

Web Intelligence (WI)

Some Research Challenges

[IJCAI 03 Invited Talk]

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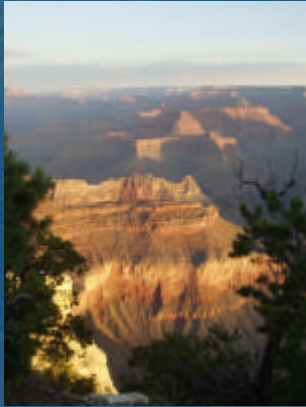


IJCAI '03 8/15/2003

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- ◆ WIC Research Centers in Australia, Canada, India, Japan, and Spain, among others
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 - ❖ A.M.D. Lab (HKBU)
 - ❖ AAMAS/AOC Group (HKBU)

- ◆ The preparation has benefited from a peaceful break in **Grand Canyon**, on the way to IJCAI'03 ...



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Outline

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

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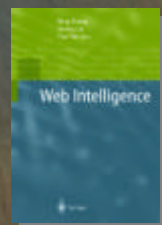


What is Web Intelligence (WI)?

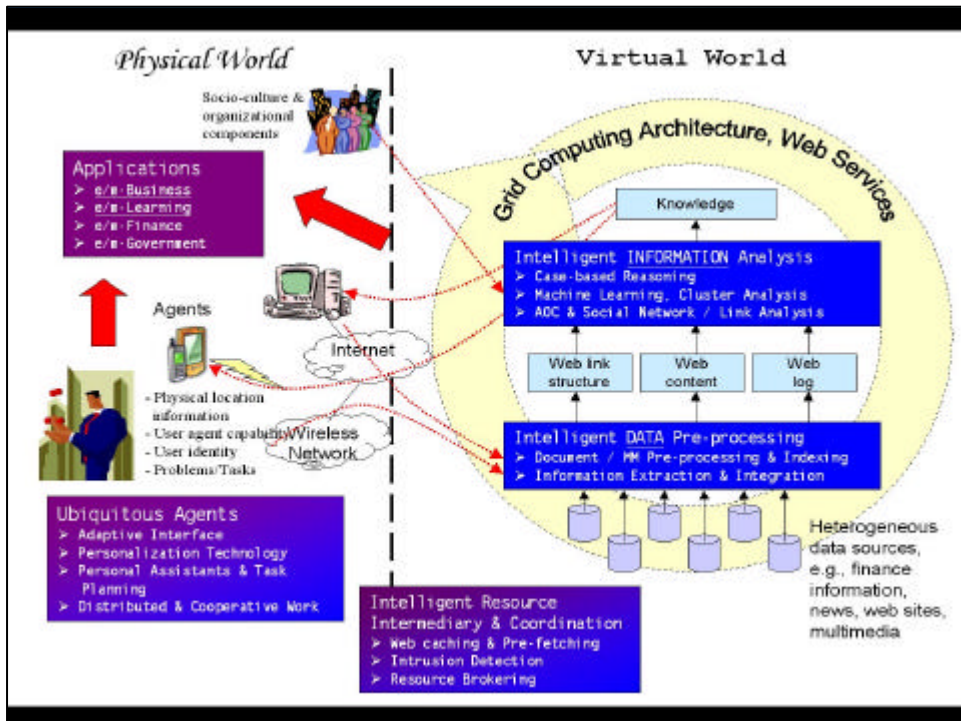
WI explores the fundamental roles as well as practical impacts of

- ❖ **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

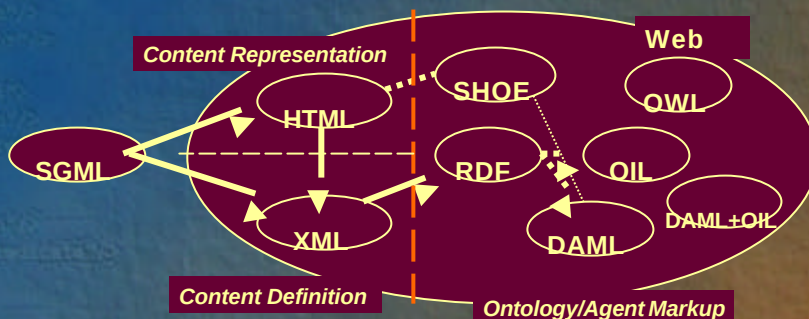
support

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 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>

```

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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)

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Operators in STRIPS

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

Action: Buy(?x)
Preconditions: At(?store) $\wedge$ Sell(?store, ?x)
Effects:
 additions: Have(?x)
 deletions:

Buy(?x)

+ Have(?x)

At(?here)

Go(?there)

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

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

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POP Algorithm

Ordering constraint

$$S_i < S_j$$

- ❖ Step S_i occurs before step S_j

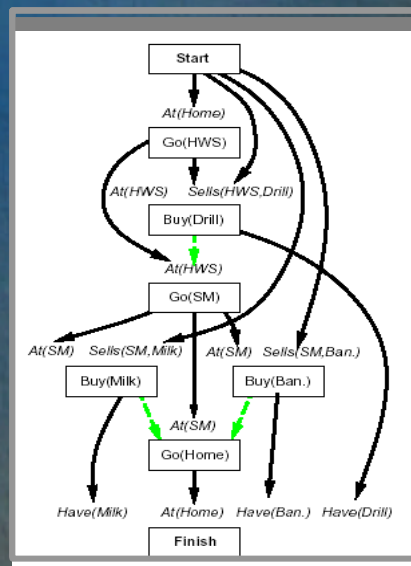
Casual link

$$S_i \xrightarrow{c} S_j$$

- ❖ S_i achieves the precondition c of S_j

Open condition

- ❖ Precondition that is not causally linked



Source: Russell & Norvig

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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

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```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
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  xmlns:daml="http://www.daml.org/2001/03/daml+oil#"
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  </rdfs:Class>
  <!-- Constant -->
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    <daml:range rdf:resource="http://www.w3.org/2000/10/XMLSchema#string"/>
  </daml:DatatypeProperty>
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    <daml:subClassOf rdf:resource="#Term"/>
  </rdfs:Class>
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    <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>
```

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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>
```



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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:
```

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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)

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```

    <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>

```

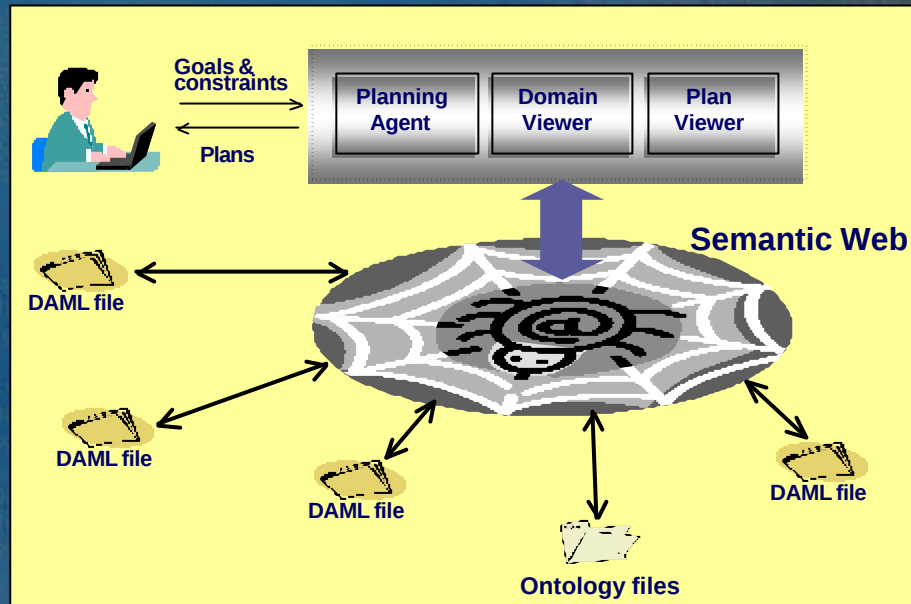
At(?store)

Sell(?store, ?x)

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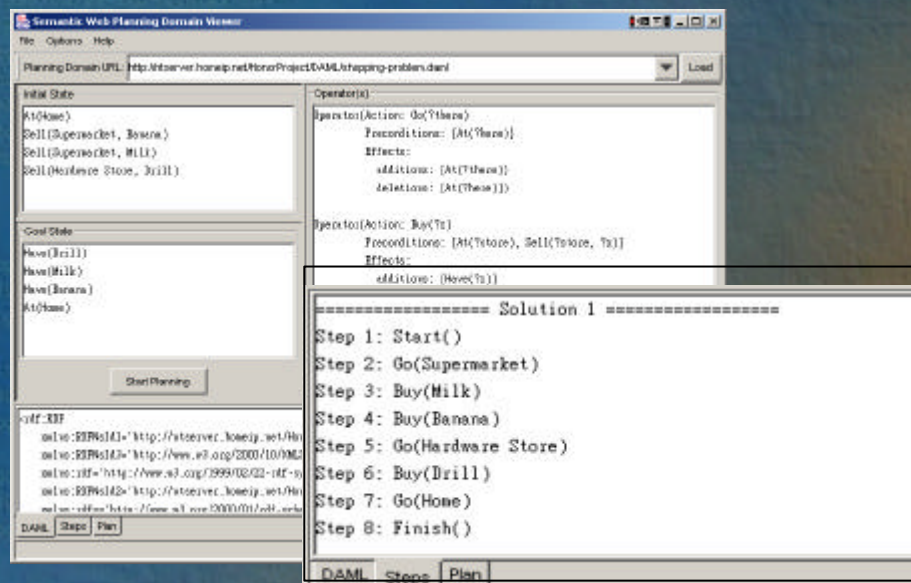
OntoPlan



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OntoPlan: Domain & Plan Viewers

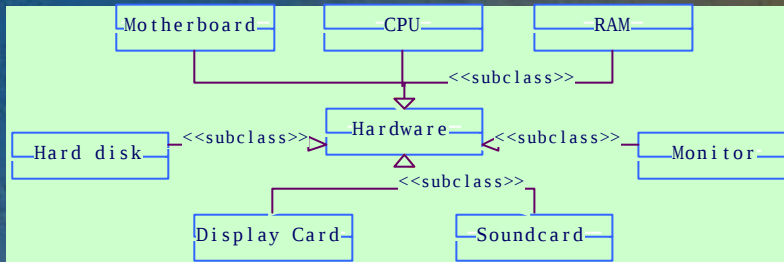


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Application

- ◆ **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



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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:

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Assembly Computer - Microsoft Internet Explorer

http://robotics.com/hku.edu.hk/~ching/monaural/robot/0001/0040/

Consultation System

Link to System

[Consultation System for a Computer Store](#)

Link to Program

[Semantic Web Planner Domain Viewer](#)

Link to DAML Ontology Files

Logic Ontology	logic-onto.daml
Planning Ontology	plan-onto.daml
Hardware Ontology	hardware-onto.daml

Link to DAML Instance Files

Planning Information	assembly.daml
AMD	AMD.daml
ASUSTek	ASUSTek.daml
Creative	Creative.daml
Gigabyte	Gigabyte.daml
Grandpower	Grandpower.daml

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Computer

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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

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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:

$$F = \bigwedge_{i=1}^m C_i \quad \text{where} \quad C_i = \bigvee_{j=1}^k l_j^i$$

? = 'and', V = 'or', C_i = clause, L_j^i = literal (variable or its negation)

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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)	

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- ◆ If
 - ❖ people are **distributed** in different places
 - ❖ the time slot information is **NOT** centralized

- ◆ Then
 - ❖ centralized local search methods become **ineffective**

How to solve it?

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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

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Formulation

- ◆ Divide variables into u groups
- ◆ Agent a_i : variable group $V_i = \{v_{i1}, \dots, v_{ik}\}$
- ◆ Environment e_i of a_i : Cartesian Product of the variable group,

$$D_i = D_{i1} \times \dots \times D_{ik}$$
- ◆ Agent's position e_i^j :

$$j^{th} \text{ value combination in } D_i = D_{i1} \times \dots \times D_{ik}$$
- ◆ The position combination of all agents $\{e_1^k, \dots, e_i^j, \dots\}$:
a possible solution
- ◆ Basic move strategies of agent a_i :

$$\psi_i: D_1 \times \dots \times D_i \times \dots \times D_u \rightarrow D_i$$
 - ❖ Best-move: $\psi_i^{-best} = e_i^{j'}, \text{ st, } eval(e_i^{j'}) = \text{Max } eval(e_i^k)$
(for all $e_i^k \in D_i$)
 - ❖ Better-move: $\psi_i^{-better} = e_i^{j'}, \text{ st, } eval(e_i^{j'}) > eval(e_i^j)$
 - ❖ Random-move: $\psi_i^{-random} = e_i^{j'}$,
 $e_i^{j'}$ is a random position in D_i

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MASSAT Procedure

```

For  $i=1$  to  $MAX-Cycles$ 
  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.

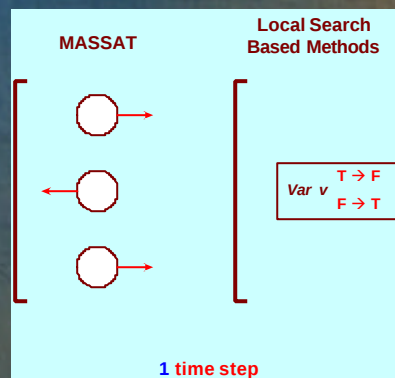
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Comparison Based on Time Step

Algorithms	uf50	uf75	uf100	uf125	fl50	fl100
SDF	156	435	876	1,879	773	7,175
MASSAT	104	223	467	1,380	427	5,536

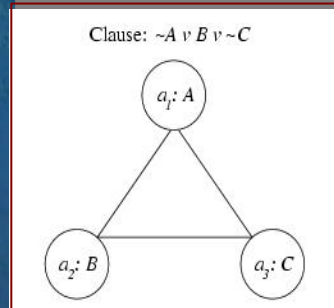
- **Benchmark SAT problem packages from SATLIB**
- **Time step** is the minimum unit
 - At each time step of SDF, only one variable is flipped
 - In MASSAT, agents move asynchronously



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MASSAT: Variable-Based Agent Representation



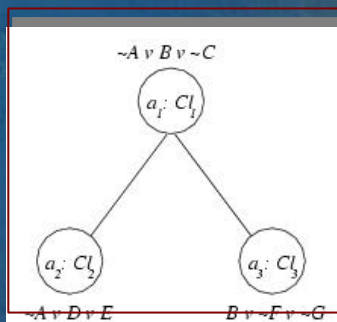
Nodes: Each agent represents a variable in an SAT problem

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

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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

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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

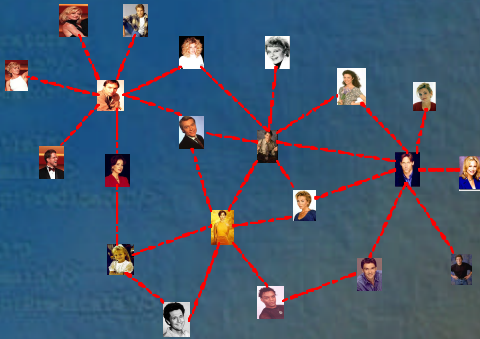
- ◆ Do agent networks formed in **MASSAT** have *small-world* topologies?

WI Challenge #3

Social Networks + Self-Organization

Social Networks

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



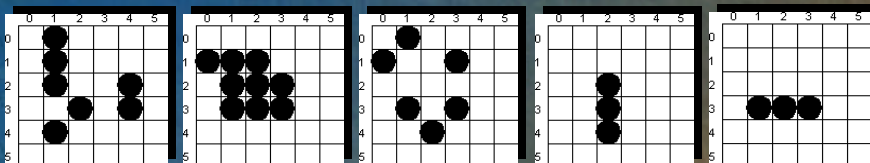
- A Social Network is a **self-organizing structure** of users, information, and communities of expertise or practice

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

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



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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:

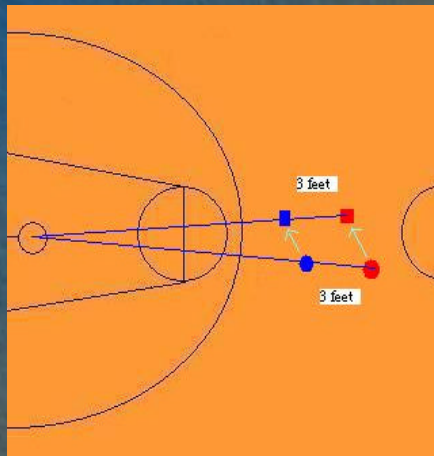
- Team players interact **locally**
- It is difficult to predict a **complete** match

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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



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Multiagent System: Tactical Strategy Simulation (MSTS)

Tactical Diagram: A soccer field with yellow lines and player positions. The field is divided into three main sections: a top-left tactical diagram, a top-right player ability table, and a bottom control/monitoring panel.

Player Ability Table:

NAME	STR	AG	DR	SH	GK	DEFENSE	OFFENSE	SPECIAL
goal_keeper03	83	79	84	85	60	75	89	77
defense_midfield1	77	79	83	74	53	68	71	79
half_midfield1	81	81	82	63	53	68	64	79
midfield_midfield1	72	84	88	84	56	58	67	67
midfield_midfield2	77	84	88	81	56	58	57	65
half_midfield2	86	58	82	87	66	65	55	59
half_midfield3	89	72	74	55	56	55	55	59
midfield_midfield3	89	80	81	59	58	61	51	54
goal_keeper04	72	80	75	56	56	50	59	59
defense_midfield2	71	50	50	56	50	50	50	59
defense_midfield3	78	50	50	51	50	55	50	59
midfield_midfield4	86	50	50	56	50	50	50	59
player12	0	0	0	0	0	0	0	0
player13	0	0	0	0	0	0	0	0
player14	0	0	0	0	0	0	0	0
player15	0	0	0	0	0	0	0	0
player16	0	0	0	0	0	0	0	0
player17	0	0	0	0	0	0	0	0
player18	0	0	0	0	0	0	0	0
player19	0	0	0	0	0	0	0	0

Control Panel:

- Number of Match: 1 Match
- Execution Speed in View Mode: 2 Times
- Playing Time: 40:00
- Buttons: Manual Initialization, Initialization Team A, Initialization Team B, New View Match, New Agent, Process, Clear, Policy

Task List:

- Program Clear
- Processing/Reading Team A Data From Interceptor Now
- Flash Reading Team A Data
- Processing/Reading Team B Data From Interceptor Now
- Flash Reading Team B Data
- Yes Can Press The Start Button
- Program Execution
- Task: A Player "midfield_midfield1" Was Is Jump Out
- Task: A Player "defense_midfield2" Press The Ball To Player "half_midfield1"
- Task: A Player "half_midfield2" Get The Ball

NBA NFL WNBA Global Terms		FANTASY GAMES STORE TICKETS HELP	
NBA FINALS 2003 			
TV SCHEDULE Game 5 San Antonio at New Jersey 8 p.m. ET Friday, ABC			
STATS	ROSTERS	PLAYOFFS	NBA.COM
 The Finals Are Here! E-196L PHOTO BUY #10T03 Watch Game 5 at 8 p.m. ET Friday on ABC.		Nets Back in the Saddle NBA Finals 2003 will be decided in the state of Texas. Jason Kidd led four free throws in the final nine seconds as the <u>Nets beat the Spurs 77-70</u> Wednesday to tie the series at 2-2. Game 5 will be 8 p.m. ET Friday (ABC) in New Jersey, with San Antonio hosting Game 6 on Sunday. • Photos: Game 4 Schedule Scores • Couch Tom Database coverage • The Ring's Free Spin Texas • Register to take the 2003 NBA Finals 2003 MVP poll. Voting Now Open	
		NBA Store Get your 2003 Finals Program now at the NBA Store !	
		NBA TV LIVE Wednesday's BestOne Vampiro : 50% + 30% FT Complete NBA Highlights	
BREAKDOWN GAME 1 San Antonio 101, New Jersey 88 Box Score Video: CBS 1200P IT The Race IT		LIVE SCORE San Antonio Spurs ☐ 70 New Jersey Nets ☐ 77 Feed Poses Box Score Highlights Leading Scorer: T. Davis	
GAME 2 New Jersey 87, San Antonio 85 Box score Video: CBS 1200P IT The Race IT		Rink ALL ACCESS PASS Ten Cool Things Some cool things about Game 2? The Rookie of the Year Award. Steve Nash's buzzer-beating shot. Reggie Miller's dunk. And more. Page 10.	
GAME 3 San Antonio 84, New Jersey 79 Box score Video: CBS 1200P IT The Race IT			
GAME 4 New Jersey 77, San Antonio 78 Box score Video: CBS 1200P IT The Race IT		See... All Broadband NBA 	
GAME 5 San Antonio at New Jersey Friday, June 13 (8 p.m. ET, ABC)		INSIDE TICKET 	
GAME 6 New Jersey at San Antonio Sunday, June 15 (8 p.m. ET, ABC)		SEE... All Broadband NBA 	
GAME 7 New Jersey at San Antonio Wednesday, June 18 (8 p.m. ET, ABC)		SEE... All Broadband NBA 	

If necessary, download schedule
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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%
◆ Cleveland Cavs	29th	0.197%

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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_najera...	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_bradley...	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...	28.2	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_snovv(2)	36.1	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_mokie(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(9)	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
eifhios_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

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Dallas Mavericks VS Philadelphia Sixers (real)

Mavericks win Sixers 107-94

MAVERICKS																
PLAYER	PO	S	MIN	FG-M-A	3GM-A	FT-M-A	REBOUNDS					PF	ST	TO	BS	PTS
							OFF	DEF	TOT	AST						
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		
DIKI 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		
Emmanuel James														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					

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Source: www.nba.com

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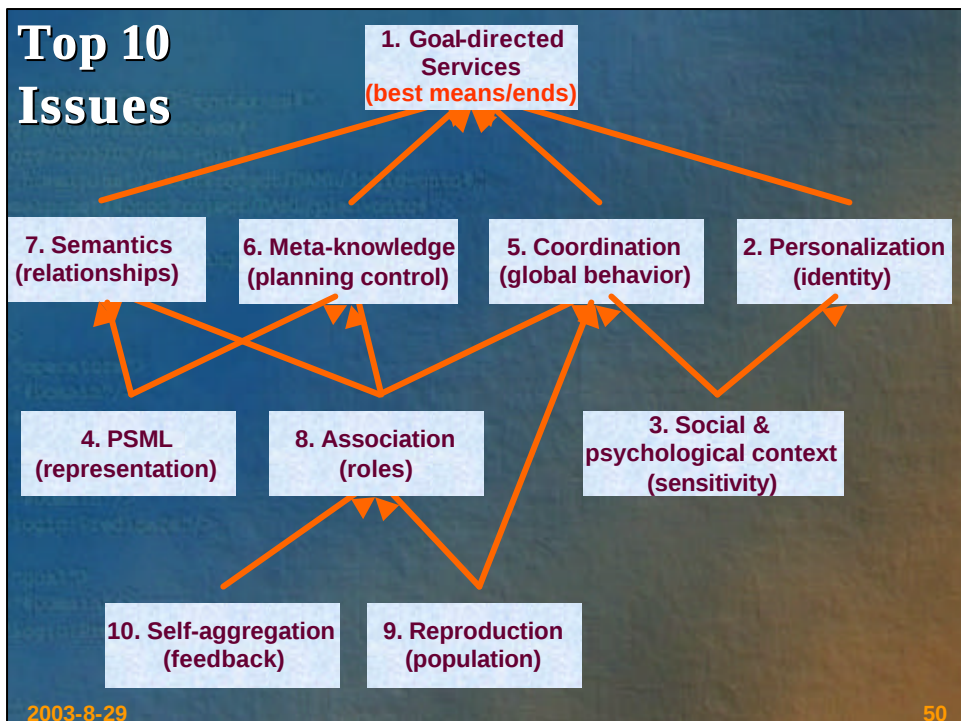
RoboNBA Games (30 matches)

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)

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Issues and Directions



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**

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Summary

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

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The End



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