Software Technologies

Mobile Code

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Aglets

- Originates from a combination of two terms: “Applet” and “Agent”
  - Applet known from Java Applets
  - Agent
- Do not mix up these two:
  - Applets belong to code-on-demand paradigm
    - code is mobile
    - stack is static
    - data is static
  - Aglets belong to the mobile-agent paradigm

Programming Language

- Aglets are implemented in Java
  - easy to implement MA systems
    - dynamic class loading
    - multi-threaded programming
    - serialization
    - reflection
    - platform independence
  - in 1996 Java was „the“ thing

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Aglet Environment

- IBM Aglets Workbench
  - Tahiti as management application
    - **Tahiti** is an application program that runs as an agent server. You can run multiple servers (**Tahiti**) on a single computer by assigning them different port numbers. **Tahiti** provides a user interface for monitoring, creating, dispatching, and disposing of agents and for setting the agent access privileges for the agent server. (Tahiti user's guide)
  - Aglet API
  - example Aglets
- Resources
  - http://aglets.sourceforge.net/
  - http://www.trl.ibm.com/aglets/

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Aglet API

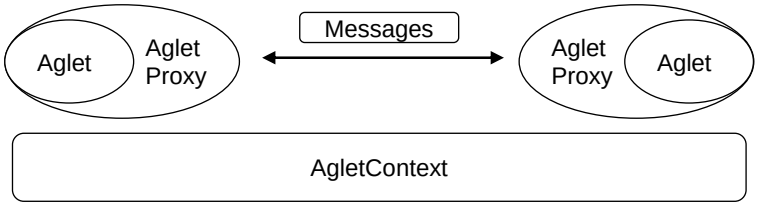
- Four Basic Elements
  - **Aglet:** eq. to mobile agent
  - **Proxy:** eq. to stub in client/server
  - **Context:** eq. to places
  - **Identifier**
- Aglet
  - the mobile agent
  - reactive (responds to messages)
  - proactive (runs within own thread of execution)
  - autonomous (can move on its own volition)
- Proxy
  - protects the agent from direct access
  - forwards messages to a remote Aglet

Aglet API

- Context
  - equivalent to a place in the OMG MASIF
  - one Tahiti basically runs one context
- Identifier
  - unique identifier for each aglet
- Missing (compared to Grasshopper):
  - region
  - region registry

Relationship: Aglet and Proxy

- Proxy represents the agent
- Protects the agent from direct access (attacks)
- Allows location transparent access



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Operations

- Tahiti and Aglets can perform six basic operations on another Aglet.
- Six basic operations
  - creation
  - cloning
  - dispatching
  - retraction
  - activation and Deactivation
  - disposal

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Operations

- Creation
  - initializes a new aglet
  - creates a new thread
  - assigns an identifier
- Cloning
  - produce an identical copy of an Aglet
  - assigns a different identifier (unique)
- Dispatching
  - Aglet is transported between two Tahiti contexts
  - usually between different locations

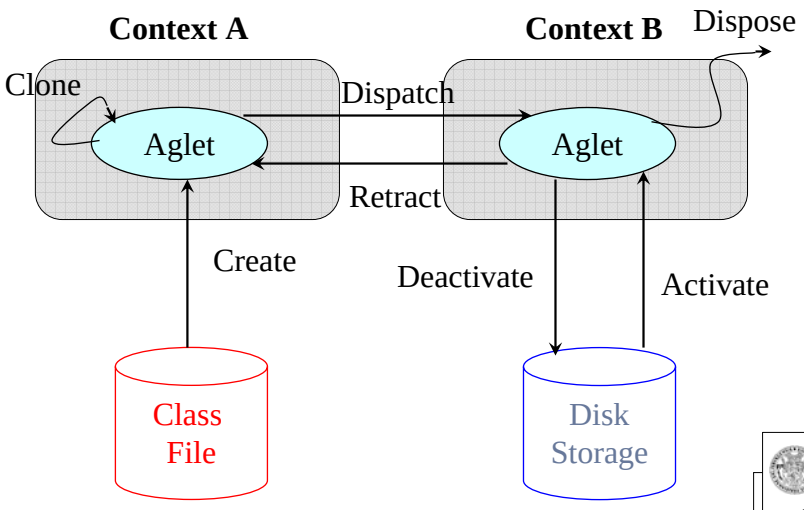
Basic Operations

- Retraction
  - calls back an Aglet
  - moves the Aglet from foreign context to the local context
- Deactivation and Activation
  - stops and resumes an Aglet
  - deactivate must occur before activate
  - useful before restarting Tahiti
  - differences to Grasshopper
    - no wake-up events

Basic Operations

- Disposal
  - stops execution of an Aglet
  - frees all used resources (e.g., thread group) -> garbage collection
  - removes an Aglet from its current context

Agent Life-Cycle Model



Aglet Methods

- Aglet programming model
  - uses Java for implementing the Aglets
  - uses observer pattern
  - callback model
- Available listeners
  - clone listener
  - mobility listener
  - persistence listener

Aglet Methods

- Listener specifics
  - similar to Java events
  - methods are invoked after the event occurs
  - methods and events have similar names
  - allow customized behavior (e.g., vetos)

Event Model Listeners

- Clone listener
  - listens for cloning events
  - actions can be customized to occur before or after cloning
    - onCloning()
    - afterCloning()

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Event Model Listeners

- Mobility listener
  - listens for mobility events
  - can customize actions before and after moving actions
    - onDispatch()
    - onReverting()
    - onArrival()

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Event Model Listeners

- Persistence listener
  - listens for persistence events
  - actions can be customized to occur when an Aglet is about to be deactivated or has been activated
    - `onDeactivating()`
    - `onActivation()`

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Aglet API

- Aglet API
  - simple and flexible
  - represents lightweight pragmatic approach to mobile agents (compare it to the Grasshopper API)
  - not as lightweight as other approaches
- Java classes
  - Aglet
  - Message
  - Futurereply
  - Agletid
  - Agletproxy

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Aglet API

- Java interfaces
  - AgletProxy
  - AgletContext
- Aglet class
  - contains all methods needed to perform the basic aglet operations
    - moving, messaging, …
  - contains all the elements of the aglet
    - Aglet id

Aglet API

- Aglet creation
  - create a customized aglet
  - extend the class com.ibm.aglet.Aglet

```
import com.ibm.aglet.*;
public class MyFirstAglet extends Aglet{
//Put aglet's methods here
}
```

- Similar to Grasshopper:
  - specific methods for specific actions
  - to not use the standard OO approaches !! (e.g., new operator)

Operation Examples

- Dispatch operation
  - dispatches an aglet to a remote context
  - uses URLs (Grasshopper uses separate class)

```
dispatch(new URL(atp://remote.host.com/context"));
```

- Dispose operation
  - removes the aglet from the current context

```
dispose();
```

- See the API for similar ones
- We will try more in the lab…

Messaging Example

- Message class
  - communication is performed by exchanging dedicated objects (message objects)
  - AgletProxy class is responsible for actually sending and receiving messages
- Message creation
  - define the field 'Type'
  - second field of is optional (can contain additional information)

Messaging Example

- Code

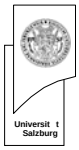
```
Message myName = new Message("my name", "Lois");
```

or

```
Message yourName = new Message("Steve");
```

- The handleMessage method receives all messages (return true ! -> chain of responsibility pattern)

```
public boolean handleMessage(Message msg){
   if(msg.sameKind("hello")){
      doHello();   //respond to 'hello' message
      return true; //yes I handled message
   }
   else
     return false; //not handled message
}
```

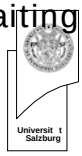



AgletProxy and FutureReply

- Message objects are sent using the AgletProxy class methods
  - Object sendMessage(Message msg)
  - FutureReply sendFutureMessage(Message msg)
  - void sendOnewayMessage(Message msg)
- Code example

```
proxy.sendMessage(myName);
String name =
     (String)proxy.sendMessage(yourName);
```

- FutureReply Class
  - used for asynchronous messaging
  - the Aglet can continue execution while waiting for the reply

FutureReply Example

- FutureReply objects are retrieved using the AgletProxy class method
  - `sendFutureMessage(msg)`
- Code example
  - the sender can continue executing periodic tasks while waiting for a reply

```
FutureReply future = proxy.sendFutureMessage(msg);
while (!future.isAvailable()){
   doPeriodicWork();
}
Object reply = future.getReply();
```


AgletID Class

- AgletID Class
  - represents the identifier of the Aglet
  - the identifier is unique to each Aglet
  - the identifier object hides the implementation specific representation of the Aglet identity
- Code cxample
  - identifier can be retrieved from the Aglet and its proxy

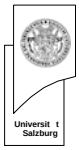
```
AgletID aid = proxy.getAgletID();
```

  - query the context to retrieve Aglet with identity **`aid`** (**`aid`** and Context must be known)

```
proxy = context.getAgletProxy(aid);
```

Aglet API: Interfaces

- AgletProxy interface
  - the handle of the Aglet
  - abstraction of the real implementation (separation of concerns & frameworks)
- Benefits
  - used by other Aglets for communication
  - provides protection mechanisms (e.g., cannot directly invoke dispose)
  - can provide a remote location for the Aglet
  - possibility for standardization

AgletProxy

- Retrieval and setting methods of proxies
  - Aglet can get its own proxy object

```
Aglet.getProxy();
```

  - retrieve an enumeration of all proxies within the current context

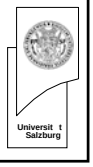
```
AgletContext.getAgletProxies();
```

  - get an Aglet proxy for a given identifier

```
aid.getAgletProxy();
```

  - place AgletProxy object into context property (useful for sharing resources, provide services)

```
AgletContext.setProperty();
```

AgletContext

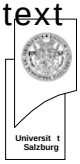
- Aglet Context
  - execution environment for Aglets
  - equivalent to the place
  - hosts the Aglets
  - Aglets only exist inside a context
- AgletContext interface
  - abstract interface of the Aglet context
  - get information about environment
  - send messages to environment
- AgletContext interface methods
  - Aglet class can gain access to current context

```
Context = GetAgletContext();
```

  - Aglet can create new Aglets

```
Context.CreateAglet(…);
```





AgletContext

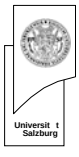
- AgletContext interface methods
  - retract (pull) remotely located Aglets into current context

```
Context.Retractaglet(remotecontexturl, Agletid);
```

  - retrieve a list of proxies of its fellow Aglets in the same context

```
Proxies = Context.Getagletproxies();
```





Example: Remote File Update

- Aglet Example: Remote File Update
  - premise: large multiple remote files that must be updated by word replacement
  - one solution: move files to central server, perform update, and move files back
  - another solution: an Aglet that updates files by replacing all occurrences of one specified word in the files with another specified word
  - distributes the load of updates to multiple servers
  - we're moving "Code" rather than files

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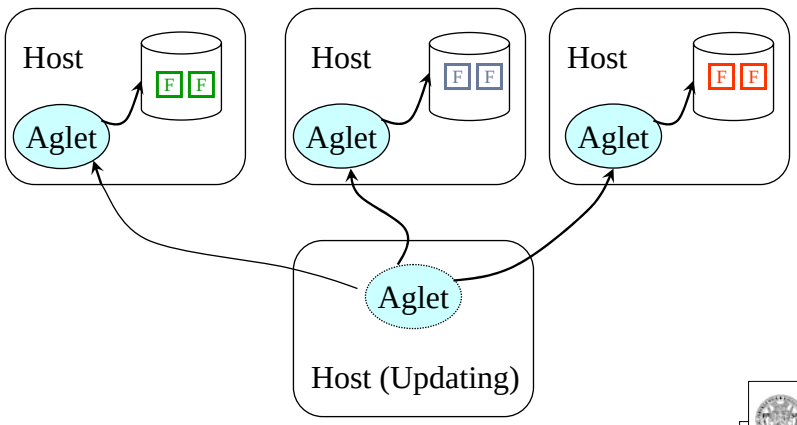
Example



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Update File Aglet

```
Import com.ibm.aglet.*;
import com.ibm.aglet.event.*;
import java.net.*;
import java.io.*;
public class UpdateFile extends Aglet{
   URL destination = null;
   File dir = null;
   String from = null;
   String to = null;
   public void onCreation(Object args){
      destination = (URL)((Object[])args)[0];
      dir = (File)((Object[])args)[1];
      from = (String)((Object[])args)[2];
      to = (String)((Object[])args)[3];
      addMobilityListener(){
        new MobilityAdapter(){
```


Update File Aglet

```
          Public void onArrival(MobilityEvent e){
            replace(args.file,args.from,args.to);
            dispose(); }
          }
        }
        try{
          dispatch(args.destination);
        }catch (Exception e){
          System.out.println("Failed to dispatch.");
        }
   }
   void replace(File, file, String, from, Sting to){
      //Open 'file' and replace 'from' with 'to'
}
```

References

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[3]: http://www.msci.memphis.edu/~franklin/AgentProg.html

[4]: http://www.javaworld.com/javaworld/jw-04-1997/jw-04-hood.html

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[6]: http://luckyspc.lboro.ac.uk/Docs/Papers/Mesela97.html

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[10]: Kimble Cheron, Professor Steven A. Demurjian, and Mitch Saba course on Software Agents and Aglets as basis of this slides