Web Intelligence (WI)

Some Research Challenges

[IJCAI 03 Invited Talk]

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  - AAMAS/AOC Group (HKBU)

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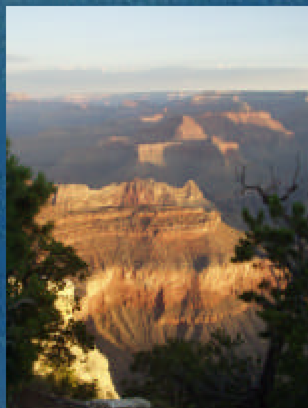
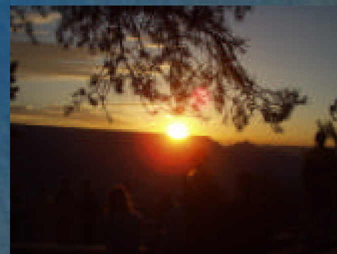
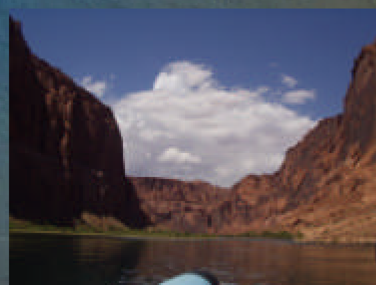




Outline

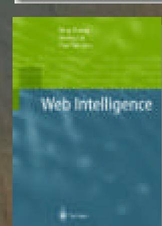
- Background
- Challenges
  - Semantic Web + Planning
  - Distributed Agents + Coordination
  - Social Networks + Self-Organization
- Issues and Directions

What is Web Intelligence (WI)?

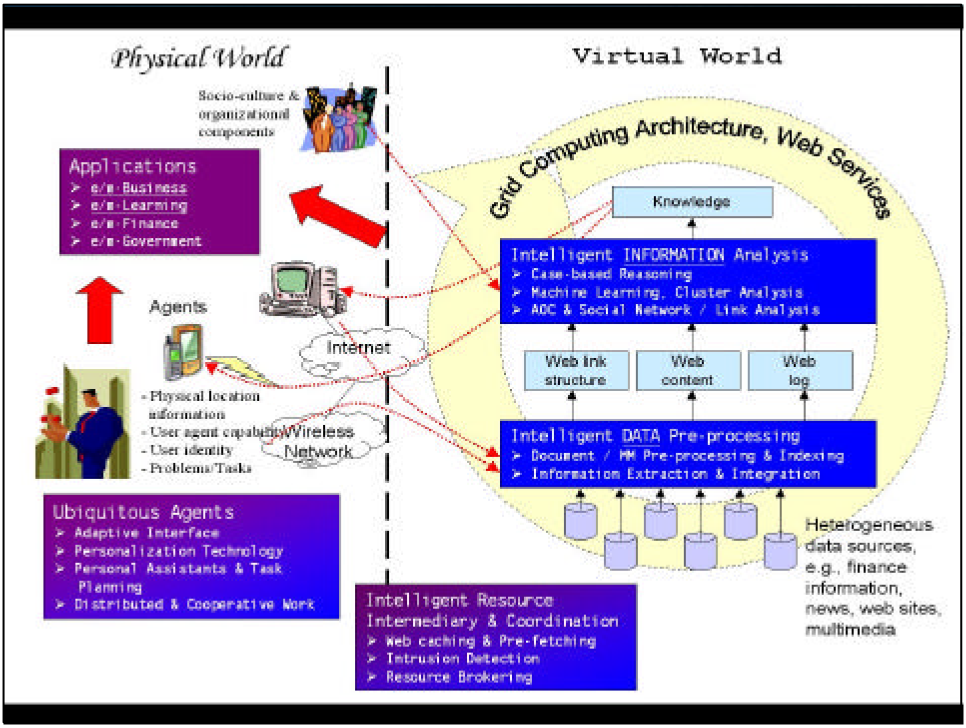
WI explores the fundamental roles as well as practical impacts of

- **Artificial Intelligence (AI)** (e.g., knowledge representation, planning, knowledge discovery, agents, and social intelligence) and
- **Advanced Information Technology (IT)** (e.g., wireless networks, ubiquitous devices, social networks, and data/knowledge grids)

on the next generation of Web-empowered systems, environments, and activities



Zhong, N , Liu, J , and Yao, Y Y (eds.) *Web Intelligence*, Springer, 2003



Four Levels of WI Support

Level-4	Application-level ubiquitous computing and social intelligence utilities
Level-3	Knowledge-level information processing and management tools
Level-2	Interface-level multi-media presentation standards
Level-1	Internet-level communication, infrastructure, and security protocols

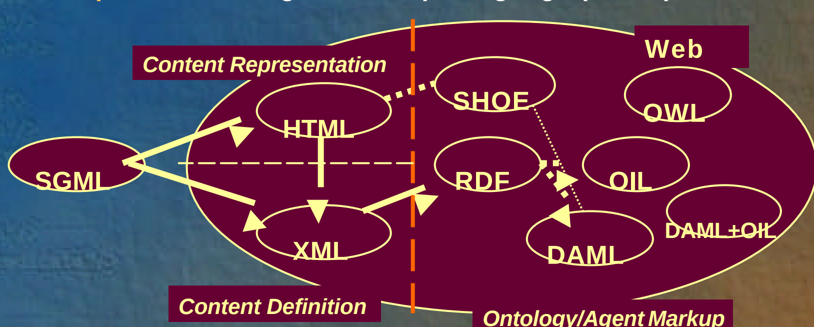
support

WI Challenge #1

Semantic Web + Planning

Semantic Web

- **Ontology:** Define meanings and relationships of vocabularies (in terms of classes and properties)
- **Semantic Web:** Add semantic meanings to Web information based on pre-defined ontology
- **Benefits:** Enable better human-computer communications as well as software agents access
- **Example:** DARPA Agent Markup Language (DAML)



```xml
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:daml="http://www.daml.org/2001/03/daml+oil#"
  xml:base="http://ntserver.homeip.net/HonorProject/DAML/logic-onto#">
  <daml:Ontology daml:versionInfo="1.0">
  <daml:comment>An example for logic ontology</daml:comment>
  </daml:Ontology>
  <!-- Term -->
  <rdfs:Class rdf:ID="Term"/>
  <!-- Variable -->
  <rdfs:Class rdf:ID="Variable">
    <daml:subClassOf rdf:resource="#Term"/>
  </rdfs:Class>
  <!-- Constant -->
  <rdfs:Class rdf:ID="Constant">
    <daml:subClassOf rdf:resource="#Term"/>
  </rdfs:Class>
  <daml:DatatypeProperty rdf:ID="value">
    <daml:domain rdf:resource="#Constant"/>
    <daml:range rdf:resource="http://www.w3.org/2000/10/XMLSchema#string"/>
  </daml:DatatypeProperty>
  <!-- Predicate -->
  <rdfs:Class rdf:ID="Predicate">
    <daml:subClassOf rdf:resource="#Term"/>
  </rdfs:Class>
  <daml:ObjectProperty rdf:ID="arguments">
    <daml:domain rdf:resource="#Predicate"/>
    <daml:range rdf:resource="#Term"/>
  </daml:ObjectProperty>
  <!-- Common Property -->
  <daml:DatatypeProperty rdf:ID="name">
    <daml:domain rdf:resource="#Variable"/>
    <daml:domain rdf:resource="#Predicate"/>
    <daml:range rdf:resource="http://www.w3.org/2000/10/XMLSchema#string"/>
  </daml:DatatypeProperty>
</rdf:RDF>
```


Planning

- Planning example: STRIPS
- States: conjunctions of ground literals

```
At(Home) ^ Sell(Supermarket, Banana) ^
Sell(Supermarket, Milk) ^ Sell(Hardware Store, Drill)
```

- Goals: conjunctions of literals (possibly containing variables)

```
Have(Drill) ^ Have(Milk) ^ Have(Banana) ^ At(Home)
```

```
At(?x) ^ Sells(?x, Milk)
```

Operators in STRIPS

At(?store), Sell(?store, ?x)

Buy(?x)

+ Have(?x)

```
Action: Buy(?x)
Preconditions: At(?store) ^ Sell(?store, ?x)
Effects:
   additions: Have(?x)
   deletions:
```

At(?here)

Go(?there)

+ At(?there)
- At(?here)

```
Action: Go(?there)
Preconditions: At(?here)
Effects:
   additions: At(?there)
   deletions: At(?here)
```


POP Algorithm

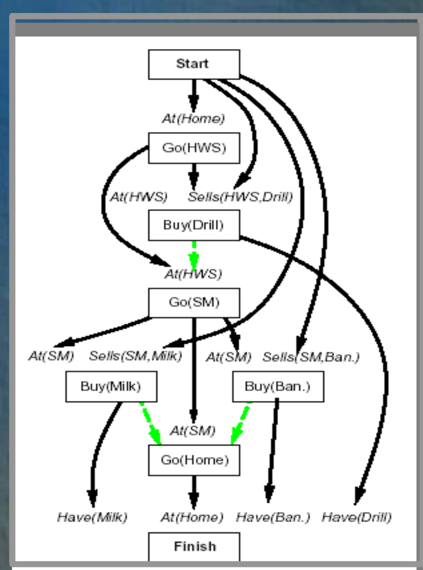
- **Ordering constraint**

  $S_i < S_j$

  - Step S_i occurs before step S_j
- **Casual link**

  $S_i \xrightarrow{c} S_j$

  - S_i achieves the precondition c of S_j
- **Open condition**
  - Precondition that is not causally linked



Source: Russell & Norvig

Semantic Web + Planning
(with Kelvin Tsang)

- The planning agent is **goal**-directed
- A **plan** is a sequence of **actions** to achieve the goals, given an initial state
- A **logic-based language** is used to describe the problem
- General planner is based on **Partial Order Planning** (POP), coupled with **heuristic search**
- Meanings and relationships of the words in the documents are specified in **ontologies**
- **Planning information** is interpreted from semantic Web documents


```
<?xml version="1.0"?>
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  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
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  </daml:ObjectProperty>
  <!-- Common Property -->
  <daml:DatatypeProperty rdf:ID="name">
    <daml:domain rdf:resource="#Variable"/>
    <daml:domain rdf:resource="#Predicate"/>
    <daml:range rdf:resource="http://www.w3.org/2000/10/XMLSchema#string"/>
  </daml:DatatypeProperty>
```

Ontology Modeling

```
<!-- Planning domain -->
<rdfs:Class rdf:ID="Domain"/>
<daml:ObjectProperty rdf:ID="operators">
  <daml:domain rdf:resource="#Domain"/>
  <daml:range rdf:resource="#Operator"/>
</daml :ObjectProperty>
<daml:ObjectProperty rdf:ID="initial">
  <daml:domain rdf:resource="#Domain"/>
  <daml:range rdf:resource="logic:Predicate"/>
</daml :ObjectProperty>
<daml:ObjectProperty rdf:ID="goal">
  <daml:domain rdf:resource="#Domain"/>
  <daml:range rdf:resource="logic:Predicate"/>
</daml :ObjectProperty>
```

Instance Files

- DAML instance files: To encode planning information in Semantic Web documents that use the vocabularies in
  - logic ontology (logic-onto.daml)
  - planning ontology (plan-onto.daml)
- shopping-problem.daml

```
Action: Buy(?x)
Preconditions: At(?store) ^ Sell(?store, ?x)
Effects:
   additions: Have(?x)
   deletions:
```

Examples of Operators

```
<!-- Buy(?x) -->
<plan:Operator>
  <rdfs:comment>Buy the ?there</rdfs:comment>
  <plan:action>
    <logic:Predicate>
      <logic:name>
        <rxsd:string rdf:value="Buy"/>
      </logic:name>
      <logic:arguments rdf:parseType="daml:collection">
        <logic:Variable>
          <logic:name>
            <rxsd:string rdf:value="?x"/>
          </logic:name>
        </logic:Variable>
      </logic:arguments>
    </logic:Predicate>
  </plan:action>
  <!-- Preconditions -->
  <plan:preconditions rdf:parseType="daml:collection">
    <!-- At(?store) -->
    <logic:Predicate>
      <logic:name>
        <rxsd:string rdf:value="At"/>
      </logic:name>
```

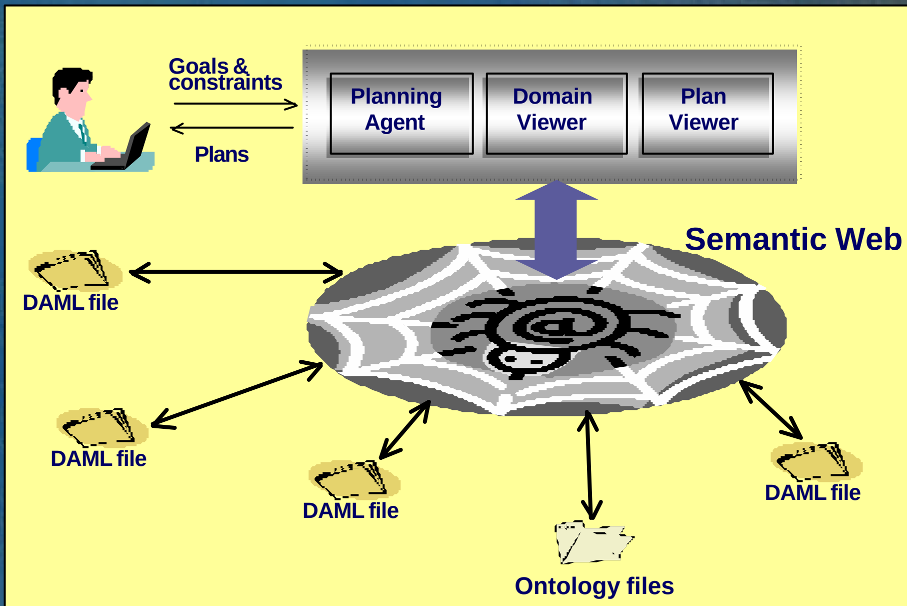
Buy(?x)


```
      <logic:arguments rdf:parseType="daml:collection">
        <logic:Variable>
          <logic:name>
            <rxsd:string rdf:value="?store"/>
          </logic:name>
        </logic:Variable>
      </logic:arguments>
    </logic:Predicate>
    <!-- Sell(?store, ?x) -->
    <logic:Predicate>
      <logic:name>
        <rxsd:string rdf:value="Sell"/>
      </logic:name>
      <logic:arguments rdf:parseType="daml:collection">
        <logic:Variable>
          <logic:name>
            <rxsd:string rdf:value="?store"/>
          </logic:name>
        </logic:Variable>
        <logic:Variable>
          <logic:name>
            <rxsd:string rdf:value="?x"/>
          </logic:name>
        </logic:Variable>
      </logic:arguments>
    </logic:Predicate>
  </plan:preconditions>
```

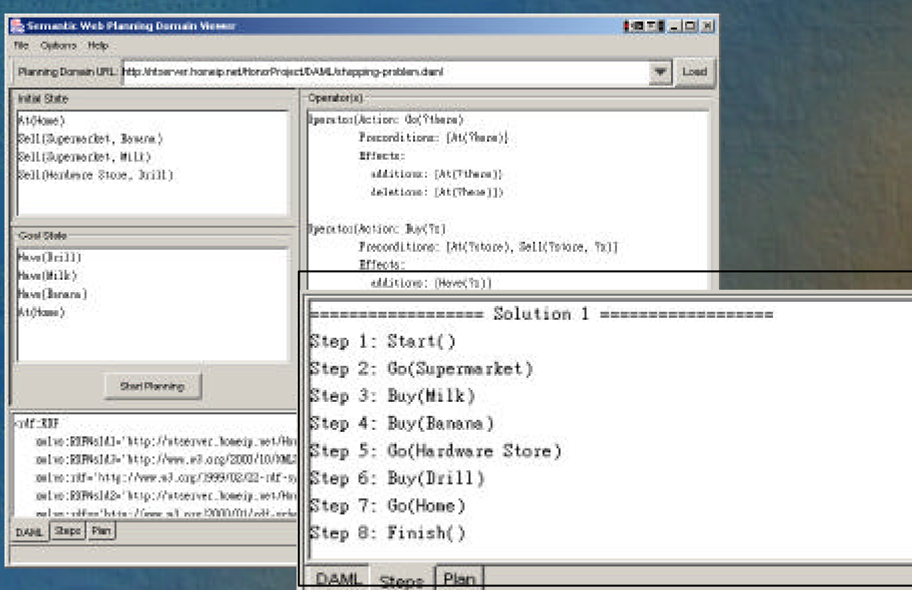
At(?store)

Sell(?store, ?x)

OntoPlan

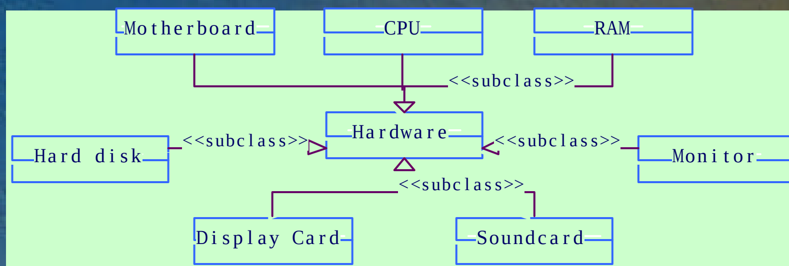


OntoPlan: Domain & Plan Viewers



Application

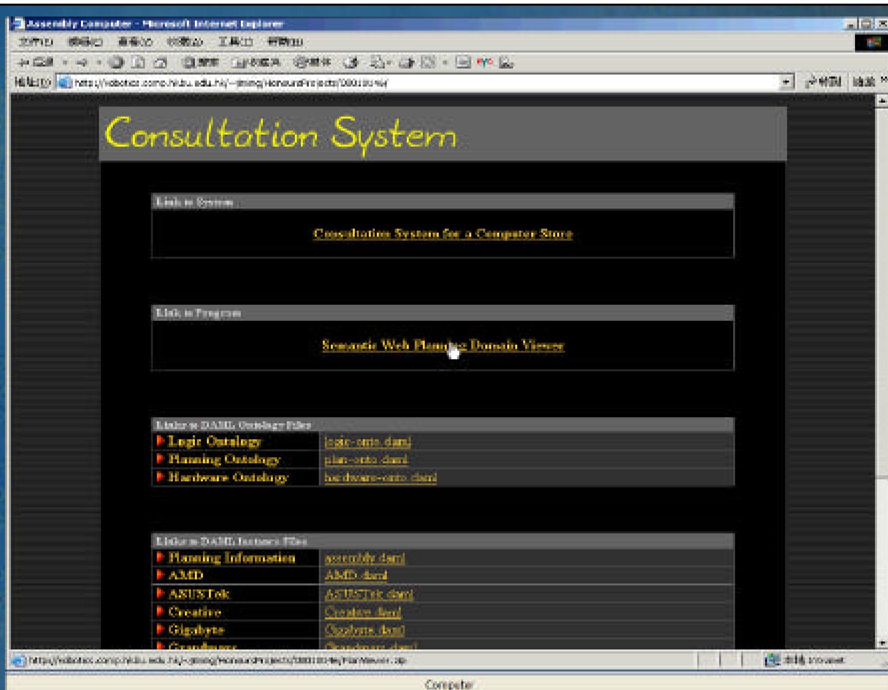
- A consultation system for computer configurations
  1. To suggest compatible hardware components
  2. To meet user preference
- Hardware Ontology: hardware-onto.daml
- Distributed product information (from manufacturers) are located in distributed instance files, as well as in local sources



Example of Operators

- Socket of the motherboard fits the CPU
- FSB of the motherboard is compatible with the bus speed of the CPU

```
Action:
    BuyCPU(?x)
Preconditions:
    CPU(?x), HaveMotherboard(?y),
    platform(?x, ?socket), cpuPlatform(?y, ?socket),
    systemBusSpeed(?x, ?fsb), maxFSB(?y, ?fsb)
Effects:
    additions: HaveCPU(?x)
    deletions:
```



WI Challenge #2

Distributed Agents + Coordination

Example: Distributed Scheduling

Given:

- A group of people, each of whom has specific available **time slots**
- A set of **constraints** among people (e.g., persons A and B will not be present at the same time)

Find:

- An available time slot when **all constraints are satisfied**

Satisfiability Problems (SAT)

Person and time slots	Variable and its domain
Constraint	Clause
Persons involved in a constraint	Literals in a clause
Meeting scheduling	SAT

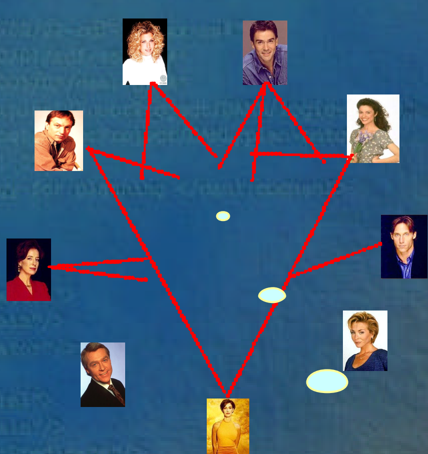
CNF: $F = \wedge_{i=1}^{m} C_i \quad \texttt{where} \quad C_i = \vee_{j=1}^{k} l_j^i$

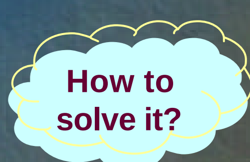
? = 'and', V = 'or', *Ci* = clause, *Lji* = literal (variable or its negation)

Local Search
(Selman, Levesque, and Mitchell, 1992; Gu, 1992)

- **Take the solution space (i.e., the Cartesian product of all variable domains) as a search space, and search it based on a certain rule**
  - **Randomly select one position as the start point to search**
  - **At each step, move to a neighboring position according to the rule (i.e., heuristic)**

GSAT (1992)	WalkSAT (1994)
GWSAT (1994)	WalkSAT/Tabu (1997)
GWSAT/Tabu (1997)	Novelty (1997)
	R-Novelty (1997)
	Novelty+ (1999)
	R-Novelty+ (1999)
SDF (2001)	
UnitWalk (2002)	





- **If**
  - **people are distributed in different places**
  - **the time slot information is *NOT* centralized**
- **Then**
  - **centralized local search methods become *ineffective***

Multi-Agent SAT (MASSAT)

(with X. Jin)

- Use multiple computational agents
- Decompose the search space into several sub-spaces
- Each agent decides how to locally search a sub-space (i.e., its environment)
- Through local interactions between agents and their environments, the agents coordinately find a global solution to the given problem

Formulation

- Divide variables into u groups
- Agent a_i: variable group $V_i = \{v_{i1}, \ldots, v_{ik}\}$
- Environment e_i of a_i: Cartesian Product of the variable group,
  $D_i = D_{i1} \times \ldots \times D_{ik}$
- Agent 's position e_i^j:
  j^{th} value combination in $D_i = D_{i1} \times \ldots \times D_{ik}$
- The position combination of all agents $\{e_1^k \ldots, e_i^j, \ldots\}$:
  a possible solution
- Basic move strategies of agent a_i:
  $$\psi_i : D_1 \times \ldots \times D_i \times \ldots \times D_u \rightarrow D_i$$
  - Best-move: $\psi_i^{-best} = e_i^{j'}$, st, $eval(e_i^{j'}) = Max\ eval(e_i^k)$ $(for\ all\ e_i^k \in D_i)$
  - Better-move: $\psi_i^{-better} = e_i^{j'}$, st, $eval(e_i^{j'}) > eval(e_i^j)$
  - Random-move: $\psi_i^{-random} = e_i^{j'}$, $e_i^{j'}$ is a random position in D_i

MASSAT Procedure

For $i = 1$ to $MAX\text{-}Cycles$

If all clauses are satisfied Then return T;

For *all distributed agents*

Select one (or more) of three behaviors {Best-move, Better-move, or Random-move};

Perform selected behavior(s);

EndFor

If no agent moves Then

Modify the weights of unsatisfied clauses;

End

Update T according to new positions of agents;

EndFor

$$W_i^{t+1} = \begin{cases} W_i^t & \text{if } T(C_i^t) = True \\ W_i^t + \delta & \text{if } T(C_i^t) = False \end{cases}$$

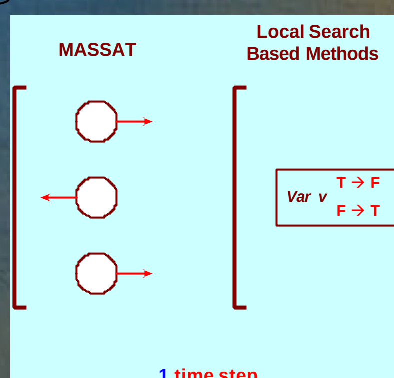
where W_i^t is the weight of clause C_i at time t.

δ is a learning rate.

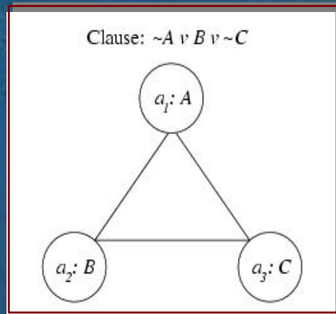
Comparison Based on Time Step

Algorithms	uf50	uf75	uf100	uf125	flat50	flat100
SDF	156	435	876	1,879	773	7,175
MASSAT	104	223	467	1,380	427	5,536

- Benchmark SAT problem packages from SATLIB
- **Time step** is the minimum unit
  - At each time step of SDF, only one variable is flipped
  - In MASSAT, agents move asynchronously



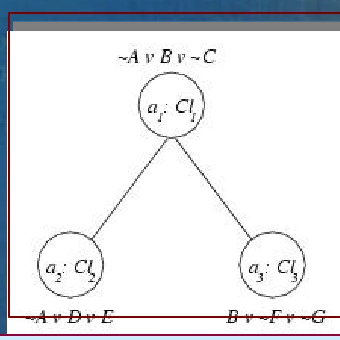
MASSAT: Variable-Based Agent Representation



Nodes: Each agent represents a variable in an SAT problem

Edges: If two variables appear in a common clause, there will be an edge between the agents corresponding to these two variables, indicating these two agents need to coordinately assign their respective values

Clause-Based Agent Representation



Nodes: Each agent represents a clause in an SAT problem

Edges: If clauses represented by two agents have a common literal, there will be an edge between these agents, which indicates these two agents need to coordinate

Agent Networks

- How does the topology of an agent network reflect the complexity of solving distributed SAT?
  - Jin and Liu (AAMAS'03) have experimentally proven that constraint satisfaction in a *small-world* is inefficient

Small-World

1. Highly clustered
2. The shortest path length between any two nodes is small

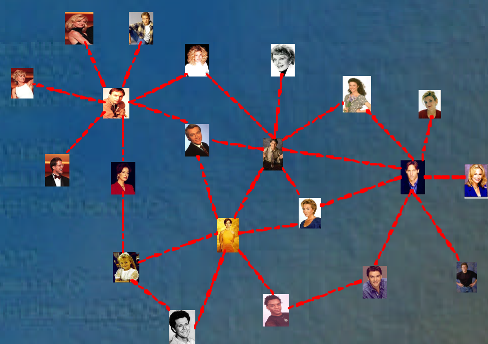
- Do agent networks formed in MASSAT have *small-world* topologies?

WI Challenge #3

Social Networks + Self-Organization

Social Networks

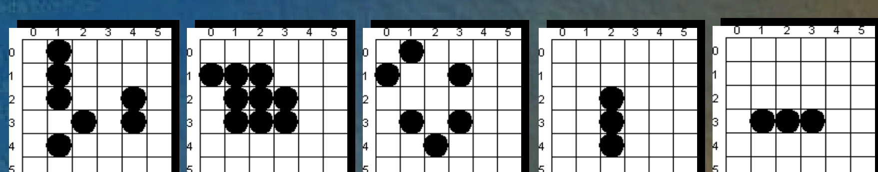
- A Social Network comprises a group of people with a pattern of interactions among them



- A Social Network is a self-organizing structure of users, information, and communities of expertise or practice

Self-Organization: Game of Life (Conway, 1970)

- `Life' rules are applied to an initial population of live cells (i.e., black circles)



Social Networks + Self-Organization: Game of RoboNBA (with C. H. Ng)

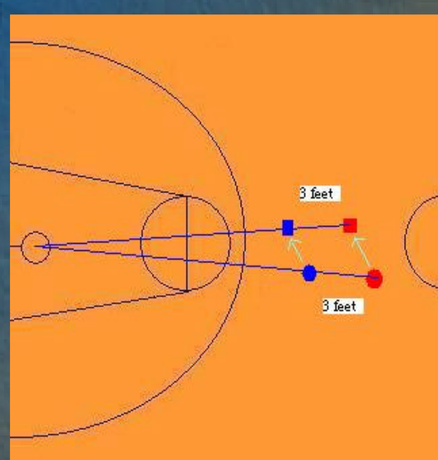
- Live cells → Distributed player agents
- `Life' rule → Decision/strategy
- Environment → Virtual court
- Patterns → NBA-like games

Basketball competition is a complex behavior:

- Team players interact **locally**
- It is difficult to predict a **complete** match

Example: Moving Action (1 of 8)

- blue circle – defender's old position
- red circle – offender's old position
- blue square – defender's new position
- red square – offender's new position




TEAM ABILITY
Basketball


NBA FINALS 2003
TV SCHEDULE
Nets Back in the Saddle
The Finals Are Here!
NBA STORE
BREAKDOWN
LIVE SCORE
Ten Cool Things
SEE...
All
Broadband
NBA

www.nba.com

RoboNBA **Games**

- **The teams used for testing the accuracy of the system:**

Team Name	Rank in NBA	Wins
Dallas Maverick	1st	0.75%
Philadelphia Sixers	10th	0.592%
Washington Wizards	20th	0.461%
Cleverland Cavs	29th	0.197%

Dallas Mavericks VS Philadelphia Sixers (5 matches)

Mavericks win Sixers 4 –1 (averages 90.6 –79.2)

MAVERICKS	MIN	OFF	DEF	RED	BLK	STL	3PM-A	3P%	2PM-A	2P%	3PT	2PT	PTS
dirk_nowitzki(0)	35.6	2.8	7.2	10.0	1.4	2.8	0.6-1.0	0.60	12.-28.	0.42	1.8	25.6	27.4
michael_finley(1)	34.2	1.0	4.2	5.2	0.8	2.0	1.0-1.4	0.71	7.4-17.	0.43	3.0	14.8	17.8
steve_nash(2)	26.8	2.4	3.8	6.2	0.4	0.6	0.8-2.0	0.40	4.2-10.	0.42	2.4	8.4	10.8
nick_van_exel...	23.3	2.0	3.6	5.6	0.4	0.2	0.6-0.8	0.74	2.6-7.0	0.37	1.8	5.2	7.0
raef_lafrentz(4)	15.4	0.2	2.6	2.8	0.4	0.6	0.4-1.0	0.40	3.4-6.4	0.53	1.2	6.8	8.0
eduardo_najer...	17.0	1.0	4.4	5.4	0.6	0.4	0.0-0.0	0.00	0.0-0.2	0.00	0.0	0.0	0.0
shawn_bradle...	15.5	1.0	2.0	3.0	1.0	0.8	0.0-0.0	0.00	3.6-6.0	0.60	0.0	7.2	7.2
walt_williams(7)	12.8	0.2	2.0	2.2	0.4	0.8	0.0-0.4	0.00	2.0-3.6	0.55	0.0	4.0	4.0
tariq_abdul-wa...	13.6	0.6	1.4	2.0	0.2	0.4	0.0-0.0	0.00	0.8-1.4	0.57	0.0	1.6	1.6
adrian_griffin(9)	16.4	0.2	2.8	3.0	0.6	1.6	0.2-0.8	0.25	0.6-1.4	0.42	0.6	1.2	1.8
avery_johnson...	5.0	0.2	1.0	1.2	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
raja_bell(11)	9.66	0.4	1.0	1.4	0.0	0.2	0.0-0.0	0.00	0.0-0.2	0.00	0.0	0.0	0.0
popeye_jones(...	4.62	0.2	0.2	0.4	0.2	0.0	0.0-0.0	0.00	0.6-2.6	0.23	0.0	1.2	1.2
antoine_rigaud...	3.47	0.0	0.4	0.4	0.2	0.0	0.2-0.2	1.0	0.6-0.8	0.74	0.6	1.2	1.8
evan_eschme...	6.3	0.0	0.0	0.0	0.0	0.6	0.0-0.0	0.00	1.0-3.8	0.26	0.0	2.0	2.0
mark_stricklan...	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 18	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
TOTAL	240.	12.2	36.6	48.8	6.6	11.0	3.8-7.6	0.50	39.-89.	0.43	11.4	79.2	90.6

SIXERS	MIN	OFF	DEF	RED	BLK	STL	3PM-A	3P%	2PM-A	2P%	3PT	2PT	PTS
allen_iverson(0)	34.8	1.0	6.4	7.4	0.2	0.8	1.0-1.6	0.62	7.4-13.	0.56	3.0	14.8	17.8
keith_van_hor...	26.2	1.6	6.6	8.2	0.6	0.6	1.0-2.6	0.38	6.8-16.	0.42	3.0	13.6	16.6
eric_snow(2)	35.1	2.0	3.8	5.8	0.6	0.6	0.0-0.4	0.00	1.2-2.8	0.42	0.0	2.4	2.4
kenny_thomas(3)	25.6	1.4	3.6	5.0	1.2	0.4	0.0-0.0	0.00	1.4-3.2	0.43	0.0	2.8	2.8
derrick_colem...	19.5	1.2	1.6	2.8	0.4	0.8	0.2-0.8	0.25	1.2-4.0	0.30	0.6	2.4	3.0
aaron_mckie(5)	24.0	2.8	4.8	7.6	0.0	0.8	0.2-0.4	0.50	1.0-2.4	0.41	0.6	2.0	2.6
todd_maccullo...	17.5	0.4	2.2	2.6	0.8	1.8	0.0-0.0	0.00	6.0-13.	0.46	0.0	12.0	12.0
brian_skinner(7)	13.3	0.6	1.4	2.0	0.4	1.0	0.0-0.0	0.00	7.2-18.	0.40	0.0	14.4	14.4
greg_buckner(8)	14.3	0.4	1.6	2.0	0.2	0.0	0.0-0.0	0.00	0.4-1.0	0.40	0.0	0.8	0.8
monty_william...	8.39	0.2	1.0	1.2	0.2	0.4	0.0-0.0	0.00	0.2-0.4	0.50	0.0	0.4	0.4
tyrone_hill(10)	12.9	0.8	2.2	3.0	0.4	0.6	0.0-0.0	0.00	3.0-11.	0.27	0.0	6.0	6.0
john_salmons(...	5.34	0.2	0.8	1.0	0.0	0.2	0.0-0.0	0.00	0.2-0.2	1.0	0.0	0.4	0.4
efthimios_rent...	0.98	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.8	0.00	0.0	0.0	0.0
kenny_satterfi...	1.44	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 18	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
player 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0	0.00	0.0-0.0	0.00	0.0	0.0	0.0
TOTAL	240.	12.6	36.0	48.6	5.0	8.0	2.4-5.8	0.41	36.-88.	0.40	7.2	72.0	79.2

Dallas Mavericks VS Philadelphia Sixers (real)

Mavericks win Sixers 107-94

MAVERICKS

PLAYER	POS	MIN	FGM-A	3GM-A	FTM-A	REBOUNDS OFF	DEF	TOT	AST	PF	ST	TO	BS	PTS
MICHAEL FINLEY	G	40	8-14	1-4	2-2	1	2	3	5	1	1	2	0	19
STEVE NASH	G	37	8-20	2-5	3-3	1	3	4	13	3	1	1	0	21
RAJA BELL	F	41	1-5	0-0	0-0	0	2	2	0	5	2	0	1	2
DIRK NOWITZKI	F	35	12-19	2-5	4-4	2	12	14	2	1	0	3	1	30
SHAWN BRADLEY	C	24	4-7	0-0	0-0	4	5	9	0	1	2	2	5	8
Nick Van Exel		22	5-8	4-5	2-2	0	2	2	3	3	1	1	0	16
Walt Williams		13	4-6	3-3	0-0	1	1	2	0	2	0	0	0	11
Adrian Griffin		12	0-2	0-0	0-0	0	2	2	1	0	0	0	0	0
Raef LaFrentz		7	0-2	0-0	0-0	0	0	0	0	4	0	0	0	0
Antoine Rigaudeau		7	0-1	0-0	0-0	0	1	1	0	2	0	1	0	0
Avery Johnson		2	0-1	0-0	0-0	0	0	0	0	0	0	0	0	0
Popeye Jones														DNP
TOTAL		240	42-85	12-22	11-11	9	30	39	24	22	7	10	7	107
			49.4%	54.5%	100.0%	Team Rebs: 3						Total TO: 10		

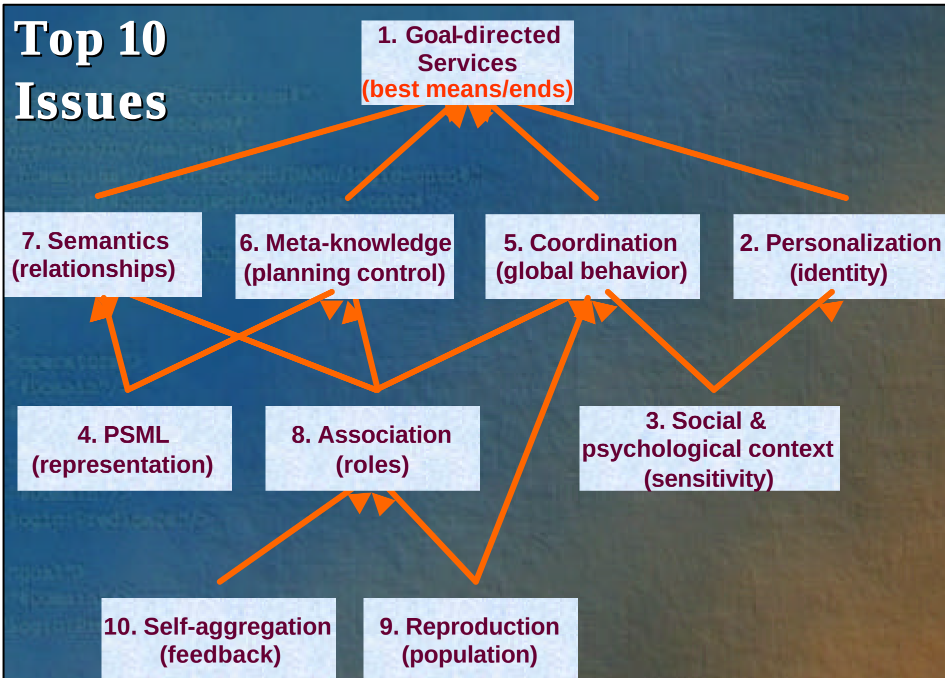
Source: www.nba.com

RoboNBA **Games** (30 matches)

TEAMS	Sixers (right)	Wizards (right)	Cavs (right)
Mavericks (left)	22 – 8 **(87.0 – 83.7)** (real: 107-94)	24 – 6 **(86.0 – 73.5)** (real: 106-101)	25 – 5 **(82.7 – 72.9)** (real: 114-93)
Sixers (left)		18 – 12 **(78.7 – 76.5)** (real: 88-80)	24 – 6 **(75.4 – 69.0)** (real: 116-103)
Wizards (left)			14 – 16 **(69.3 – 74.3)** (real: 93-84)

Issues and Directions

Top 10 Issues



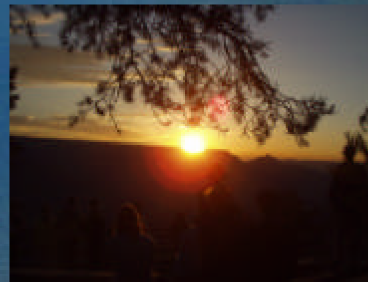
The Wisdom Web

- To enable humans to gain practical wisdom of *living*, *working*, and *playing*
  - Wisdom: (Webster Dictionary, page 1658)

    The quality of being wise; knowledge, and the capacity to make due use of it; **knowledge of the best ends and the best means**
- To provide
  - a medium for knowledge and experience (e.g., of the Grand Canyon) sharing
  - a supply of self-organized resources for driving sustainable knowledge creation and scientific or social development/evolution

Summary

- Background
- Challenges
  - Semantic Web + Planning: OntoPlan
  - Distributed Agents + Coordination: MASSAT
  - Social Networks + Self-Organization: RoboNBA
- Issues and Directions
  - The Wisdom Web



The End