Discovery Systems in Ubiquitous Computing

Article summary
Article summary

• What is discovery?
• Characterizing discovery systems
• Discovery in practice
• New research directions for ubiquitous discovery systems
What is discovery?

Discovery the process where a client is notified spontaneously of the availability of services (resources) on the network.

Example:
Your mobile device (client) receives a message about all the printers (resources) in a building.
What is discovery?

Discovery process:

1. A printer (resource) registers itself to the discovery system when it enters the network. This makes the printer available to clients.

2. Clients specify what kind of resources they are interested in, and the discovery system identifies resources matching the client’s criteria.
What is discovery?

Important property of discovery systems: Spontaneity
(Clients find resources automatically, no pre-configuration is necessary)
There are different kinds of discovery systems.

- Common ultimate goal: Spontaneous resource discovery.
- Achievement of ultimate goal is done in different ways.

The following dimensions are used to compare different discovery systems:

- Topology
- Transport
- Scope
- Search
- Security

<table>
<thead>
<tr>
<th>Discovery system</th>
<th>Topology</th>
<th>Transport</th>
<th>Scope</th>
<th>Search</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 1</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>System 2</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Characterizing discovery systems

Describing discovery systems

Topology | Transport | Scope | Search | Security

Topology: Mapping of resources (within a discovery system).

A discovery system can use… (examples)

• peer to peer, where clients discovery resources directly
• a directory of available resources (the directory handles resource registration and client queries)
• or a combination of these
Characterizing discovery systems

Describing discovery systems

Topology | Transport | Scope | Search | Security

Transport: How the discovery system transports data.

A discovery system can use for transportation (examples):
• IP infrastructure
• Bluetooth
• RFID
• Infrared (IR)
• …
Characterizing discovery systems

Describing discovery systems
Topology | Transport | Scope | Search | Security

Scope = Those resources a client can discover.

Example:
• A mobile device in a wireless LAN enters a discovery system, which is not using directories.
  – If the client’s IP is 192.168.1.10, it’s scope is resources with IP addresses between 192.168.1.1-192.168.1.255
• For Bluetooth or IR, the scope is resources within a physical area
Characterizing discovery systems

Describing discovery systems
Topology | Transport | Scope | Search | Security

Search: When comparing discovery systems, clients can search for resources, but with different detail level.

Two extremes:
• A client can only specify resource type (e.g. printers, theaters, taxi centrals)
• A client can specify a search using a full blown predicate language ("i want to go to a theatre")
Security: Security mechanisms for the discovery system.

For instance:

• A discovery system using encryption for all data, authentication and authorization.
• No security
There are different kinds of discovery systems, built on different design choices.

Four systems are presented here:

• Simple Service Discovery Protocol (SSDP)
• Jini’s Discovery Protocols (JDP)
• Bluetooth Service Discovery Protocol (SDP)
• Service Location Protocol (SLP)
**Discovery in practice**

Four discovery systems

SSDP | JDP | SDP | SLP

Simple Service Discovery Protocol (SSDP)

- Used in Universal Plug and Play (UPnP) (which is a set of networking protocols to make networks easy to handle)
## SSDP (Simple Service Discovery Protocol)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>P2P (= no directory)</td>
</tr>
<tr>
<td>Transport</td>
<td>IP (HTTP, URIs, XML, SOAP)</td>
</tr>
<tr>
<td>Scope</td>
<td>Subnet</td>
</tr>
<tr>
<td>Search</td>
<td>Resource type or ID</td>
</tr>
<tr>
<td>Security</td>
<td>Authentication, access control</td>
</tr>
</tbody>
</table>
Discovery in practice

Four discovery systems
SSDP | JDP | SDP | SLP

Jini’s Discovery Protocols (JDP)
• Created by Sun Microsystem
• Uses proxy objects for communication (Java RMI)
## Discovery in practice

Four discovery systems

SSDP | **JDP** | SDP | SLP

### Jini’s Discovery Protocols (JDP)

| Dimension | 
| --- | --- |
| **Topology** | Proxy objects (resources specify their own proxy object) |
| **Transport** | IP |
| 1. Find proxy object with multicast UDP |
| 2. Unicast TCP with proxy object from 1. |
| **Scope** | Subnet, bridgeable (by connecting proxy objects) |
| **Search** | Resource type, ID or attributes |
| **Security** | Authentication, encryption, security policies |
Discovery in practice

Four discovery systems

SSDP | JDP | SDP | SLP

Bluetooth Service Discovery Protocol (SDP)

• Focuses on very efficient use of bandwidth
## Discovery in practice

Four discovery systems

SSDP | JDP | **SDP** | SLP

### Bluetooth Service Discovery Protocol (SDP)

<table>
<thead>
<tr>
<th>Dimension</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>P2P</td>
</tr>
<tr>
<td>Transport</td>
<td>Device discovery: Link Manager Protocol. Service discovery within a device: Logical Link Control and Adaptation Protocol</td>
</tr>
<tr>
<td>Scope</td>
<td>+- 10m</td>
</tr>
<tr>
<td>Search</td>
<td>Resource type or attribute ID</td>
</tr>
<tr>
<td>Security</td>
<td>Link-level or service level encryption, authentication</td>
</tr>
</tbody>
</table>
Discovery in practice

Four discovery systems
SSDP | JDP | SDP | SLP

Service Location Protocol (SLP)
• Focuses on discovery in large, administrated networks
## Discovery in practice

### Four discovery systems
SSDP | JDP | SDP | SLP

## Service Location Protocol (SLP)

<table>
<thead>
<tr>
<th><strong>Dimension</strong></th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topology</strong></td>
<td>P2P or directory</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>If present: Directory agents (handles all requests)</td>
</tr>
<tr>
<td></td>
<td>If not: Direct discovery (multicast)</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Subnet, bridgeable</td>
</tr>
<tr>
<td><strong>Search</strong></td>
<td>Type, attributes, predicates (booleans, wild cards, etc.)</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Optional service authentication</td>
</tr>
</tbody>
</table>
New research directions

• None of the mentioned discovery systems were designed specifically for ubiquitous computing
• What is needed for an ubiquitous discovery system?
New research directions

• None of the mentioned discovery systems were designed specifically for ubiquitous computing
• What is needed for an ubiquitous discovery system?

1. Providing infrastructure, without the infrastructure
   1. A key challenge is getting the properties of a fixed infrastructure: Scalability, security, easy administration, shared naming, +

Discovery Systems in Ubiquitous Computing
New research directions

• None of the mentioned discovery systems were designed specifically for ubiquitous computing
• What is needed for an ubiquitous discovery system?

1. Providing infrastructure, without the infrastructure
2. Connecting islands of discoverability
   1. Different network standards and protocols creates isolated "islands" (containing a discovery system with resources and clients). Ideally all networks should be interconnected.
New research directions

• None of the mentioned discovery systems were designed specifically for ubiquitous computing
• What is needed for an ubiquitous discovery system?

1. Providing infrastructure, without the infrastructure
2. Connecting islands of discoverability
3. A search appropriate for ubiquitous computing
   1. Context aware applications often need to find resources based on location. Discovery systems should support this.
New research directions

• None of the mentioned discovery systems were designed specifically for ubiquitous computing
• What is needed for an ubiquitous discovery system?

1. Providing infrastructure, without the infrastructure
2. Connecting islands of discoverability
3. A search appropriate for ubiquitous computing
4. The human issue

1. **Usability**: Discovery system needs to provide good information so the user fully understands the discovery process in his/her device.