bidding agents
- Recommender agents
- Personal Assistants
- Middle agents/brokers
- Etc.

# An agent and its environment



# Agent Properties


- Act in a goal-oriented manner.
- Autonomy/Autonomous execution.
- Webster's:
  - Autonomy: "The quality or state of being self-governing"
- More generally, being able to make decisions without direct guidance.
- Being adaptable. Adaptation involves changing an agent's model/behavior in response to a perceived change in the world.
- Learning ability.

# Learning

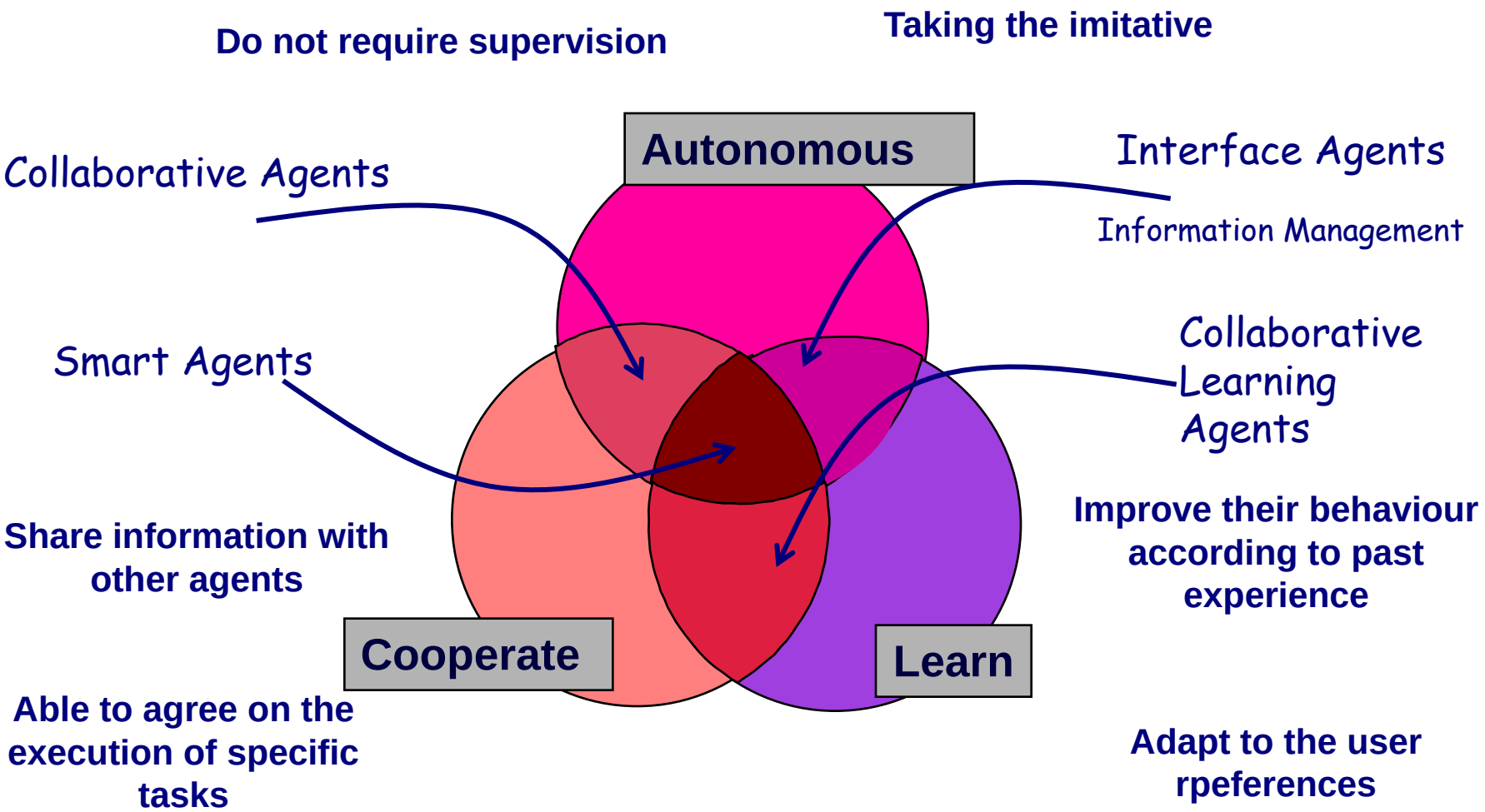

- Learning involves constructing and updating a *hypothesis.*
- An agent typically tries to build and improve some representation of the world.
- Proactive.
- Try to anticipate the future.
- Most agents will use both **learning** and **adaptation**.

**Learning is a must-have characteristic for an intelligent agent**

# Objects vs. Agents

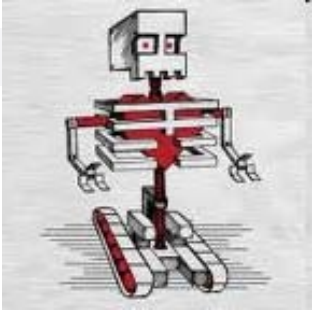

- So how are agents different from objects.
- Objects: passive, noun-oriented, receivers of action.
- Agents: active, task-oriented, able to take action without receiving a message.

# An Agent Typology




SOURCE: NWANA 1996

# Skeleton agent



**function** SKELETON-AGENT (*percept*) **returns** action
  static: *memory*, the agent's memory of the world

  *memory* ← UPDATE-MEMORY(*memory,percept*)
  *action* ← CHOOSE-BEST-ACTION(*memory*)
  *memory* ← UPDATE-MEMORY(*memory, action*)
  **return** *action*

On each invocation, the agent's memory is updated to reflect the new percept, the best action is chosen, and the fact that the action was taken is also stored in the memory. The memory persists from one invocation to the next.

Input = Percept, not history

NOTE: Performance measure is not part of the agent

# Examples of different agent implementations

***Less sophisticated***

1. Table-driven agent
2. Simple reflex agent
3. Reflex agent with internal state
4. Agent with explicit goals
5. Utility-based agent

***More sophisticated***

# Table-driven agent

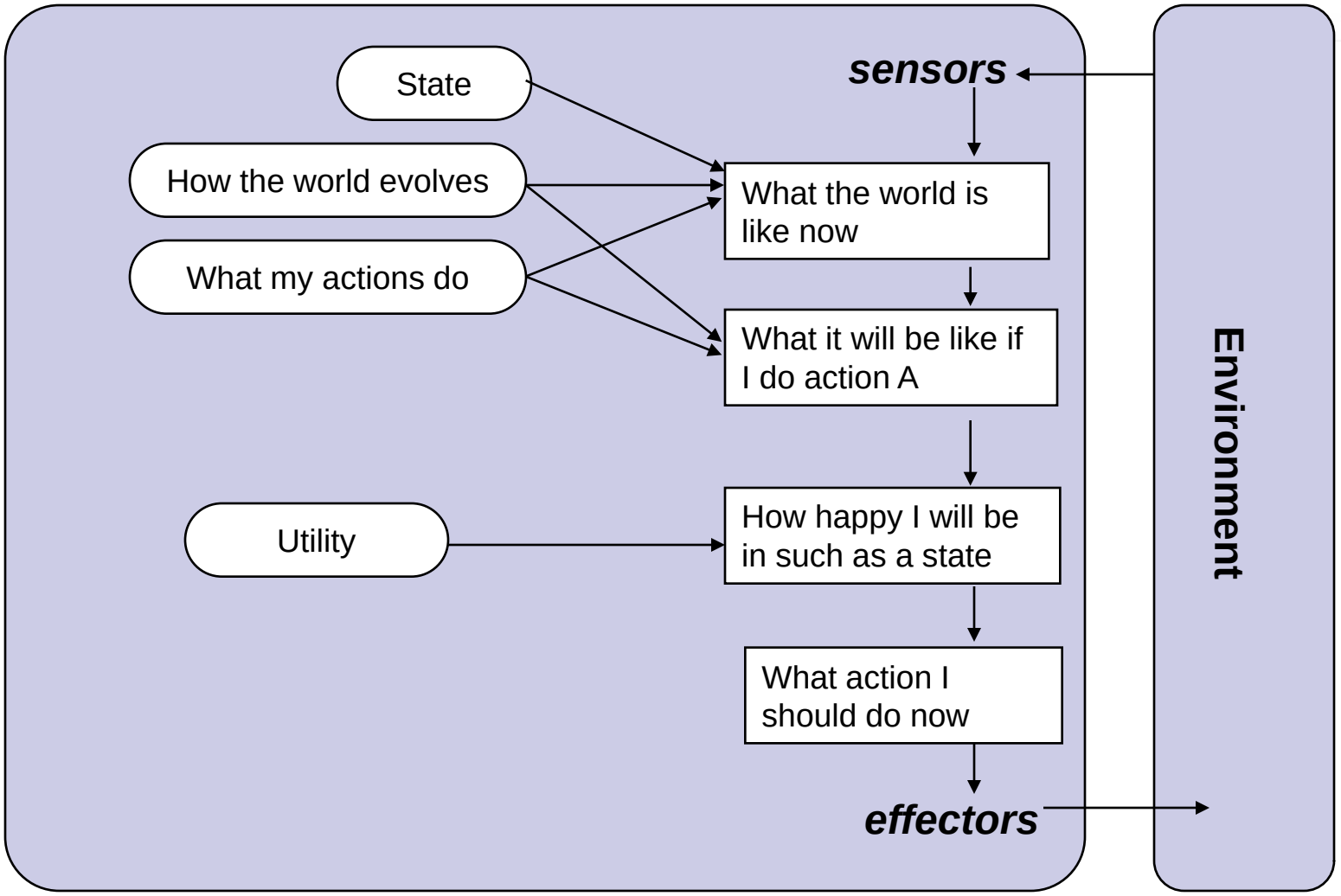
```
function TABLE-DRIVEN-AGENT (percept) returns action
  static: percepts, a sequence, initially empty
          table, a table, indexed by percept sequences, initially fully specified

  append percept to the end of percepts
  action ← LOOKUP(percepts, table)
  return action
```

An agent based on a prespecified lookup table. It keeps track of percept sequence and just looks up the best action

- **Problems**
  - Huge number of possible percepts (consider an automated taxi with a camera as the sensor) => lookup table would be huge
  - Takes long time to build the table
  - Not adaptive to changes in the environment; requires entire table to be updated if changes occur

# Utility-based agent



# PART IV:
# Agent-Mediated Electronic Commerce

# Benefits of Agent-Mediated EC

- Concurrent Monitoring and participation in multiple markets
- User needs identification
- Coalition formation with other agents
- Prediction of prices from history data
- Calculation of current maximum profit
- Deployment of complicated bidding strategies
- Automatic submission of bids

# Varying degree of agent automation

- Find e-markets where desired good can be purchased
- Find relevant purchasing information from identified e-market
- Rank identified goods and e-markets.
- Select e-market(s) where will attempt to purchase good.
- Determine precise conditions for purchasing the good in chosen e-market (this may range from obtaining the fixed price, through participating in an auction, to direct negotiation)
- Decide to purchase the good.
- Pay for the good.
- Arrange delivery.

***No automation: all activities are manual***

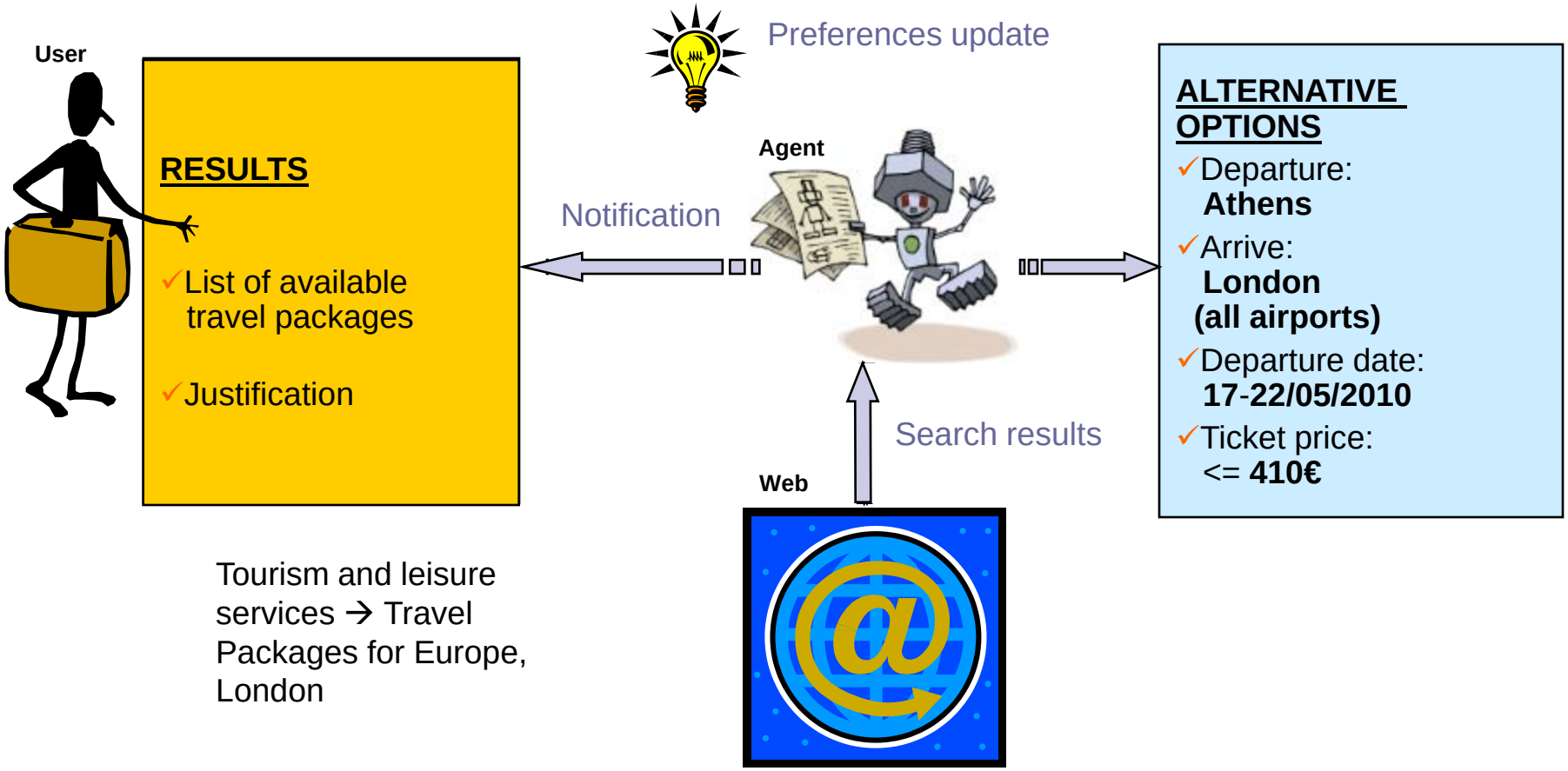
**Increasing automation**

***Full automation: all activities performed by a software agent***

# Websites with e-commerce agents

# EC Agent Scenario (1)

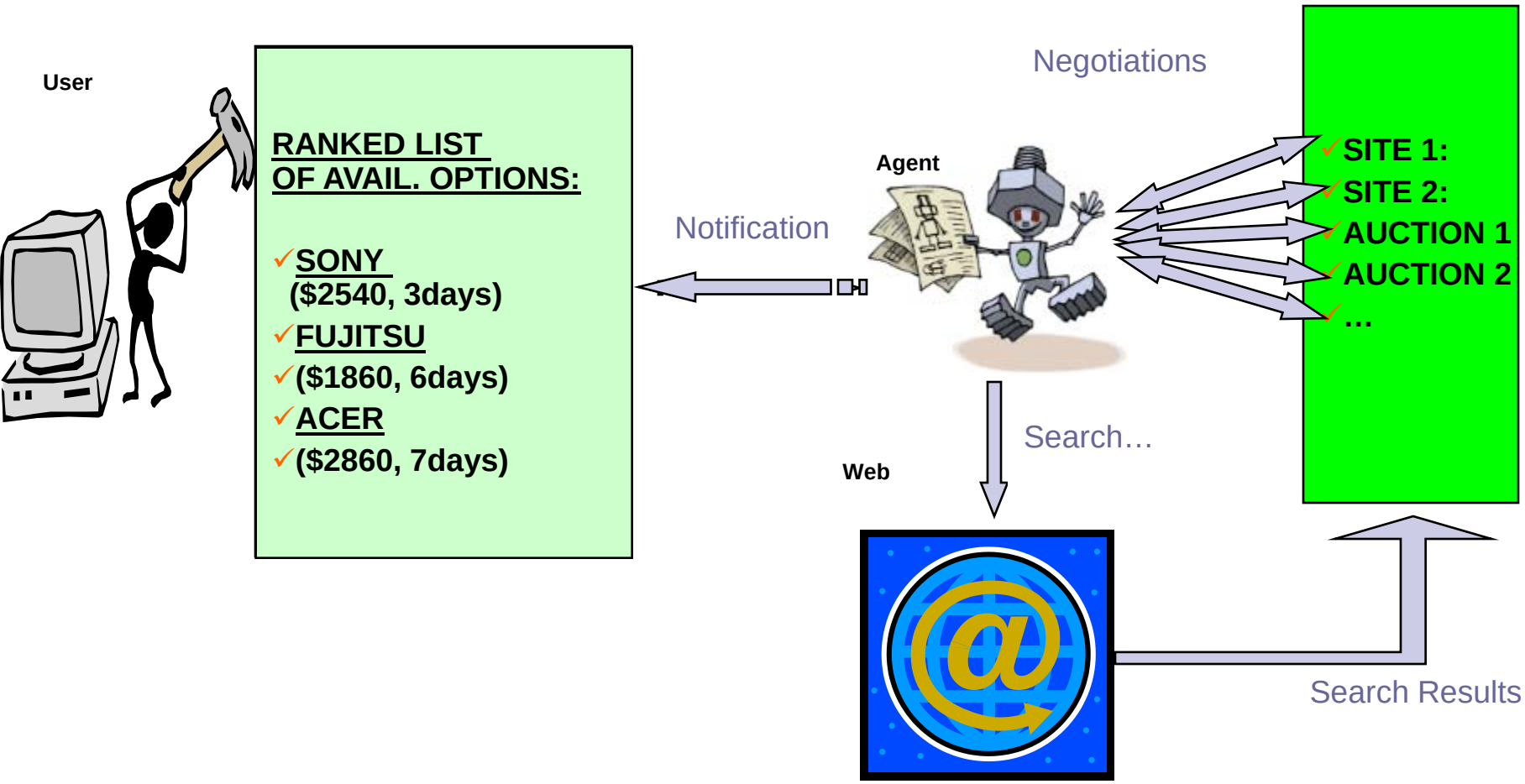
- Scenario: User wants to find a travel package that meet his requirements in he best possible way



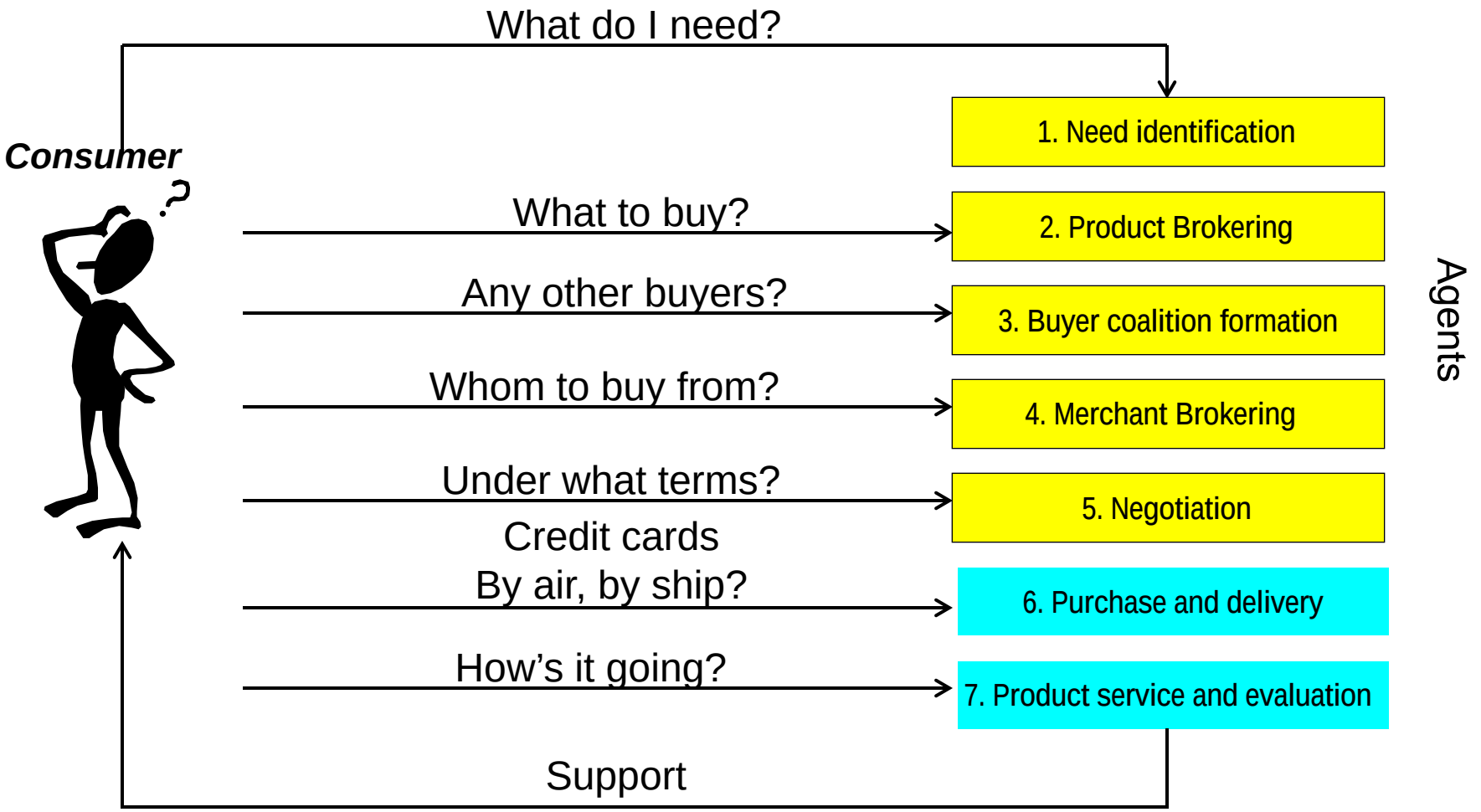

Tourism and leisure services → Travel Packages for Europe, London

# EC Agent Scenario (2)

- Scenario: Buy a computer and deliver it on a specific date



# Consumer Behaviour Model



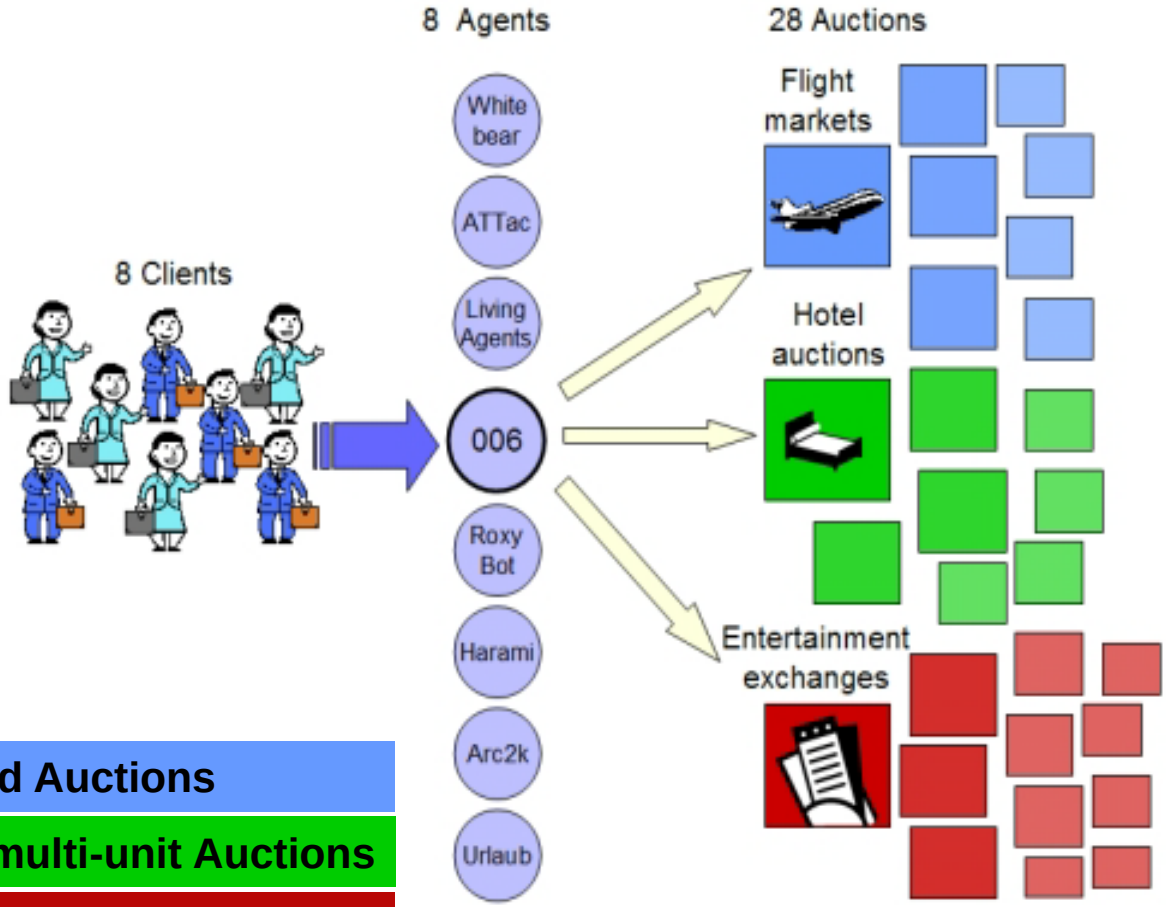
# Agents in auctions

- Manage history data in order to predict closing price or other agents' behavior
- Monitor parallel auctions, compare price, choose the best auction to bid
- Submit bids
- Adapt bidding strategy according to changes in the environment
- Estimate bidding time and price of the bid to be submitted in order to maximize profit

# The Trading Agent Competition

## Classic Game

- 8 agents
- Each has 8 Clients
- Clients have preferences
- 3 types of Auctions:




**Continuous One-Sided Auctions**

**Standard English ascending multi-unit Auctions**

**Continuous Double Ascending Auctions**

**http://www.sics.se/tac/**

# Calculating score

- At the beginning agents receive client preferences over travel packages
- At the end agent's score is calculated by

$$Score = Utility - Cost$$

***Utility*** *= 1000+HotelBonus+EntertainmentBonus*

***Cost*** *= The cost for acquiring goods*

- **Goal** : "Maximize utility at the minimum cost"

# Agent Mertacor

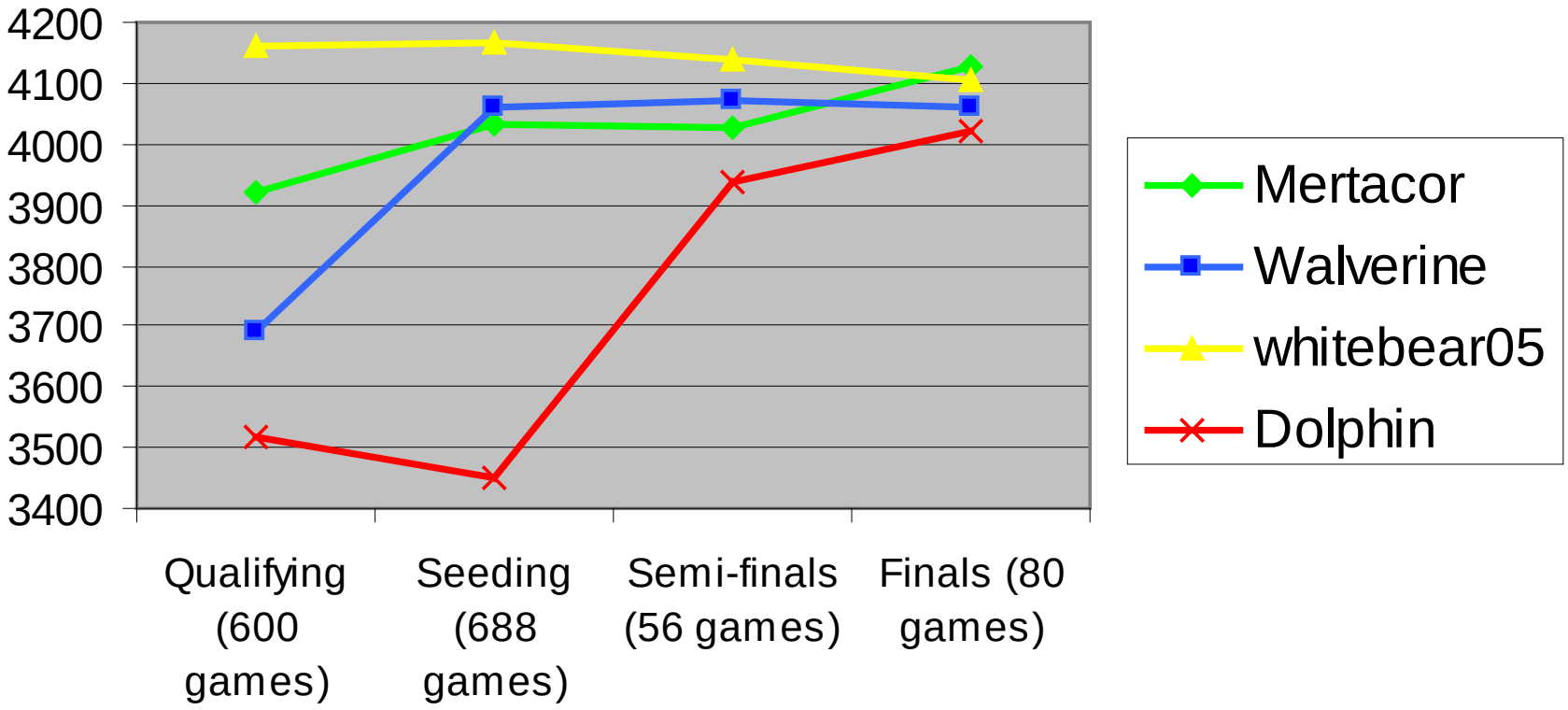
- Created in 2005 by:
  - Aristotle University of Thessaloniki
  - CERTH/ITI
- What's in a name?

*MerTACor ← Mercator(=trader in Latin) + TAC*

- Unique case-study in TAC history:
  - High-level performance from the beginning
  - Played against top agent researchers
  - 1st participation in TAC (2005), ended up **1st** in Finals
- Solid scientific background:
  - Encapsulated TAC-oriented theoretic results
  - Innovative treatment of the TAC problem
  - New algorithms designed and implemented for all types of auctions

# Agents Performance in CDAs

# Agents Overall Performance



# Finals


## Score tables for TAC 2005 Finals - 3rd August

### TAC Classic

| Position | Agent | Average Score | Games Played | Zero Games |
|---|---|---|---|---|
| 1 | **Mertacor** (tac1, tac2) | 4126.49 | 80 | 0 |
| 2 | **whitebear05** (tac1, tac2) | 4105.68 | 80 | 0 |
| 3 | **Walverine** (tac1, tac2) | 4058.90 | 80 | 2 |
| 4 | **Dolphin** (tac1, tac2) | 4022.79 | 80 | 0 |
| 5 | **SICS02** (tac1, tac2) | 3972.29 | 80 | 0 |
| 6 | **LearnAgents** (tac1, tac2) | 3899.24 | 80 | 0 |
| 7 | **e-Agent** (tac1, tac2) | 3451.25 | 80 | 0 |
| 8 | **RoxyBot** (tac1, tac2) | 3167.64 | 80 | 10 |

*The scores have been combined from the TAC 2005 finals at tac1.sics.se and tac2.sics.se.*

# The Trading Agent Competition Today


- **TAC Classic** run from 2002 to 2006
- **TAC SCM** 2002-today: agents are PC manufacturers aiming at maximising their profit.
- New challenges:
  - **Power TAC**: Agents act as retail brokers in a local power distribution region, purchasing power from a wholesale market as well as homes and businesses with solar panels, and selling power to local customers and into the wholesale market.
  - **TAC Ad Auctions:** Agents representing Internet advertisers bid for search-engine ad placement over a range of interrelated keyword combinations.
  - **TAC Market Design:** Agents represent market makers whose goals are to attract potential buyers and sellers as customers, and then to match buyers with sellers.
  - **Lemonade Stand Game** (affiliated game): Agents sell lemonades on a beach during the summer.

# Conclusions

- The use of software agent technology in EC can lead to a new fully automated EC era.
- Agents are able to perform in auctions in such ways that human bidders cannot even imagine.
- A set of limitations prevent agents from being fully adopted
  - Trust and Security
  - Lack of interoperability and standards
- Further work is required on improving agents performance
  - The application of data mining on historical data for price prediction
  - Revision of theoretical models to allow more profitable transactions

# Questions?


I ♥ My Agent


World's Hottest
AGENT


REAL MEN BECOME
AGENTS


WORLD'S COOLEST
AGENT


Mommy's Little
Agent


KISS ME
I'M AN
AGENT


AGENTS
ROCK!


I LOVE
AGENTS