LEAF

Learning Agent FIPA Compliant Community Toolkit

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Learning Agent FIPA Compliant Community Toolkit

interacting Java based learning agents existing in multiple communities to solve goals requiring collective behaviour – **communication**, **coordination**, **analysis**, **scalability**…

Plan of this talk

1. Agents, FIPA.
2. LEAF – concepts
3. FIPA-OS
4. LEAF – toolkit
5. Applications

LEAF Agents

- Autonomous
- Domain knowledge
- Learning behaviour
- Communication via Internet
- Interoperable (FIPA compliant)
- Research objective: deploy LEAF agents to perform goals that require collective effort, and support the scalability of this approach.

FIPA - Foundation for Intelligent Physical Agents

Standards for interoperable agent systems, to which developers adhere:

communication protocols

message transport

agent management

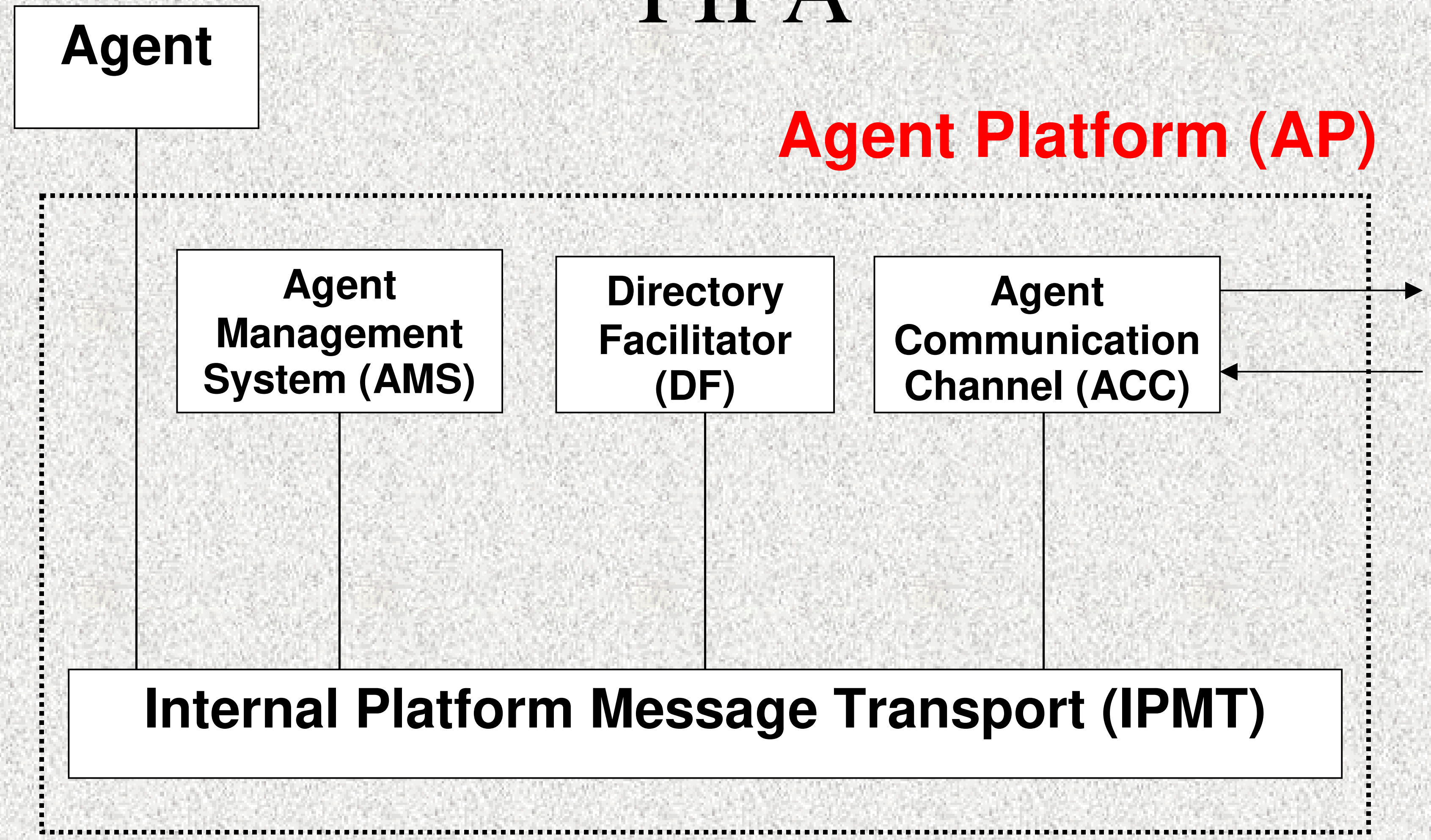
Mandatory specificatios

agent architectures

```
(request
:sender     buyer_agent
:reciever   seller_agent
:content     (buy(apples,10))
:language   prolog
:ontology   market-trader
:protocol   fipa-request
)
```

FIPA Agent Communication Language

FIPA


Agent
Agent Platform (AP)
Agent Management System (AMS)
Directory Facilitator (DF)
Agent Communication Channel (ACC)
Internal Platform Message Transport (IPMT)

Support provided by LEAF

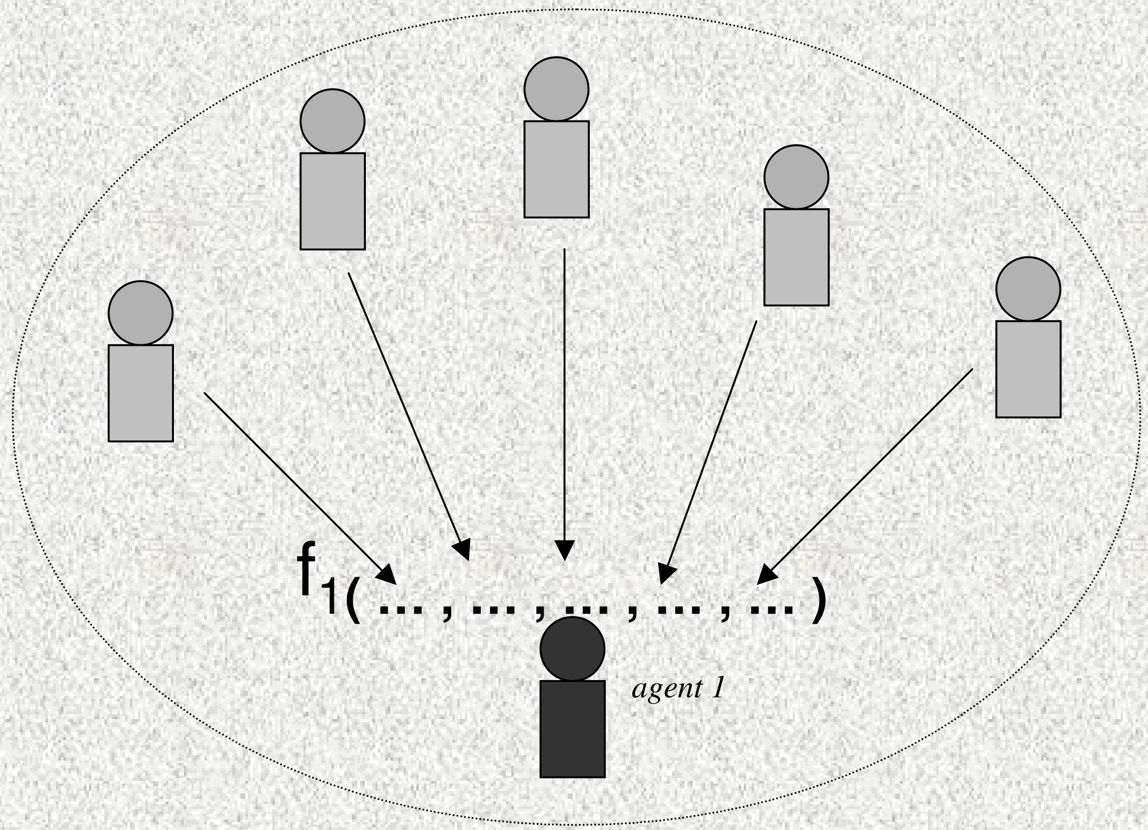
- **Implementation** → Java API, utilisation of FIPA-OS toolkit
- **Coordination** → Utility function assignment
- **Learning** → Mixed learning techniques – Neural Networks, RL etc.
- **Performance Analysis** → Functional utility, Performance utility
- **Scalability** → Multiple utility function assignment

Utility Function Assignment

Utility:

- An analysis tool
- A reward function/coordination mechanism

Utility Function Assignment



Utility Function Assignment

Utility:

- An analysis tool
- A reward function/coordination mechanism

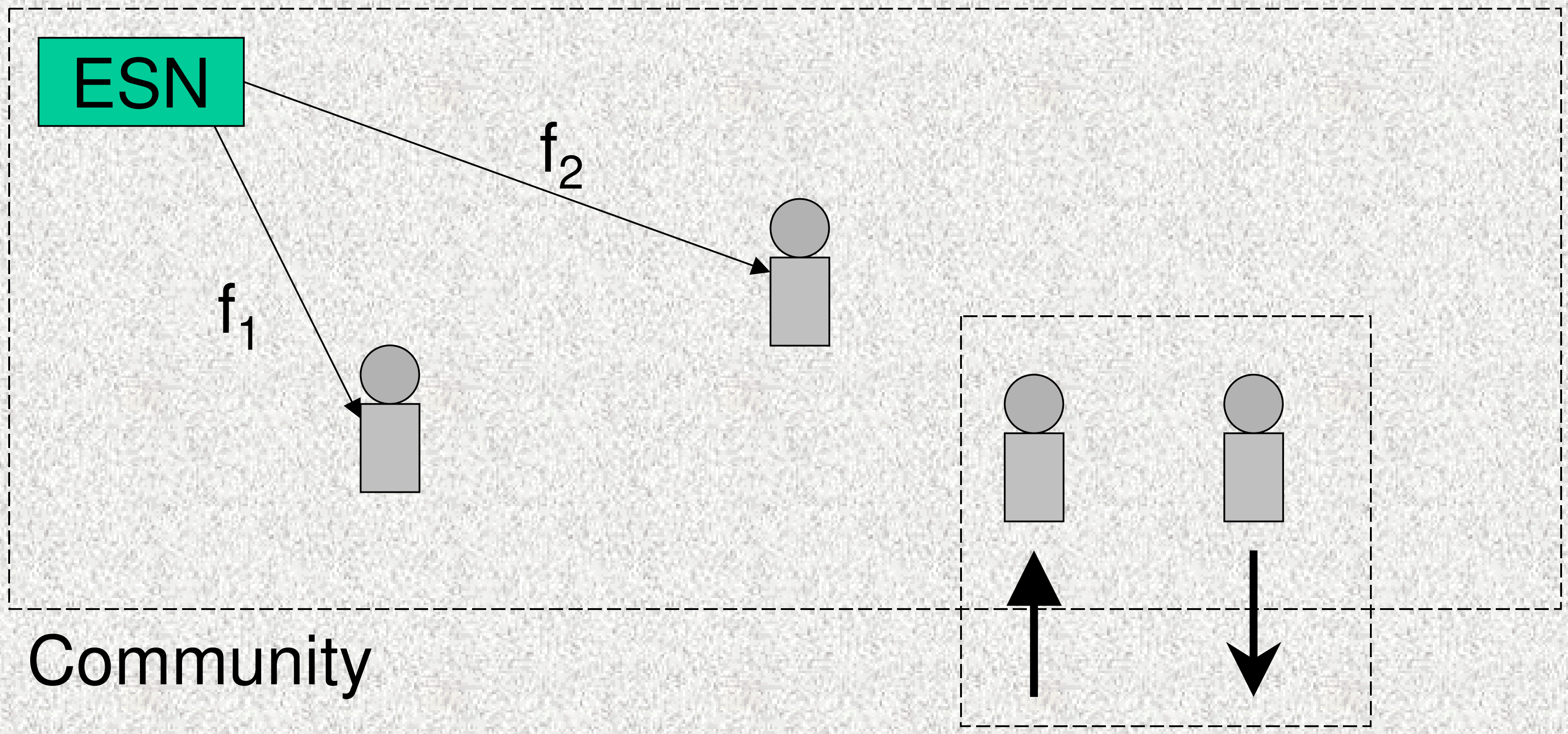
  COIN (Wolpert)
- Agents learn to maximise local utility, which in turn maximises the global utility of a community of LEAF agents
- Performance and functional utility types

Performance Utility

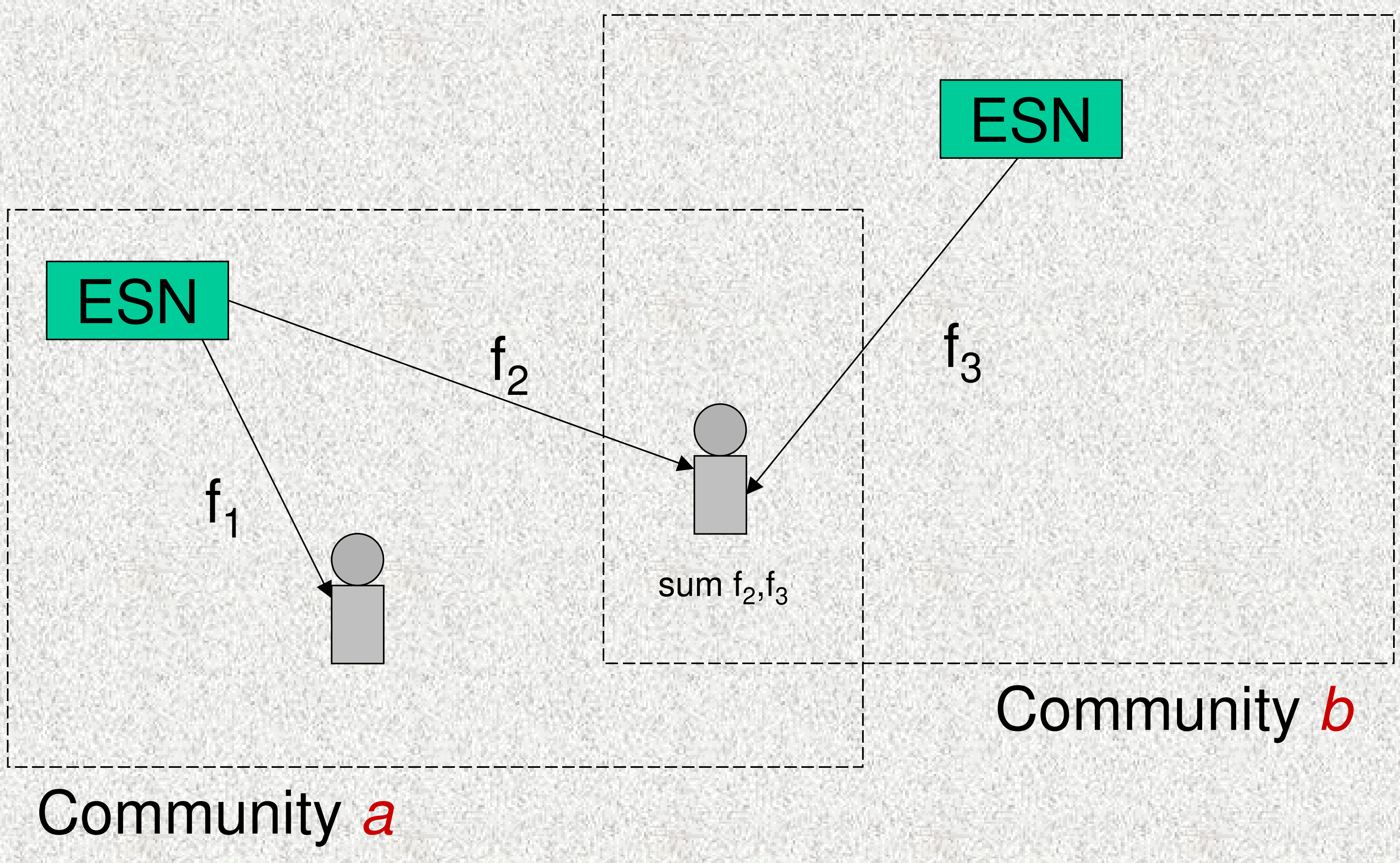
- Provides a utility measure based on performance engineering related aspects.
- The effect of ***implementation decisions*** (algorithms; languages) and ***deployment decisions*** (platforms; networks), can be assessed.
- Performance utility may have a relation to the functional utility of an agent system.

Utility function assignment

- Coordination: utility functions are assigned to agents by an environment service node.

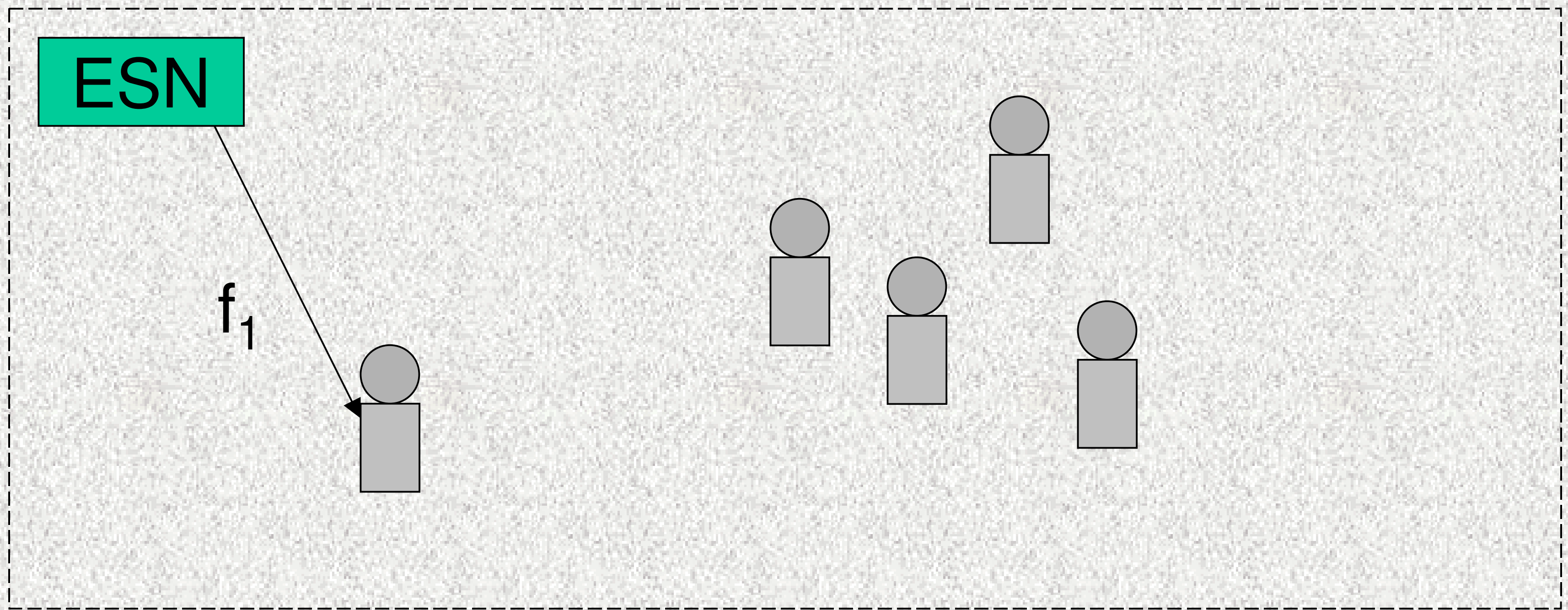


Utility function assignment



Utility function assignment

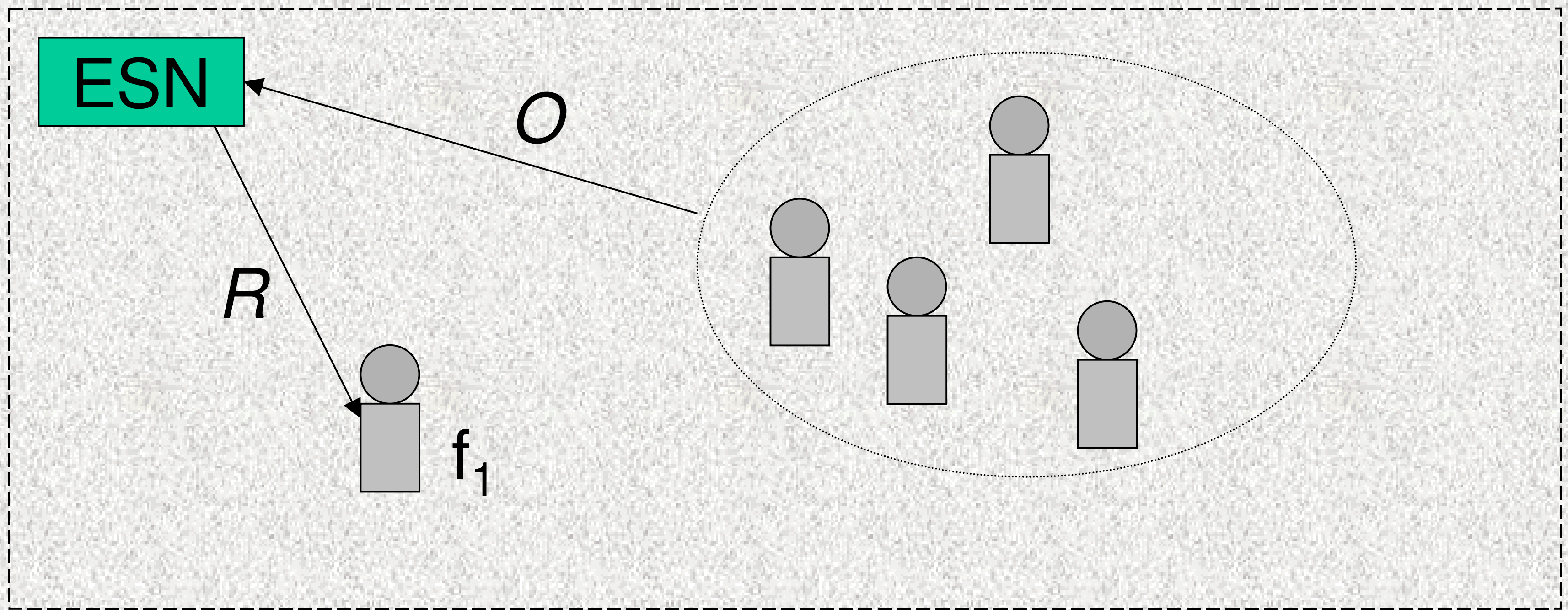
- Utility functions can have parameters not available locally to the agent.



Community

Utility function assignment

- Utility functions can have parameters not available locally to the agent.



Community

O: observable properties
R: remote parameters

LEAF implementation

- LEAF toolkit allows application specific agents/communities to be developed easily
- Toolkit implementation is based on FIPA-Open Source (FIPA-OS) from Emorphia
- Agent behaviours are programmed in Java
- Agents are composed of task components
- Utility functions implemented as Java objects – assigned using object serialization

LEAF agents

- Consist of multiple concurrently executing tasks.
- `JessLeafNode` extends FIPA-OS `JessAgent`
- `LeafNode` extends FIPA-OS `FIPAOSAgent`
- API provided for learning methods – neural network, reinforcement learning

LEAF tasks

- `LeafTask` extends the FIPA-OS `Task` class
- Developers extends the `LeafTask` class
- Task statistics (number of tasks, execution time etc.) used to parameterise performance utility functions
- LEAF automatically maintains task stats – they are available only to assigned utility functions and ESNs.

Utility Function Implementation

- Extend the **`LocalUtilityFunction`** abstract class.
- Implement the **`compute()`** method.
- Functions have access to remote parameters and observable properties.
- Utility functions can be parameterised by observable properties, remote parameters, task statistics and performance data (CPU/memory usage etc.)

Utility Function Implementation

```
package leaf.agentlib.computational;

import leaf.utility.LocalUtilityFunction;

public class ExamplePerformanceFunction extends LocalUtilityFunction {

    public synchronized double compute() {
        return 1 / source.getAverageCompletionTime("JobExecutionTask");
    }

}
```

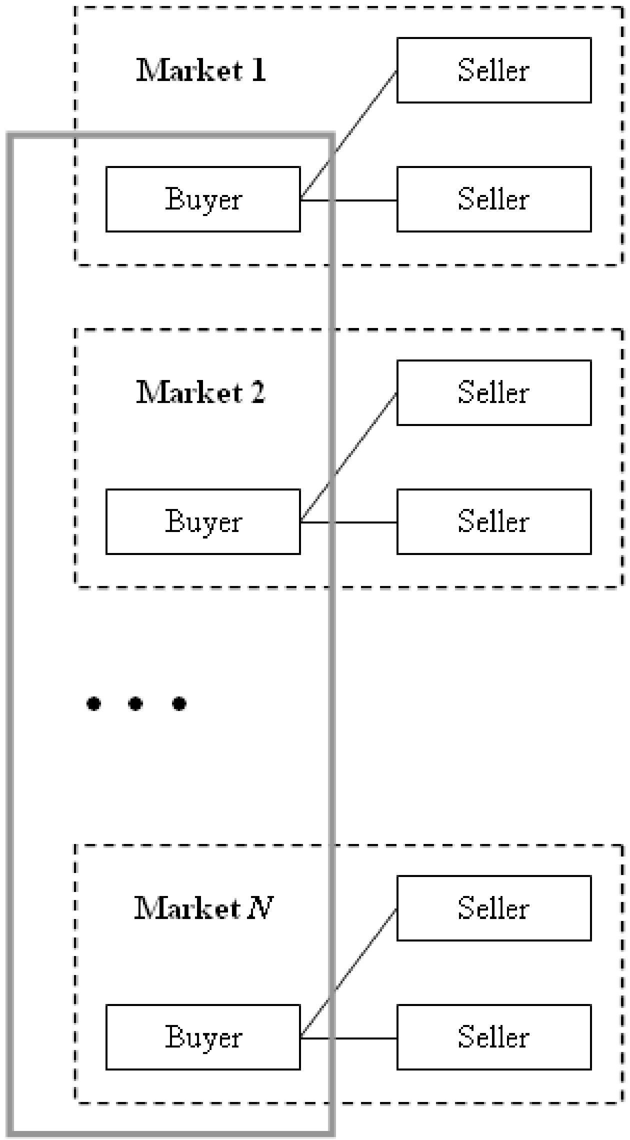
Building LEAF communities

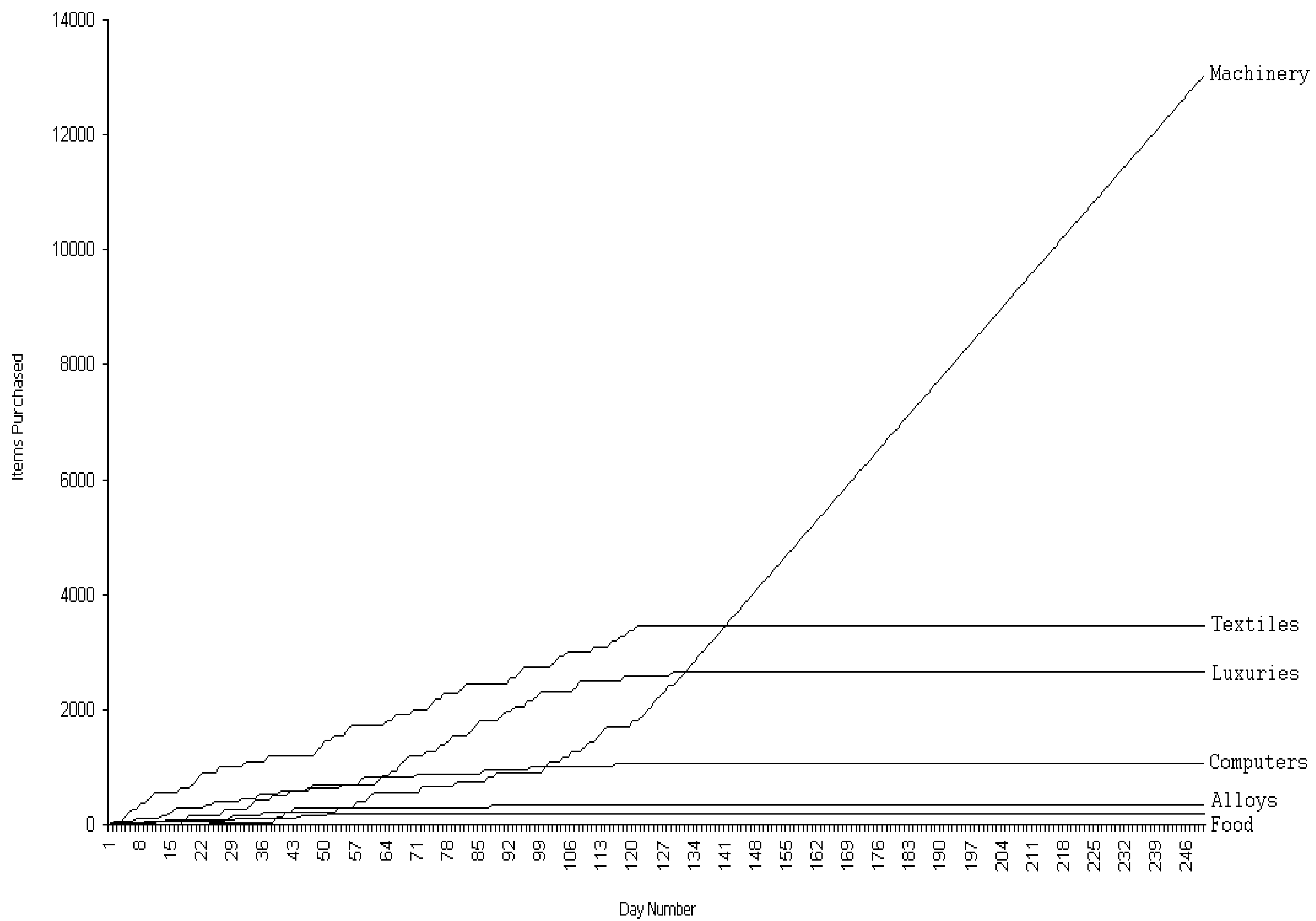
- Agents constructed using *tasks* as building blocks
- LEAF contains a *task library* from which tasks can be selected
- Behaviour is built around the maximisation of local utility (performance & functional)
- ESNs deployed with sets of local utility functions to be assigned to member agents

Applications

Coordination of buyer agents in multiple markets

- A global cost function exists, parameterised by the purchasing decision of the buyer agents
- Buyer agents are assigned utility functions aligned with the global cost function
- Agents use local reinforcement learning algorithms to maximise local utility functions
- Maximisation of local utility functions produces desired overall behaviour





Items Purchased
14000
12000
10000
8000
6000
4000
2000
0
Machinery
Textiles
Luxuries
Computers
Alloys
Food
1 8 15 22 29 36 43 50 57 64 71 78 85 92 99 106 113 120 127 134 141 148 155 162 169 176 183 190 197 204 211 218 225 232 239 246
Day Number

Applications

Management of computational resources

- Agents manage resources and process computational tasks
- Community cost functions are based on the efficiency with which tasks are processed
- Agents may adapt their behaviour – which tasks to accept, execution priorities, resource properties
- Performance utility provides an insight into the benefits of deploying resources of certain platform configurations, and the associated effect on function utility
- The eventual goal is for teams of resource agents to adapt to their environment and function coherently