Jini

Kurzfassung als Kapitel für die Vorlesung „Verteilte Systeme“

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(unter Nutzung von Teilen von Andreas Zeidler und Roger Kehr)

- Infrastructure ("middleware") for dynamic, cooperative, spontaneously networked systems
  - facilitates realization of distributed applications
Jini

- Infrastructure ("middleware") for dynamic, cooperative, spontaneously networked systems
  - facilitates realization of distributed applications

  • framework of APIs with useful functions / services
  • helper services (discovery, lookup,...)
  • suite of standard protocols and conventions

- services, devices, ... find each other automatically ("plug and play")
- dynamically added / removed components
- changing communication relationships
- mobility
Jini

- **Infrastructure** ("middleware") for dynamic, cooperative, spontaneously networked systems
  - facilitates realization of distributed applications
- Based on **Java** and implemented in **Java**
  - may use RMI (Remote Method Invocation)
  - typed (object-oriented) communication structure
  - requires JVM / bytecode everywhere
  - code shipping

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Jini

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- Based on **Java** and implemented in **Java**
  - may use RMI (Remote Method Invocation)
  - typed (object-oriented) communication structure
  - requires JVM / bytecode everywhere
  - code shipping
- **Strictly service-oriented**
  - everything is a service (hardware / software / user)
  - Jini system is a federation of services
  - mobile proxy objects for service access
Service Paradigm

- (Almost) everything is a service
  - e.g. persistent storage, software filter, ...
- Jini’s run-time infrastructure offers mechanisms for adding, removing, finding, and using services
- Services are defined by interfaces and provide their functionality via their interfaces
  - services are characterized by their type and their attributes (e.g. “600 dpi”, “version 21.1”)
- Services (and service users) “spontaneously” form a system ("federation")

Jini: Global Architecture

- Lookup Service (LUS)
  - main registry entity and brokerage service for services and clients
  - maintains information about available services
- Services
  - specified by Java interfaces
  - register together with proxy objects and attributes at the LUS
- Clients
  - know the Java interfaces of the services, but not their implementation
  - find services via the LUS
  - use services via proxy objects
Network Centric

- Jini is centered around the network
  - “the network is the computer”
- Network = hardware and software infrastructure
  - includes helper services
- View is “network to which devices are connected to”, not “devices that get networked”
  - network always exists, devices and services are transient
- Set of networked devices is dynamic
  - components and communication relations come and go
- Jini supports dynamic networks and adaptive systems
  - adding and removing components should only minimally affect other components

Spontaneous Networking

- Objects in an open, distributed, dynamic world find each other and form a transitory community
  - cooperation, service usage, ...
- Typical scenario: client wakes up (device is switched on, plugged in, ...) and asks for services in its vicinity
- Finding each other and establishing a connection should be fast, easy, and automatic
Some Fallacies of Common Distributed Computing Systems

- The **idealistic view**...
  - the network is reliable
  - latency is zero
  - bandwidth is infinite
  - the network is secure
  - the topology is stable
  - there is a single administrator
- **...isn’t true** in reality
  - Jini addresses some of these issues
  - at least it does not hide or ignore them

Bird’s-Eye View on Jini

- Jini consists of a number of **APIs**
- Is an extension to the **Java** platform dealing with distributed computing
- Is an **abstraction layer** between the application and the underlying infrastructure (network, OS)
  - Jini is a kind of “middleware”
Jini’s Use of Java

- Jini requires JVM (as bytecode interpreter)
  - homogeneity in a heterogeneous world
  - is this realistic?

- But: devices that are not “Jini-enabled” or that do not have a JVM can be managed by a software proxy which resides somewhere in the net

Jini Infrastructure

- Main components are:
  - lookup service as repository / naming service / trader
  - protocols based on TCP/UDP/IP
    - discovery & join, lookup of services
  - proxy objects
    - transferred from service to clients
    - represent the service locally at the client

- Goal: spontaneous networking and formation of federations without prior knowledge of local network environment

- Problem: How do service providers and clients learn about their local environments?
**Lookup Service (LUS)**

- Main component of every Jini federation
- **Repository** of services
- Similar to RMI registry or naming services of other middleware architectures
- Functions as a “help-desk” for services and clients
  - registration of services (services advertise themselves)
  - distribution of services (clients lookup and find services)
- Has mechanisms to bring together services and clients

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**Lookup Service**

[Diagram showing the relationship between Lookup Service, Jini Federation, Client, and Service]
Example

Lookup Service

- Uses Java RMI for communication
  - objects ("proxies") can migrate through the net
- Not only name/address of a service is stored (as in traditional naming services), but also
  - set of attributes
    - e.g.: printer(color: true, dpi: 600, ...)
  - proxies, which may be complex classes
    - e.g. user interfaces
- Further possibilities:
  - increase robustness by running redundant lookup services
  - responsibility can be distributed to a number of (logically separated) lookup services
**Discovery: Finding a LUS**

- **Goal:** Find a lookup service (without knowing anything about the network) to
  - advertise (register) a service
  - find (look up) an existing service

- **Discovery protocol:**
  - multicast to well-known address/port
  - lookup service replies with a serialized object (its proxy)
    - communication with LUS via this proxy
Multicast Discovery Protocol

- No information about the host network needed
- Active search for lookup services
- Discovery request uses multicast UDP packets
  - multicast address for discovery is 224.0.1.85
  - default port number of lookup services is 4160
  - recommended time-to-live is 15
  - usually does not cross subnet boundaries
- Discovery reply is establishment of a TCP connection
  - port for reply is included in multicast request packet

Join: Registering a Service

- Assumption: Service provider already has a proxy of the lookup service (→ discovery)
- It uses this proxy to register its service
- Gives to the lookup service
  - its service proxy
  - attributes that further describe the service
- Service provider can now be found and used in this Jini federation
Join

Join: More Features

- To join, a service supplies:
  - its proxy
  - its ServiceID (if previously assigned; “universally unique identifier”)
  - set of attributes
  - (possibly empty) set of specific lookup services to join
- Service waits a random amount of time after start-up
  - prevents packet storm after restarting a network segment
- Registration with a lookup service is bound to a lease
  - service has to renew its lease periodically
Lookup: Searching Services

- Client creates query for lookup service
  - in the form of a "service template"
  - matching by registration number of service and/or service type and/or attributes possible
  - attributes: only exact matching possible (no "larger-than", ...)
  - wildcards possible ("null")
- Via its proxy at the client, the lookup service returns zero, one or more matches (i.e., server proxies)
- Selection of several matches usually done by client

- Client uses service by calling functions of the service proxy
- Any "private" protocol between service proxy and service provider is possible

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Lookup

[Diagram showing the process of lookup with a client connecting to a lookup service and receiving matches from a service database in LUS through a proxy.]
**Proxies**

- Proxy object is stored in the lookup service upon registration
  - serialized object
  - implements one or more service interfaces
- Upon request, stored object is sent to the client as a local proxy of the service
  - client communicates with service implementation via its proxy: client invokes methods of the proxy object
  - proxy implementation hidden from client

**Smart Proxies**

- Parts of or whole functionality may be executed by the proxy at the client
- When dealing with large volumes of data, it usually makes sense to preprocess parts of or all the data
  - e.g.: compressing video data before transfer
- Partition of service functionality depends on service implementer’s choice
  - client needs appropriate resources
Leases

- Leases are contracts between two parties
- Leases introduce a notion of time
  - resource usage is restricted to a certain time frame
- Repeatedly express interest in some resource:
  - I'm still interested in X
    - renew lease periodically
    - lease renewal can be denied
  - I don't need X anymore
    - cancel lease or let it expire
    - lease grantor can use X for something else

Distributed Events

- Objects on one JVM can register interest in certain events of another object on a different JVM
- “Publisher/subscriber” model

1. Registration
2. Event occurs
3. Send notification
Distributed Events – Example

- Example: printer is **plugged in**
  - printer registers itself with local lookup service
- Maintenance application wants to update software

Maintenance application

- Maintenance application is **run on demand**, search for printers is “outsourced”
- “sensor service” looks for certain services on behalf of the maintenance application
- application registers for **events** showing the arrival of certain types of printers
- sensor observes the lookup service
- notifies application as soon as matching printer arrives via distributed events
Distributed Events – Example

- Example: printer arrives, registers with lookup service
  - printer performs discovery and join
  - sensor finds new printer in lookup service
  - checks if there is an event registration for this type of printer
  - notifies all interested objects
  - maintenance application retrieves printer proxy and updates software

Jini Issues and Problem Areas

- **Security**
  - important especially in dynamic environments
  - services use other services on behalf of the user
    - principals, delegation
  - Simply rely on Java security?
- **Scalability**
  - does Jini scale to a global level?
- **Java centric**
- **Similar, non-Java-based systems**
  - UPnP, Bluetooth SDP, SLP, HAVi, Salutation, e-speak, HP Chai,...
  - open, Internet-scale infrastructures (e.g., Web services)