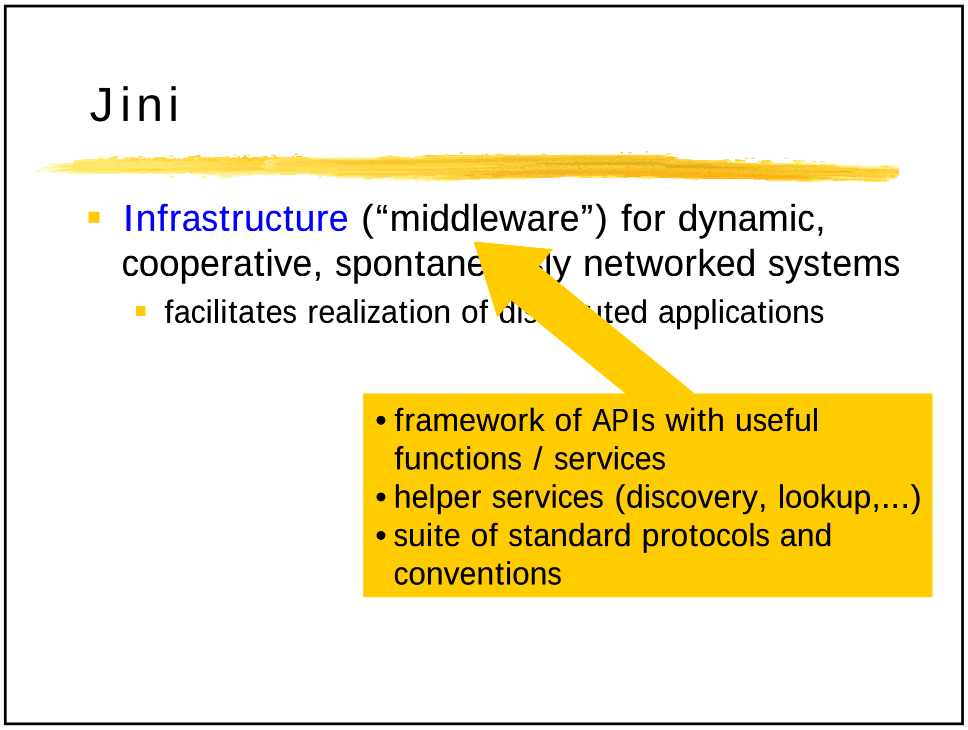
Jini

Kurzfassung als Kapitel für die Vorlesungen „Verteilte Systeme“ bzw. „Ubiquitous Computing“

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

Jini

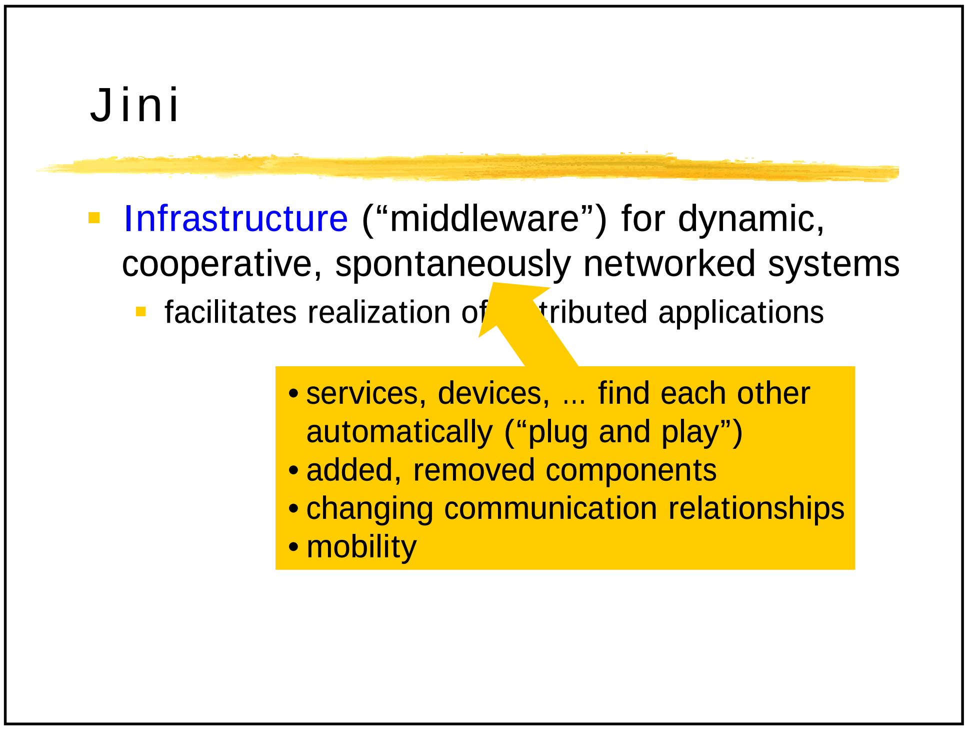
- Infrastructure (“middleware”) for dynamic, cooperative, spontaneously networked systems
  - facilitates realization of distributed applications



Jini

- Infrastructure (“middleware”) for dynamic, cooperative, spontane ly networked systems
  - facilitates realization of dis uted applications

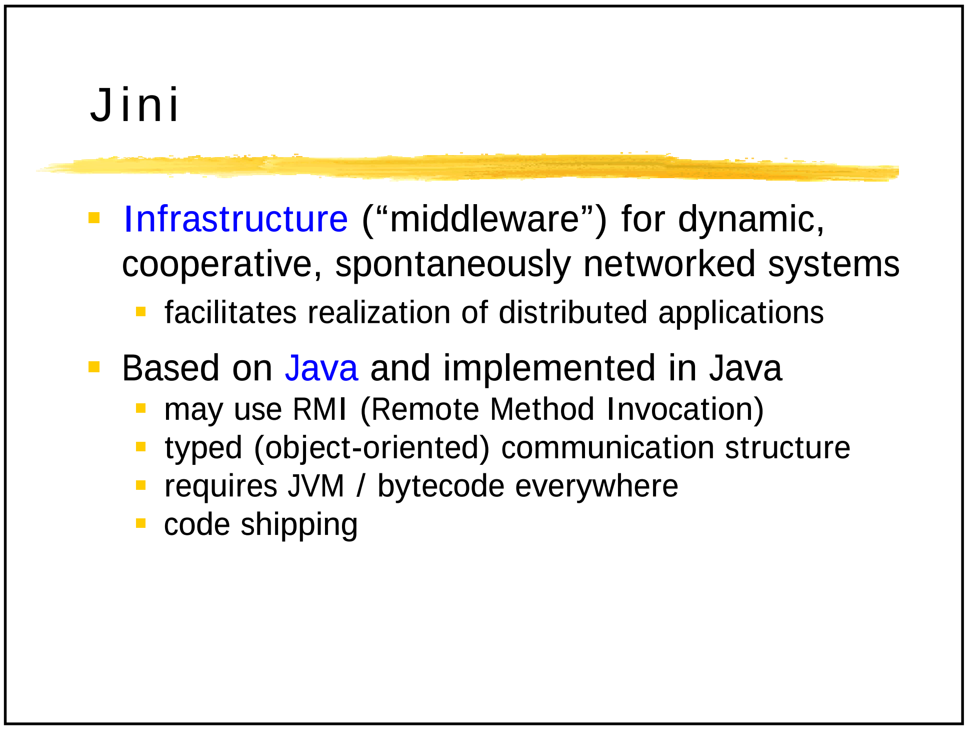
• framework of APIs with useful functions / services
• helper services (discovery, lookup,...)
• suite of standard protocols and conventions



Jini

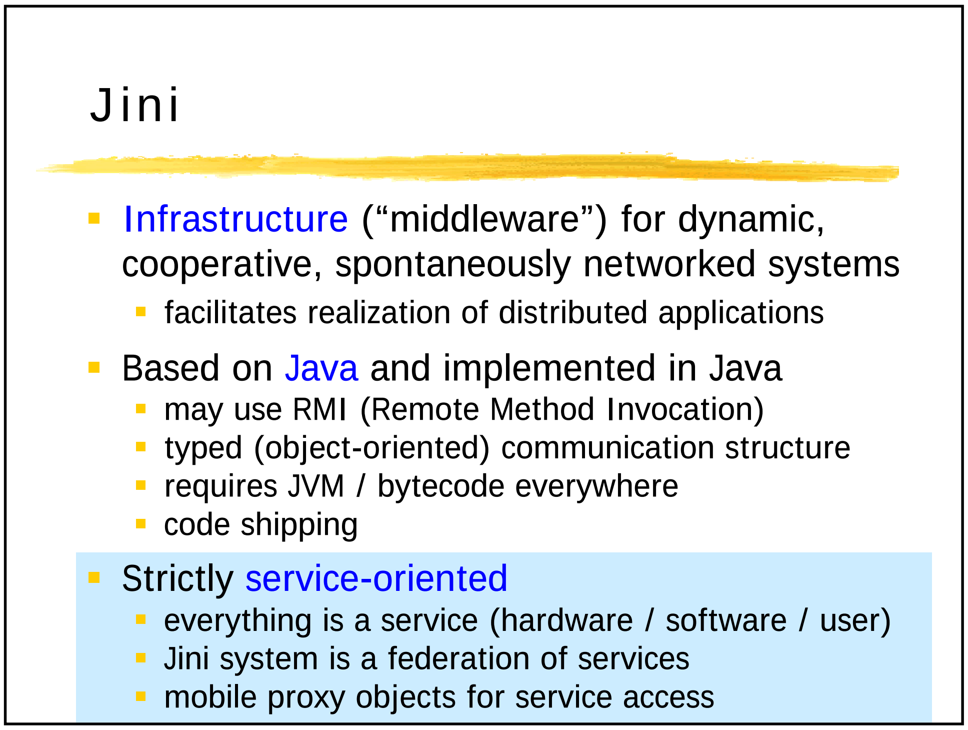
- Infrastructure (“middleware”) for dynamic, cooperative, spontaneously networked systems
  - facilitates realization of tributed applications

• services, devices, ... find each other automatically (“plug and play”)
• 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



Jini

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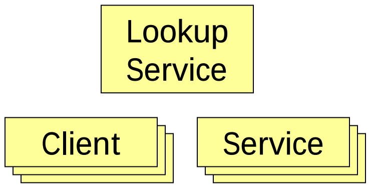
  - may use RMI (Remote Method Invocation)
  - typed (object-oriented) communication structure
  - requires JVM / bytecode everywhere
  - code shipping
- Strictly service-oriented
  - everything is a service (hardware / software / user)
  - Jini system is a federation of services
  - mobile proxy objects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

Service Paradigm

- Everything is a service
  - e.g. persistent storage, software filter, help desk, ...
- 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
  - contains informationen 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
  - remember: “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
  - added and removed components should affect other components only minimally

Spontaneous Networking

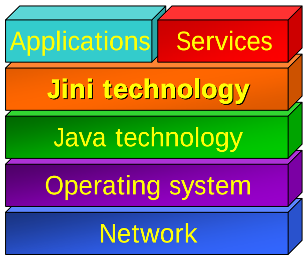
- Objects in an open, distributed, dynamic world find each other and form a transitory community
  - cooperation, service usage, ...
- Typical scenario: client wakes up (device is switched on, plugged in, ...) and asks for services in its vicinity
- Finding each other and establishing a connection should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

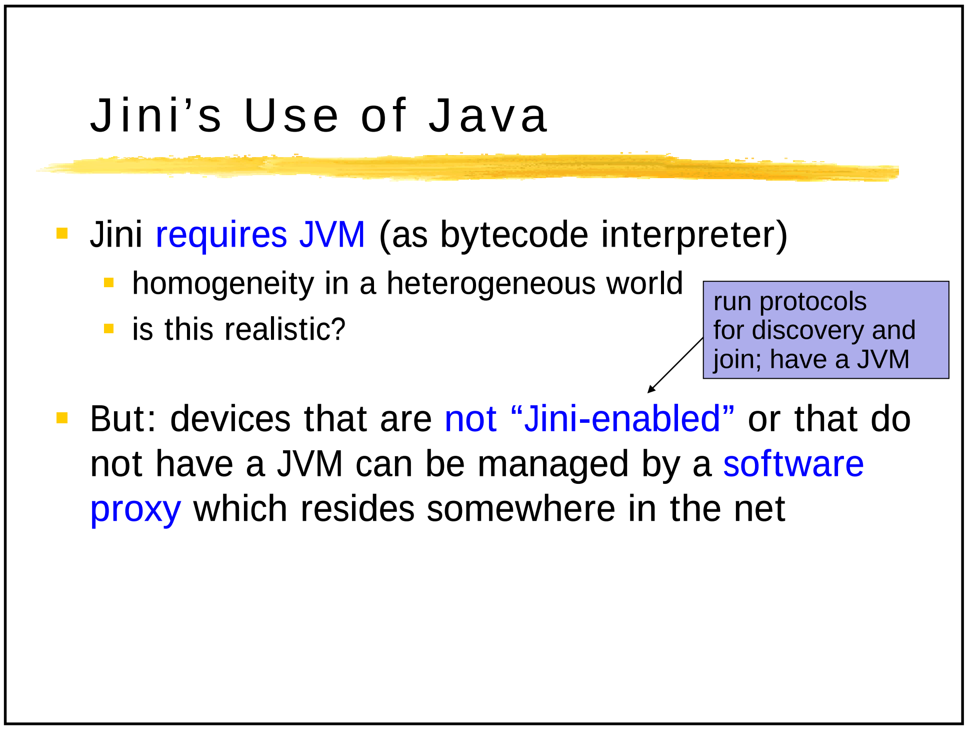
Some Fallacies of Common Distributed Computing Systems

- 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"

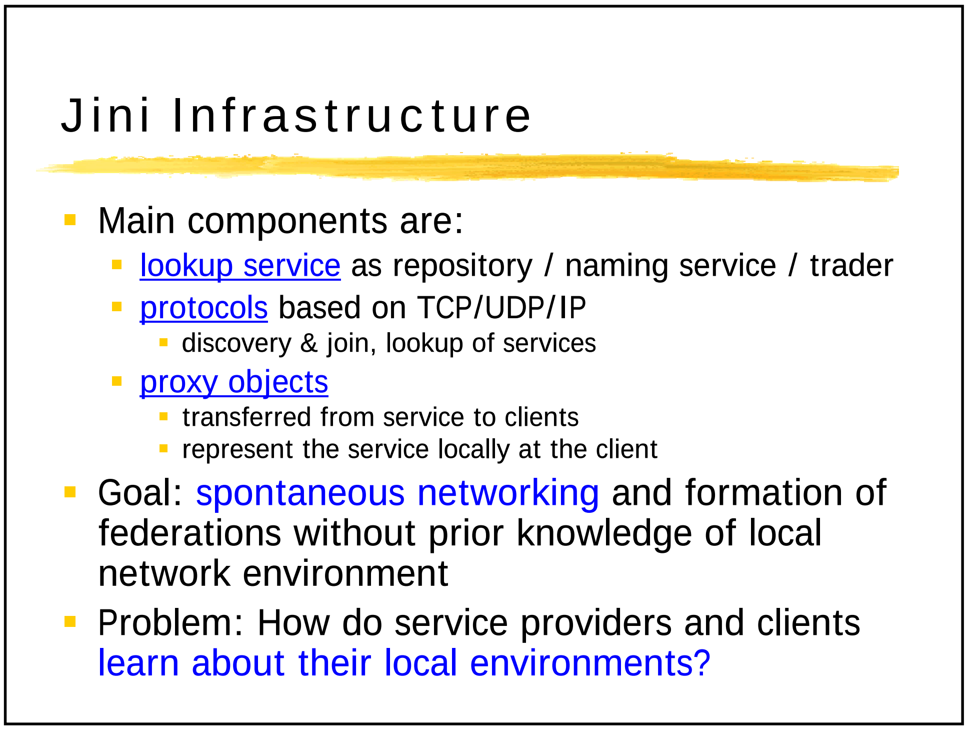




Jini’s Use of Java

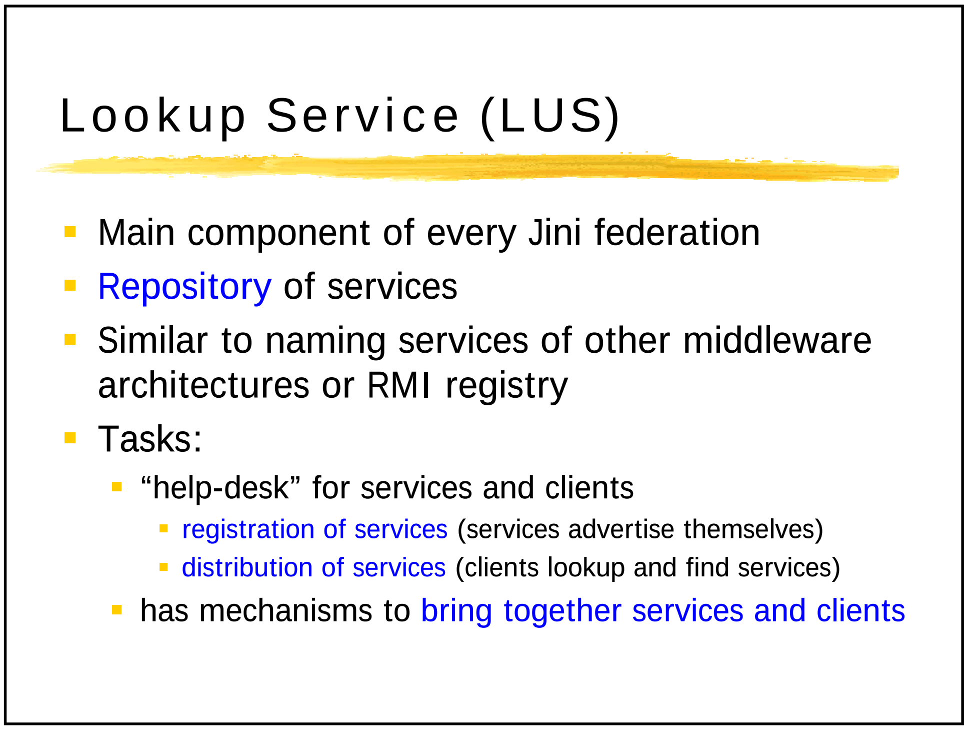
- Jini requires JVM (as bytecode interpreter)
  - homogeneity in a heterogeneous world
  - is this realistic?
- But: devices that are not “Jini-enabled” or that do not have a JVM can be managed by a software proxy which resides somewhere in the net

run protocols for discovery and join; have a JVM



Jini Infrastructure

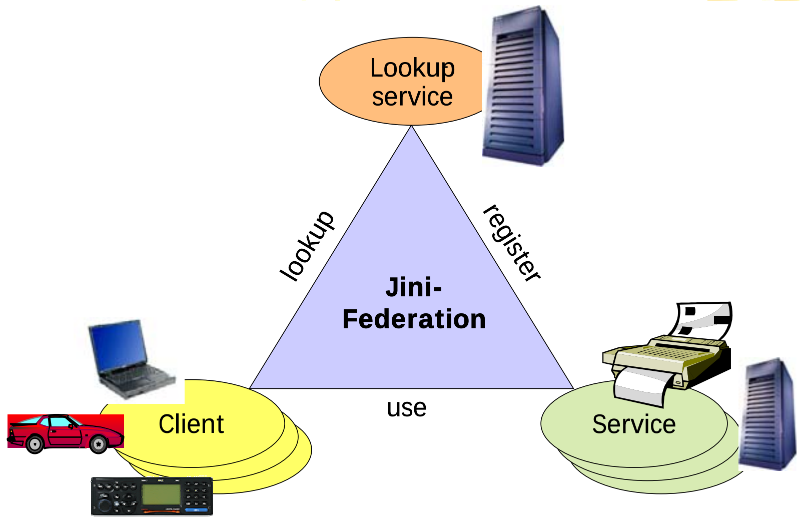
- Main components are:
  - lookup service as repository / naming service / trader
  - protocols based on TCP/UDP/IP
    - discovery & join, lookup of services
  - proxy objects
    - transferred from service to clients
    - represent the service locally at the client
- Goal: spontaneous networking and formation of federations without prior knowledge of local network environment
- Problem: How do service providers and clients learn about their local environments?



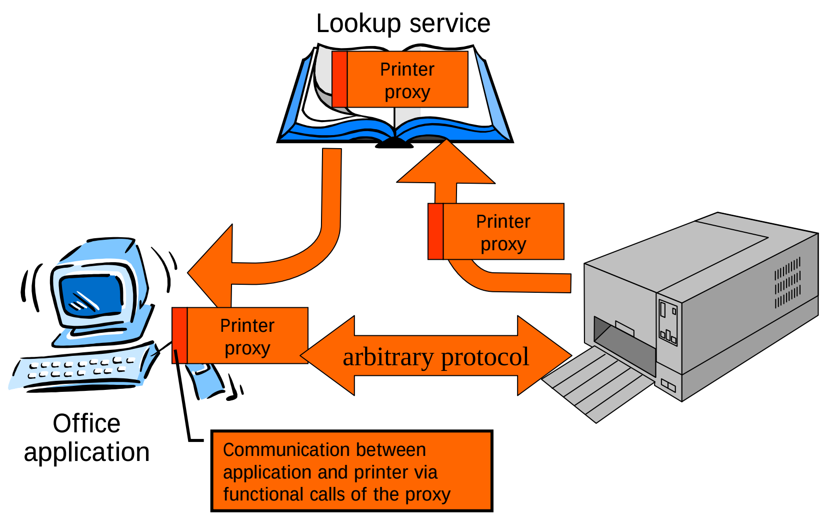
Lookup Service (LUS)

- Main component of every Jini federation
- Repository of services
- Similar to naming services of other middleware architectures or RMI registry
- Tasks:
  - “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

Lookup Service

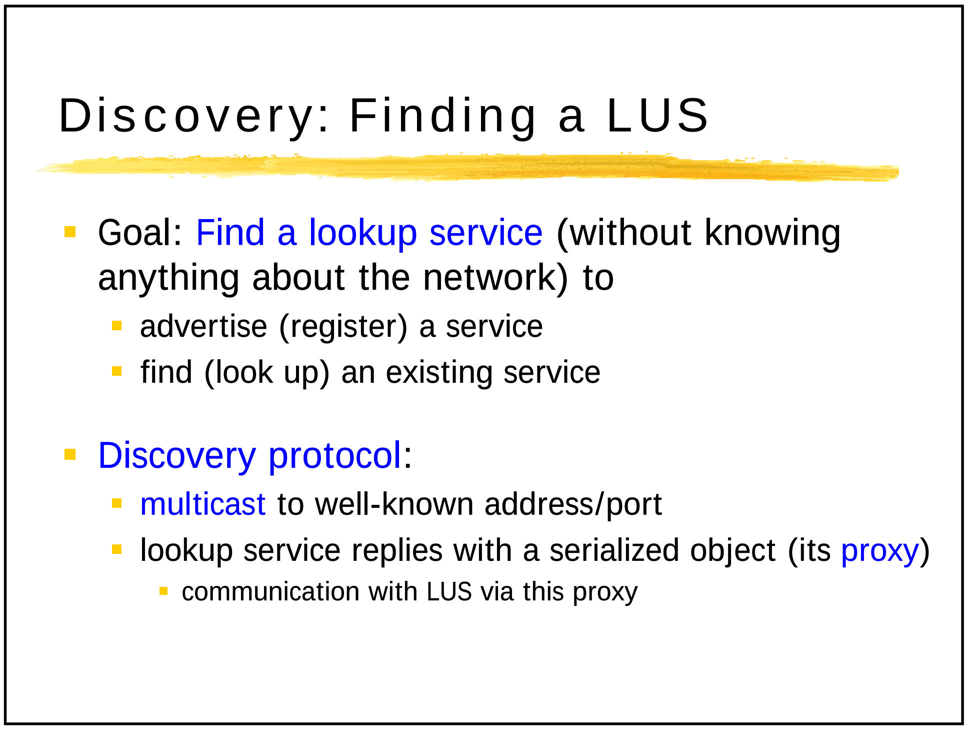


Example



Lookup Service

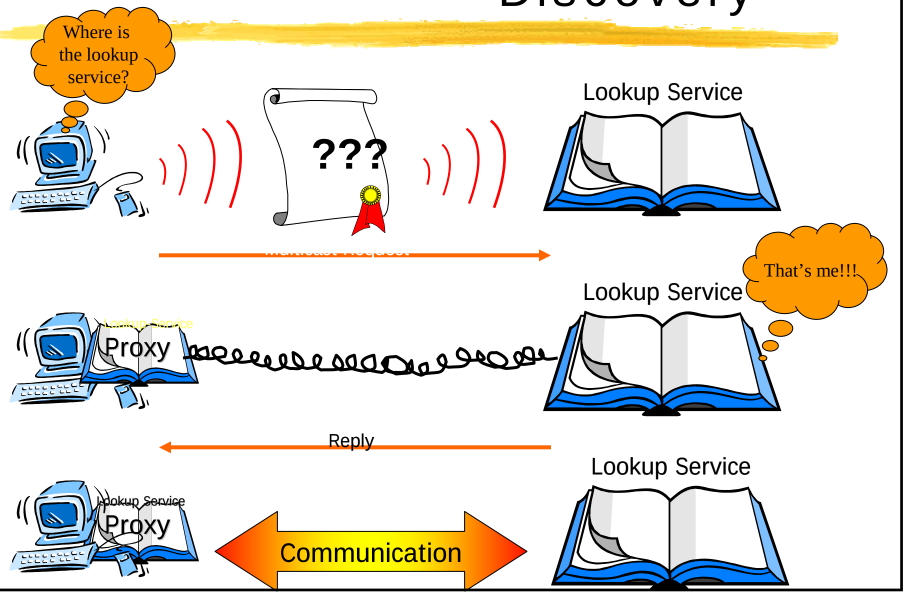
- Uses Java RMI for communication
  - objects („proxies“) can migrate through the net
- Not only name/address of a service are stored (as in traditional naming services), but also
  - set of attributes
    - e.g.: printer(color: true, dpi: 600, ...)
  - proxies, which may be complex classes
    - e.g. 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

Discovery



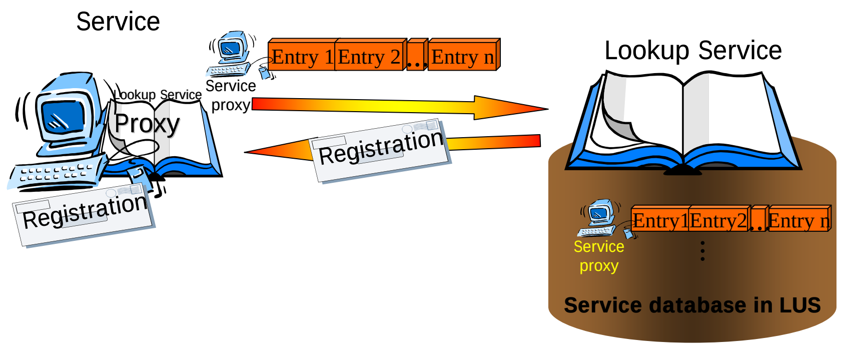
Multicast Discovery Protocol

- 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

- Service provider already has a proxy of the lookup service
- It uses this proxy to register its service
- Gives 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

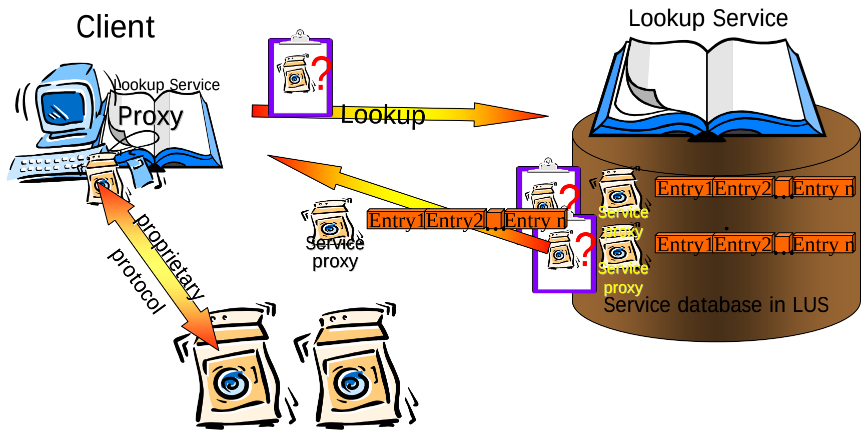
- To join, a service supplies:
  - its proxy
  - its ServiceID (if previously assigned; “universally unique identifier”)
  - set of attributes
  - (possibly empty) set of specific lookup services to join
- Service waits a random amount of time after start-up
  - prevents packet storm after restarting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

Lookup: Searching Services

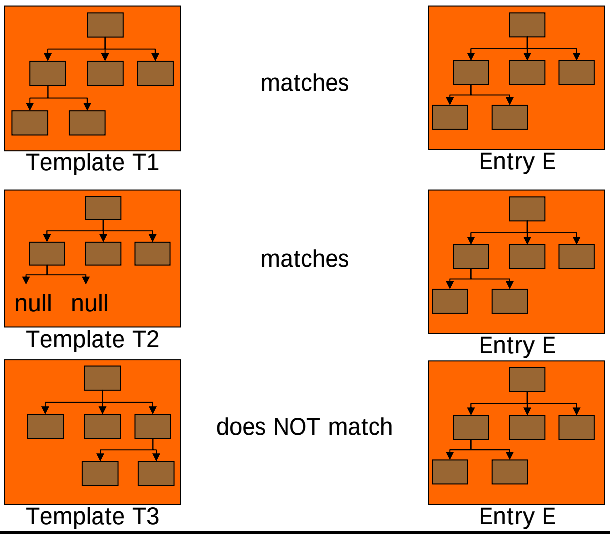
- Client creates query for lookup service
  - in form of a "service template"
  - matching by registration number of service and/or service type and/or attributes possible
  - attributes: only exact matching possible (no "larger-than", ...)
  - wildcards possible („null")
- Via its proxy at the client,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

- Client uses service by calling functions of service proxy
- Any protocol between service proxy and service provider possible

Lookup



Template Matching (Examples)

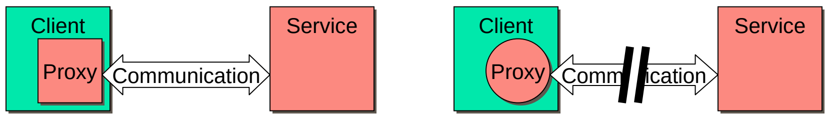


Proxies

- 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

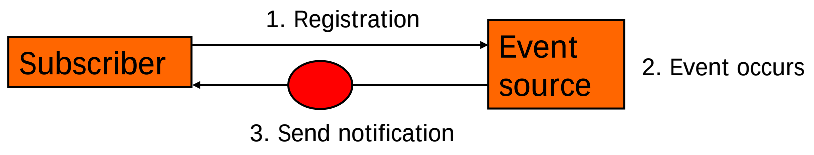


Leases

- 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

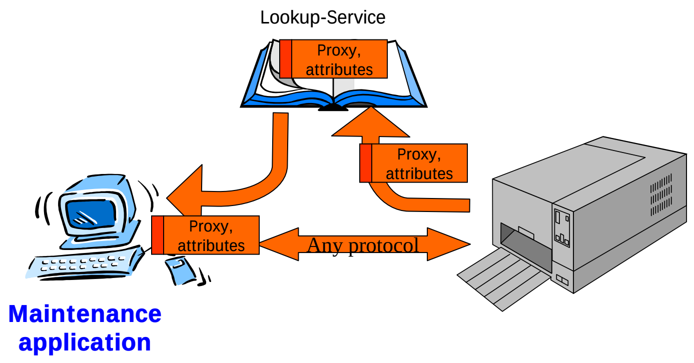
Distributed Events

- Objects in a JVM can register interest in certain events of another object in a different JVM
- "Publisher/subscriber" model



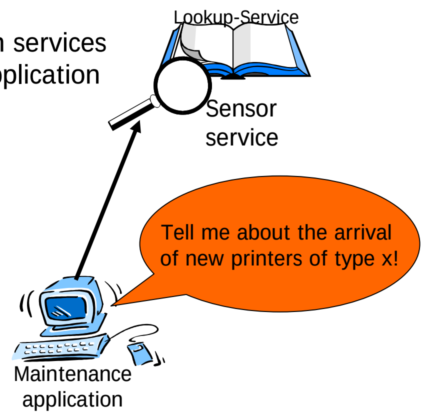
Distributed Events – Example

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



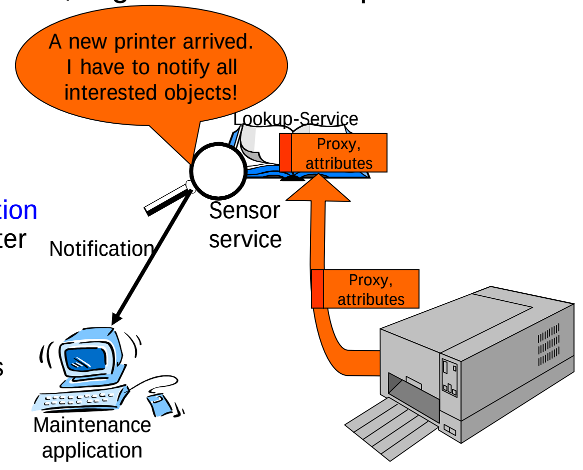
Distributed Events – Example

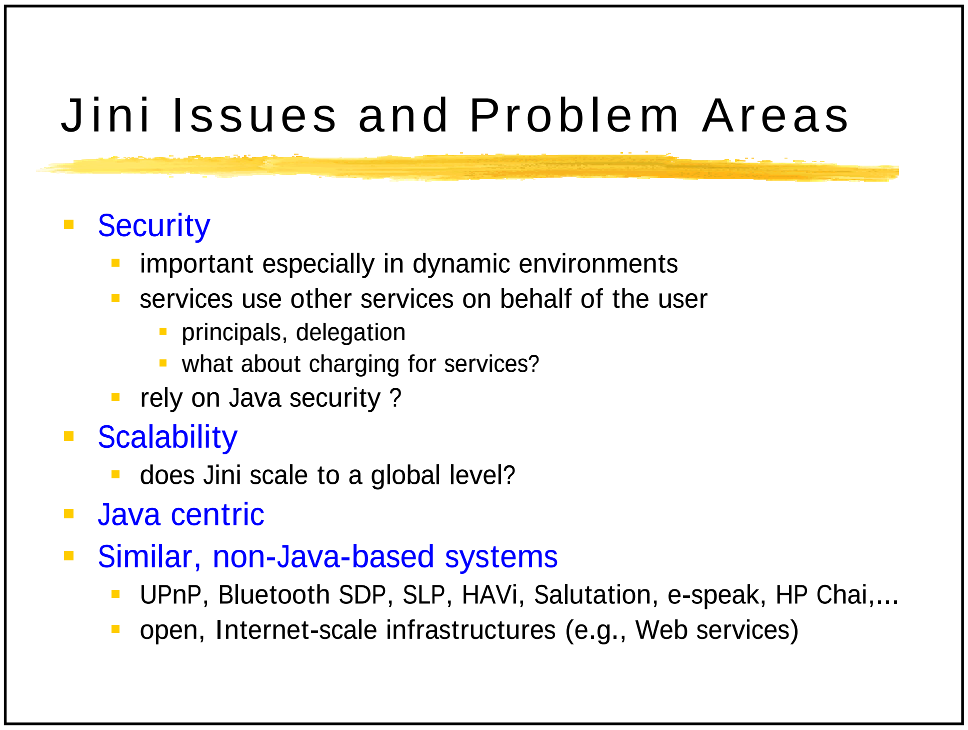
- Maintenance application is run on demand, search for printers is "out-sourced"
  - "sensor service" looks for certain services on behalf of the maintenance application
  - application registers for events showing the arrival of certain types of printers
  - sensor observes the lookup service
  - notifies 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
    - what about charging for services?
  - 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)