

# Challenges in the Large-Scale Deployment of Agents and Services

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*August, 2002*

# The Second Internet Revolution

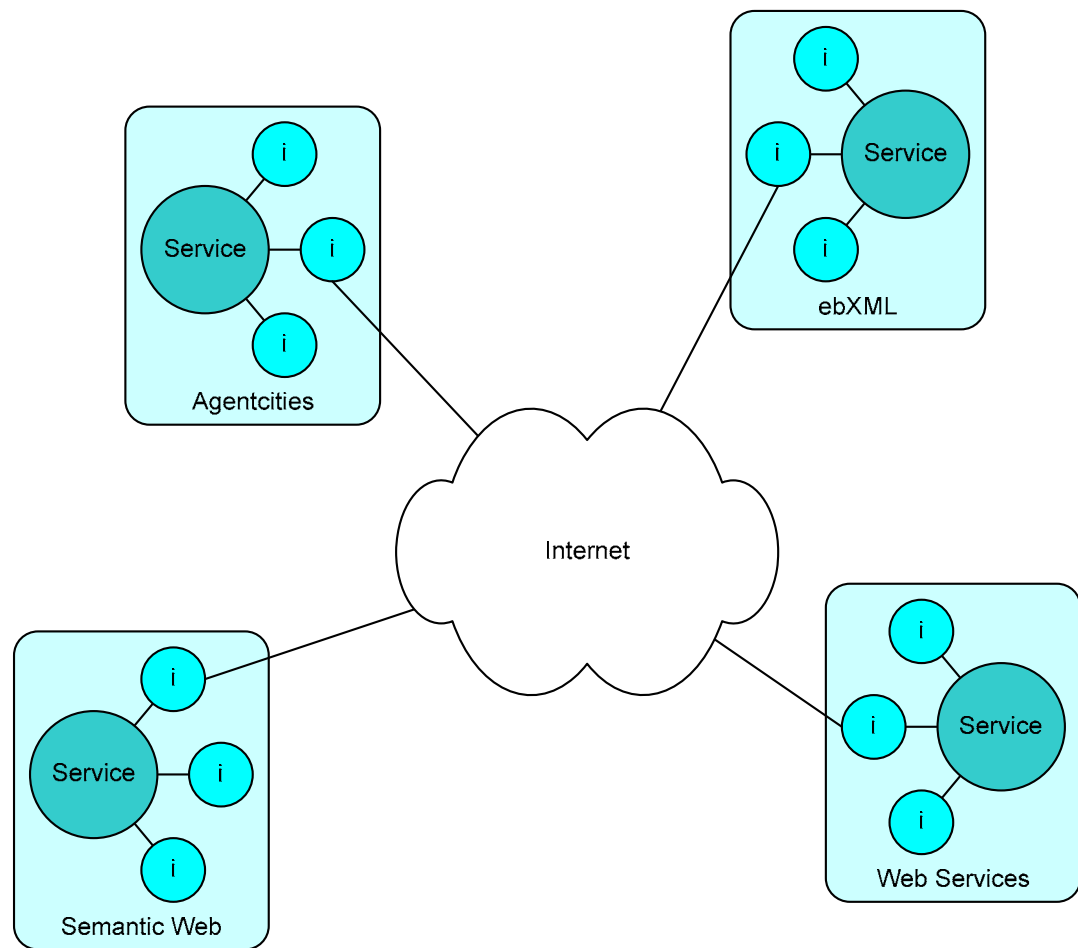
- The first Internet revolution was the Web:
  - Human readable representations (HTML)
  - Oriented around a document model (Web pages everywhere)
  - Main interaction metaphor is to browse
- The Internet is experiencing a big change:
  - Move from human to machine representations
  - Oriented around a service model (services everywhere)
  - Main interaction metaphor will be to achieve tasks
- This will lead to:
  - Business service interactions (B2C and B2B)
  - Large-scale service composition and orchestration
  - New user interaction models (autonomous and smart)

# Potential for the Internet

- The greatest potential for the Internet is to support:
  - A goal-oriented method of working
  - Ubiquitous access to services
  - Harnessing the resources of many different organisations
- This is the rational extension of down-sizing and out-sourcing:
  - Ad hoc task execution using the Internet as a global market place
  - Moving between organisational boundaries whilst preserving ownership
- Users and businesses are no longer just satisfied with browsing:
  - Powerful and intelligent tools are required to help users complete tasks
  - Software needs to move into the background

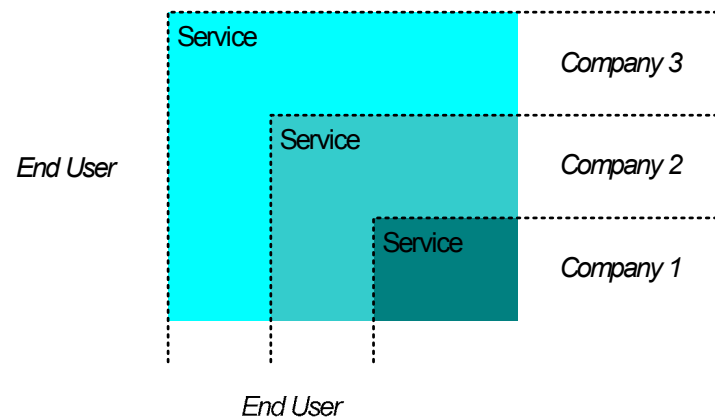
# Services Everywhere

Services will be as numerous as Web pages

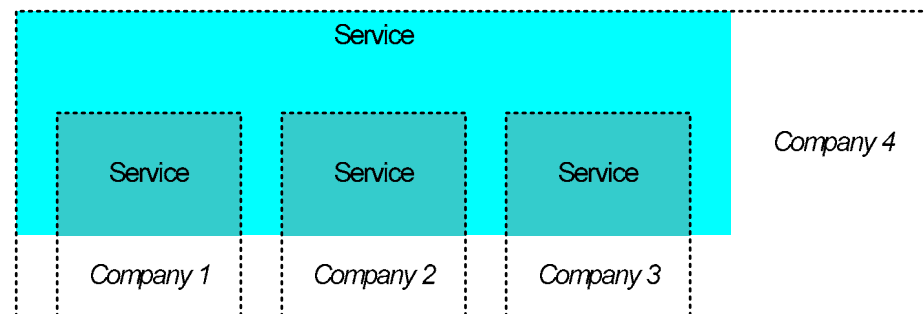


# Service Composition and Reuse

- Vertical
  - Services built on top of other services
  - Each layer adds new value



- Horizontal
  - One service is built from many other services
  - Services are combined into a new, composite service



- Mixtures of vertical and horizontal occur more naturally in business process environments

# What is Agentcities?

- Agentcities is a world wide project to create:
  - a distributed network of agent-based systems, services and applications
  - a deployment environment for next generation Internet-based and Web Services
  - a service model in which services can be dynamically composed and reused (value-add)
  - a new interaction model for users and business which is based upon delegating tasks to agents
- An Agentcity is a virtual ‘city’ that is composed of users, agents and services (not a digital city)
- The mission of Agentcities is:

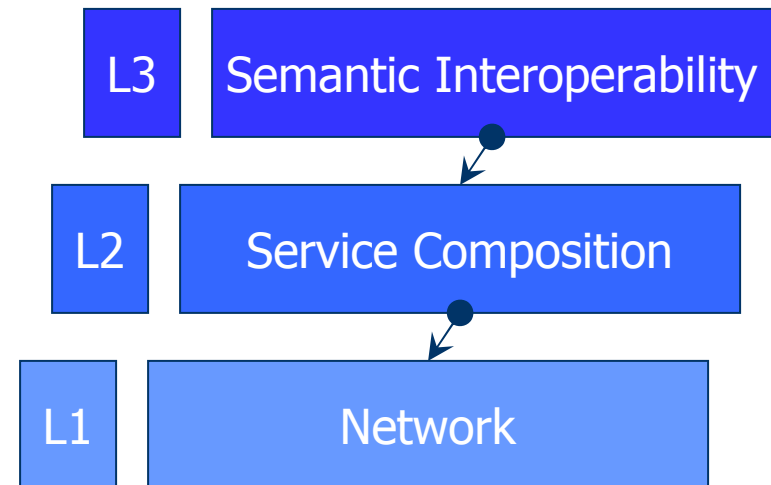
“To develop and deploy a global, open environment in which services can be dynamically, autonomously and intelligently composed to achieve user and business goals.”
- ~100 organisations involved

# EU Agentcities Project: Aims

- EU Agentcities aims to:
  - Deploy the first open, distributed agent network environment for businesses and academic institutions on a global scale
  - Build a dynamic service environment which allows services to be deployed, composed and reused
  - Encourage content providers and businesses to deploy services and content within the network to encourage growth
  - Build agent-based applications to take advantage of the services in the network to encourage use
- Two projects:
  - EU Agentcities.RTD
    - Research and deployment aspect
  - EU Agentcities.NET
    - Public relations aspect to encourage growth of the network

# EU Agentcities.RTD Project

- EU IST-2000-28385
  - Began July 2001
  - 2 year timescale; 500 man months
  - 5.5 Million Euro budget
  - 14 partners
- Actions
  - Create the basis for the Agentcities Network
  - Technology frameworks
  - Backbone network and initial mass of services
  - Research and development focus



Three layers of activity

# EU Agentcities.NET Project

- EU IST-2000-28384
  - Began November 2001
  - 18 month timescale
  - 1 Million Euro budget
  - 50+ member organizations
- Objective
  - Fund Agentcities deployment and usage in Europe
- Actions
  - Technical support
  - Deployment grants
    - 32 awarded
  - Competition
  - Information Days
  - Working Group support
  - Student and Researcher Mobility

# Agentcities Task Force (ACTF)

- An effort to provide a coordination forum for each Agentcities project
- The mission is:
  - To facilitate a worldwide, open, heterogeneous and interoperable environment in which autonomous services can be defined, deployed and utilised in a dynamic, composable and value added way*
- Main activities:
  - Cross-project coordination and collaboration
  - Agentcities Network support
  - Promotion and dissemination of the Agentcities idea
  - Liaison with other standardisation bodies and activities

# ACTF Work Groups

- Healthcare
- Ontologies and Communication
- Security
- Web Services
- Engineering Self-Organising Applications
- Business Process Infrastructure
- Service Description and Composition
- Network Architecture

<http://www.agentcities.org/>



# **Agentcities Network**

# Current Network Snapshot



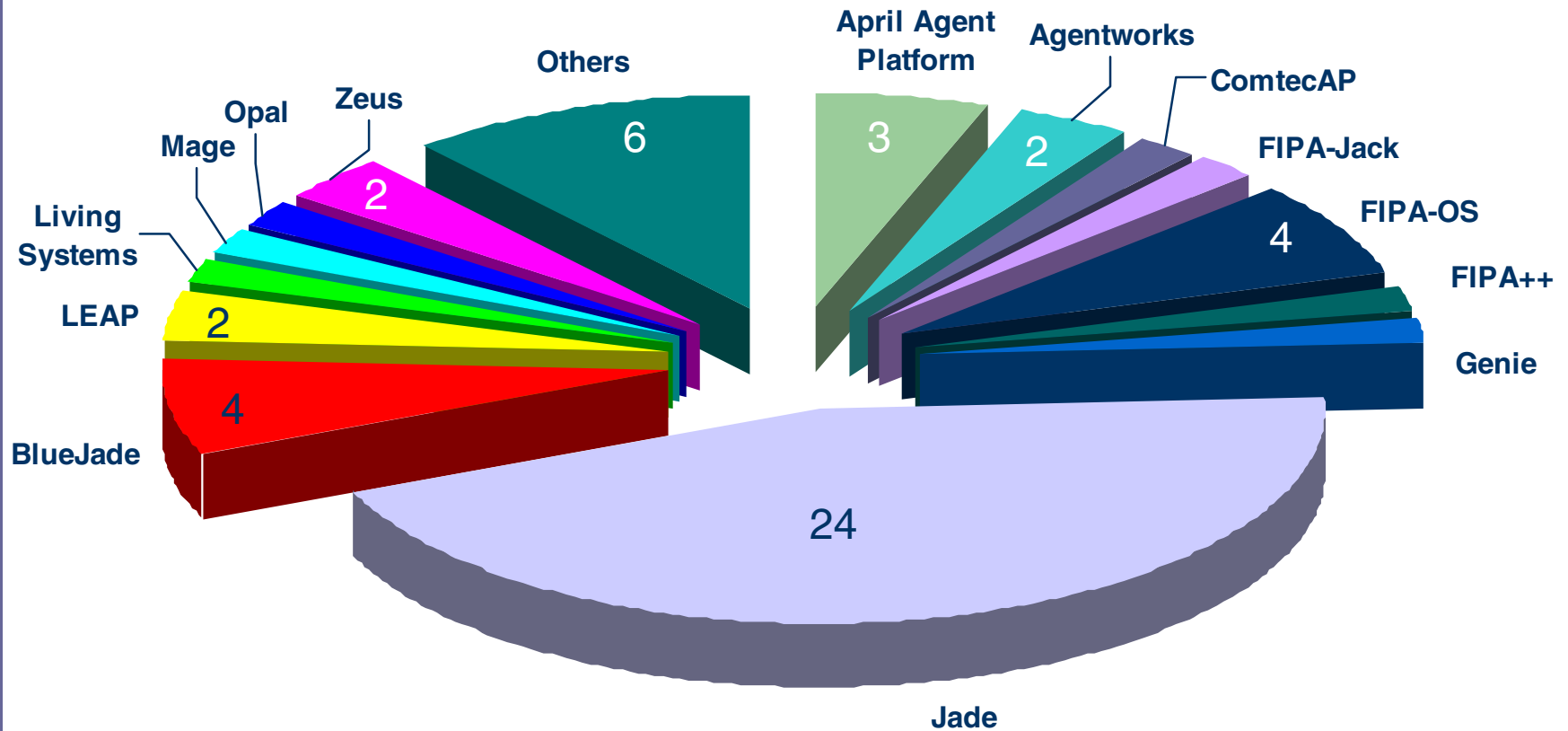
# Network Objectives

- Technical
  - Coherent framework and architecture for large-scale open networks of (agent-based) services
  - Support heterogeneous technologies and their re-use
- Operational
  - Build a significant community of users to create a realistic test environment
  - Support users in experimentation with agent based services and their composition
  - Gather experience in using and managing such large-scale open systems

# Architecture

- Standard
  - Foundation for Intelligent Physical Agents (FIPA)
  - Standard for interoperating agent-based systems
- Technologies
  - FIPA HTTP Message Transport Protocol
  - FIPA XML Envelope
  - FIPA Agent Management System (AMS)
    - White Pages
  - FIPA Directory Facilitator (DF)
    - Yellow Pages
- Structure
  - Peer-to-peer messaging
  - Centralized platform directory
  - Star topologies for agent and service directories
- Nodes
  - All FIPA platforms
  - Various platform implementations
    - Open source
    - Commercial

# Agent Platform Composition



# Challenge: Network Management

- Require

- Bootstrapping
  - Platforms
  - Agents and services
  - Service discovery
- Information sharing on configurations
- Tracking status of Network components
- Management of agents on remote platforms

- Solution

- Centralized Web-based management
- User Accounts
  - Humans enter bootstrapping data
- Automated polling to track status
- Java Server Pages (JSP)

- Problems

- Centralized, single point of failure

# Challenge: Debugging and Testing

- Testing and checking
  - Platform status
  - Message delivery and speed
  - Directory responsiveness, recall and accuracy
- Began with
  - Hand driven tests
  - No longer feasible with large numbers of platforms
- Solutions
  - Agentcities test suite
  - New on-line monitoring tools
  - Agent automated network status checking
- Problems
  - Becomes harder when decentralized

# Future: Network Evolution

- Technologies

- SOAP transport
- UDDI directory
- ebXML registry
- LDAP
- Different caching, propagation and query policies
  - DNS versus UDDI
- Message gateways
- Mobile networks
- ...

- Structure

- Model based on domains, sub-domains
- Flexible organizational structure
- Exploring various use-cases
  - Internet
  - Intranet
  - Peer-to-peer networks

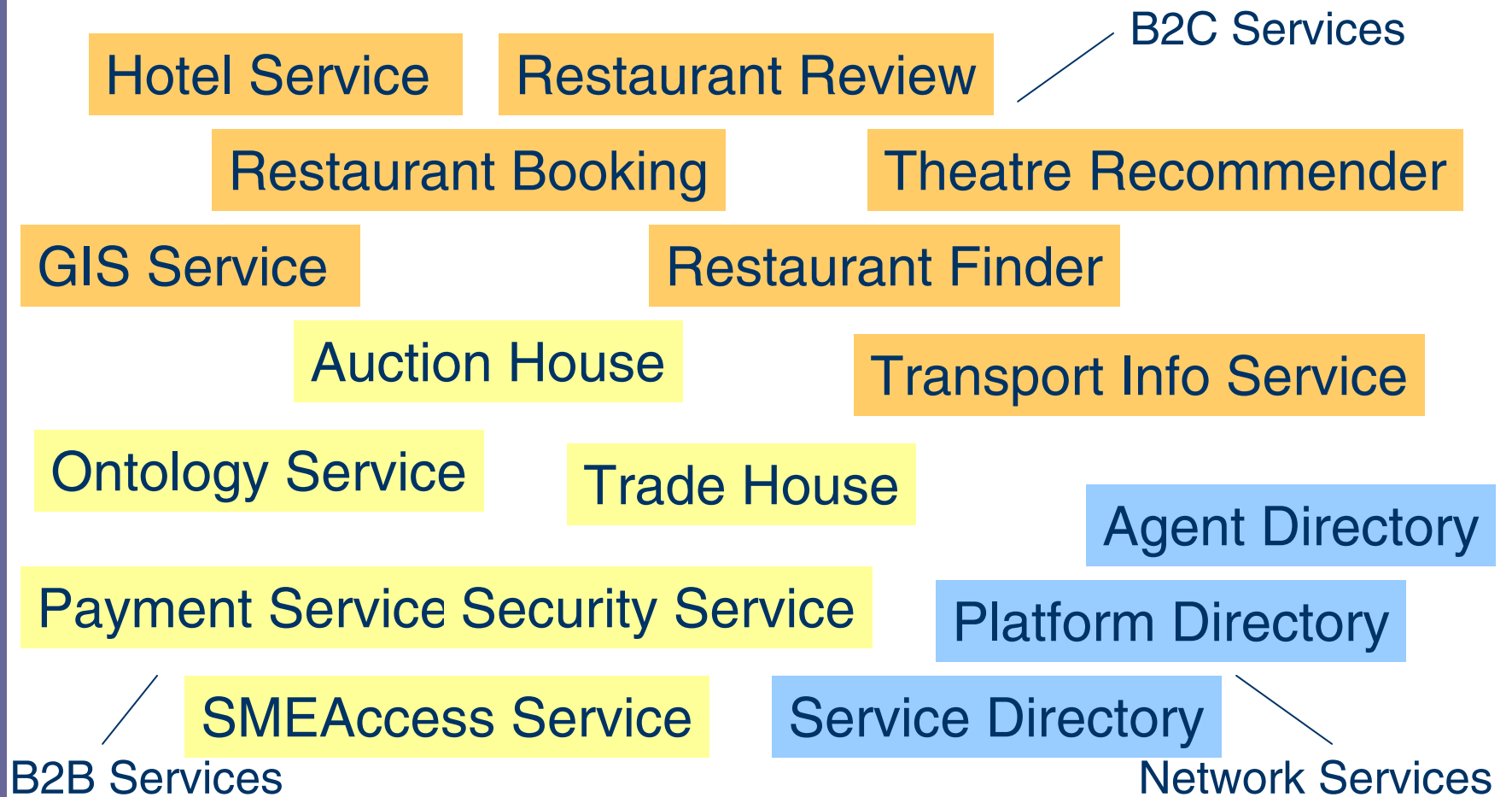


**Services**

# Service Deployment Objectives

- Technical
  - Coherent frameworks and best practice for *service interoperability* and *composition*
  - Supporting heterogeneous technologies and technology re-use
- Operational
  - Build a critical mass of service examples and support their interaction
  - Gather experience in exploiting and managing open environments

# Agentcities.RTD Services



# Demonstration Period I (July, 2002)

- Service components
  - Limited agent and service interaction
  - Deployed in the Network and accessible
- Purpose
  - Gain experience in deployment
  - Test interactions across the Agentcities Network
  - Baseline for service composition

# Service Interoperability

- Technologies

- Interaction Protocols
  - AUML protocol diagrams
- Communicative Acts
  - FIPA Agent Communication Language
- Content Languages
  - FIPA Semantic Language
  - ANSI KIF
- Ontologies
  - DAML+OIL
  - DAML-S

- Structure

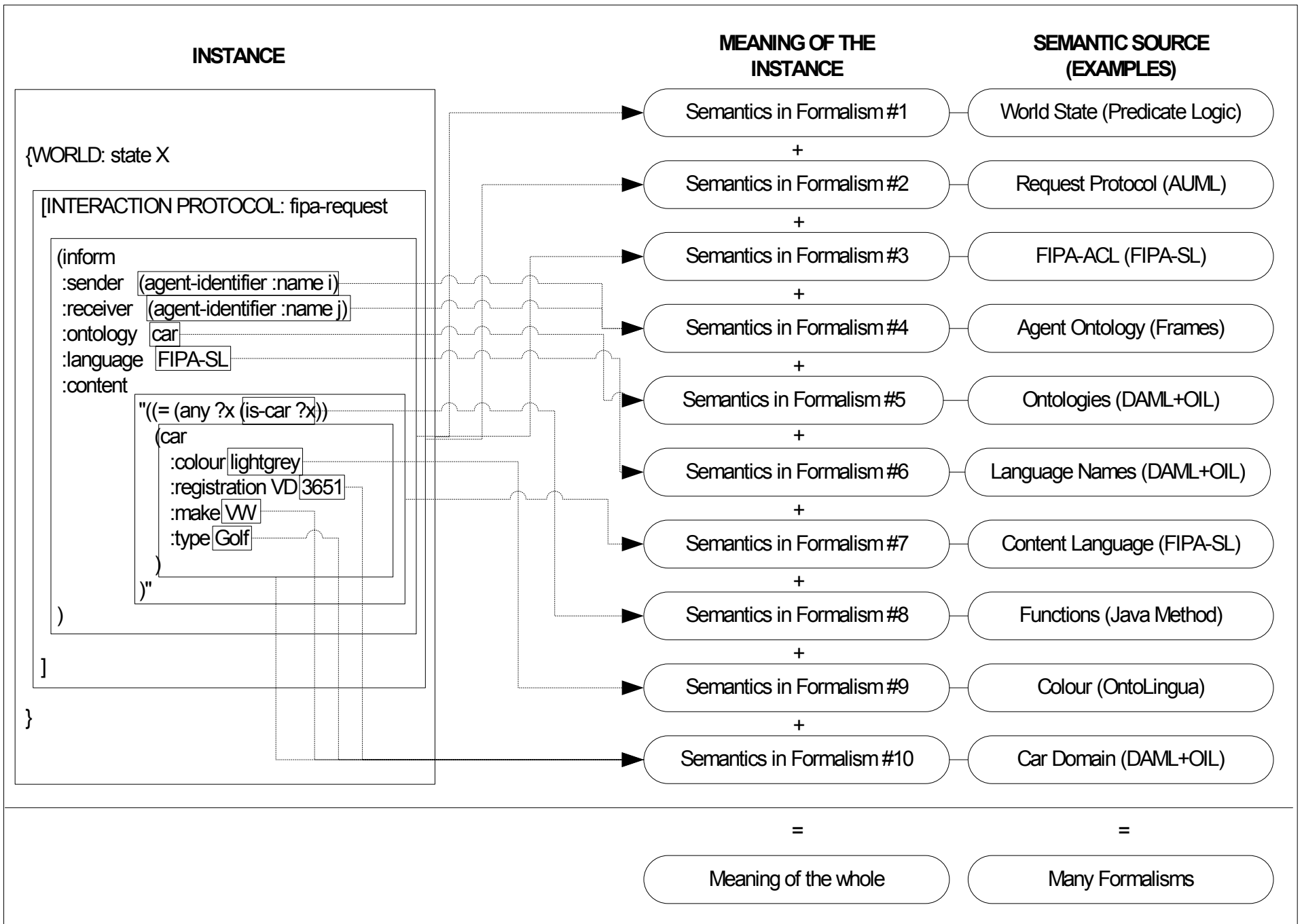
- Context
  - World state in which conversations occur
- Conversation
  - A legal sequence of messages
- Message
  - A single communication
- Content
  - Partial world state
- Domain
  - Objects, actions, functions

# Challenge: Ontology Usage

- Ontology management
  - (Cross) referencing, storing, publishing ontologies
  - Ontology evolution and versioning
- Object-oriented style ontologies and logical languages
  - No obvious way to define functions or actions
- Solutions
  - Define domain descriptions in upper ontologies for
    - Object
    - Action
    - Function
  - Build in support at the content language layer
  - Ontology server efforts and name spacing

# Challenge: Semantic Stack

- Current usage of semantics
  - Developers only
  - Hard-coded message template analysis in implementations
- Overall reasoning problem is too complex
- There are few tools to help
- Solutions
  - Targeting complete specification (for human analysis) as first goal
  - Then proceed to partial automation of message generation
  - Reducing the scope of messages in each interaction
- Longer term approach
  - Coherent semantic framework at all layers in the stack
  - Gather system building experience before finalizing framework



# Challenge: Namespaces & Names

- Referencing

- Ontologies
  - restaurant-ontology
  - fipa-agent-management
- Interaction protocols
  - fipa-request
  - english-auction
- Content languages
  - fipa-sl
  - ansi-kif

- Dereferencing

- Linking a token to a specification

- Solutions

- URN and XML namespace
- Simple Web-based:
  - Registration
  - Management
  - Creation

- Problems

- Currently not agent readable
- Centralized (no distributed management)

# Challenge: Service Descriptions

- Different description types required
  - Human readable
    - Business processes
  - Machine readable
    - WSDL
    - DAML-S
    - FIPA Service Descriptions
- Solutions
  - Use a meta-service description such as DAML-S
  - Ground services in appropriate technology
  - Limited machine readable elements in the Directory Facilitator
- Problems
  - Maintenance
  - Versioning
  - Completeness of machine readable formalisms

# Challenge: Testing

- Message interoperability
  - Checking agents can process messages defined in their interfaces
- Linking messages and behaviour
  - Verifying ACL semantics
  - Verifying correct agent action and/or response
- Solutions
  - Testing across multiple agent platforms
  - Ontologies restricted to reduce range of possible messages
- Problems
  - Still limited to simple templates
  - Logic not being exploited

# Future: Service Composition

- Service interoperability
  - Service discovery
  - Service evaluation
  - Service negotiation
  - Service acquisition and invocation
- Service composition
  - Model business process flow
  - Services to interact across organisational boundaries

# Demonstration Period II (May, 2003)

- Service Composition Demonstration
  - Dynamic Service Discovery
  - Dynamic Service Composition
    - Maintaining relationships over time
    - Reacting to changes in the dynamic service environment
  - Integration of Business and Information Services
  - Integration of Business and End Customer User Experiences

# Service Composition

- Technologies
  - Choices still being made
- Preliminary work:
  - Evaluation of different description languages
  - Experimentation with DAML-S
  - Investigation of reasoning requirements
- Structure
  - Recommendation of one or more description languages
  - Diverse reasoning strategies
  - Links to semantic frameworks and coordination technologies to capture on-going relationships



# **Conclusions and On-Going Activities**

# Conclusions

- The goals of Agentcities are to explore the use of services on the Internet:
  - Dynamic, ad hoc service composition and reuse
  - New agent-oriented interaction models
  - Rich semantic descriptions of services and business processes
  - Automated business interactions on the Internet
- The Agentcities initiative is complimentary to other activities and technologies in this area:
  - Web Services, Semantic Web, Semantic Grid, Microsoft's .NET, Oasis' ebXML
- But it builds on these by adding an agent interaction model:
  - autonomous (moving software into the background)
  - smart (I know what you mean)

# Next...

- Agentcities Task Force Working Groups
- Agentcities Competition
- Information Days
  - iD2: Lisbon, Portugal
    - 9th-10th September, 2002
  - iD3: Barcelona, Spain
    - 5th-7th February 2003
- Project activities
  - AC Finland (wireless access)
  - AC Hungary (representing libraries)
  - ...
- Agentcities.NET
  - 32 groups deploying Agentcities platforms and services
- Agentcities.RTD
  - Documentation of service deployment experiences
  - Interoperability and composition frameworks for Agentcities
  - Second generation Network architecture
  - Service composition

# Resources

- **Agencities Task Force**
  - <http://www.agencities.org/>
- **EU Agencities Project**
  - <http://www.agencities.org/EURTD/>
  - <http://www.agencities.org/EUNET/>
  - <http://www.agencities.org/Challenge02/>
- **Agencities Competition**
  - <http://www.agencities.org/EUNET/Competition/>
- **Agencities Network**
  - <http://www.agencities.net/>