Service Discovery in Pervasive Computing Environments

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Introduction

- What is it?

  Pervasive Computing Environments integrate networked computing devices with people and their ambient environments enabling the device and the service to communicate with each other
- Simply means that even if the network/ protocols are different; people should be able to use it with minimum interaction with the service providers
- Few Example Service Discovery Protocols

  - MIT's International Naming System

  - UC's Berkeley's Ninja Service Discovery Service

  - Salutation Protocol

Pervasive Environment Challenges

- Pervasive computing environments are dynamic and heterogeneous
- Unlike the Enterprise Environments; it is difficult to define a network scope for pervasive computers and it is also difficult for all services to be managed by a system administrator
- Unlike the Web services, pervasive environments focus on interactions among people than between services

Integration with people

- This is the most serious challenge to pervasive computing discovery
- First challenge is to protect the private data of users
- Second challenge is to determine how much knowledge a user or a service must have for service discovery

  People serve two roles:

  1. Users (Require less knowledge)
  2. Service providers (Require special skill)
- The third challenge is to allow multiple service-providers to coexist at a single place

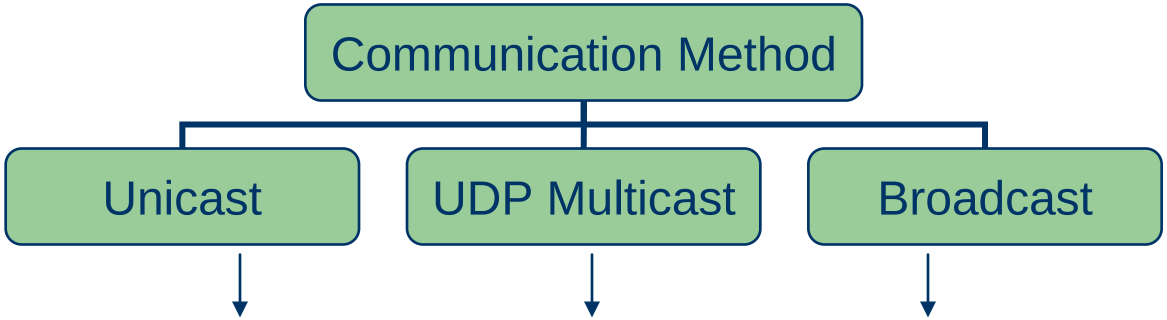
Integration with Environment

- How to define the environment that the service discovery targets?
- Pervasive Computing is heterogeneous in terms of hardware, software, network protocols and service providers
- A common protocol should be established in order to facilitate the discovery of service by the user

Service and Attribute Naming

- Two types of Service and attribute naming: **Template-based** and **Template-based and predefined**
- **Template -Based**
  - defines a format for service names and attributes
  - Example: Apple's Rendezvous is based on Internet's DNS which defines how service names can be composed
- **Template-Based and Predefined**
  - gives commonly used attributes and names
  - eliminates ambiguity regarding name and attributes in client, services, and directory interaction.

Initial Communication Method



Communication Method

Unicast

UDP Multicast

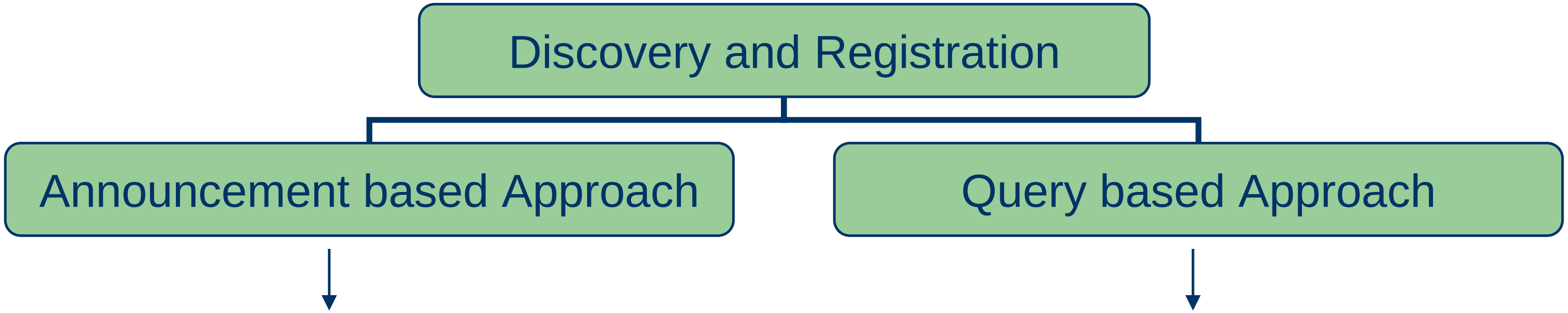
Broadcast

Requires configuration of n/w adressses with prior knowledge

After receiving few multicast messages, unicast message is determined dynamically for communication

Restricts its use to single hop of wired or wireless networks

Discovery and Registration



Discovery and Registration

Announcement based Approach

Query based Approach

Interested parties listen on a channel for the availability of a service

Eg: Processes waiting in a queue for the processor

Party receives immediate response to a query and doesn’t need to process unrelated announcements

Eg: Special Request to the server

Service Discovery Infrastructure

- Uses two service discovery infrastructure models
  - **Directory Based Model**
    - Has a dedicated component that maintains service information and processes queries announcements
    - Example of Directory Based Model would be Microsoft’s Active Directory
  - **Non-Directory Based Model**
    - No dedicated component
    - When a query arrives, every service processes and service that matches query responds
    - Example: Switch that broadcast a request to all systems on network in order to find where a new computer is located.

Service Information State

- Two service information states: **Soft State** and **Hard State**
  - **Soft State**
    - Most service discovery protocols maintain status as a soft state
    - Before service expiration, a client or directory polls the service or service then announces itself to renew registration lease.
    - Soft state simplifies system design and keeps service up to date.
  - **Hard State**
    - Requires fewer services and housekeeping jobs
    - Clients and services poll periodically to verify info is up to date.

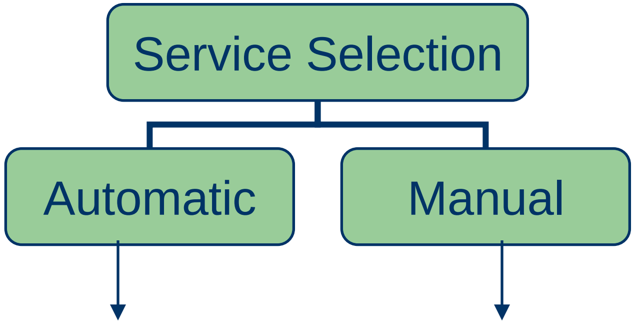
Discovery Scope

- Proper discovery scopes minimize unnecessary computation on client, services, and directories.
- **Network topologies**, **user roles**, **context information**, or a combination helps to properly define service discovery scope session targets.
- Based on **Network Topology**, **User Roles, Context Info**, or a combination of either
  - **Network Topology**
    - **Uses LAN and single hop wireless network range protocols**
    - **One can assume that the clients, services, and directories belong to same administrative domain**
    - **Setback to that is pervasive computing environments can include multiple, coexisting administrative domains as wells as different underlying networks that may not be connected**

Discovery Scope cont’d

- **User Roles**
  - Users authenticate with a domain or supply the designated domain as an attribute.
    - *User must have prior knowledge of target domain
  - Implementation of this should reflect an ambient environment according to user role
- **Context Discovery Scope**
  - Defined by temporal, spatial, and user activity information
  - Proper use can save users time and effort in discovery agencies

Service Selection



The protocols select the service; this simplifies the client program ("anycast")

It also balances the load among servers

Tedious

Users might not enough

Service Invocation

- Invocation Involves ⇨

Level 1:Network’s Service Address

Level 2: Underlying Communication Mechanism

Level 3: Operations specific to application domain

Service Usage

- Explicit Release: A client must explicitly release a service’s resources once service usage is granted
- Lease-based mechanism: A client and the service negotiate the usage period (user can cancel/ renew it later)

This service handles dynamic conditions of the pervasive systems in a better way

Service Status Inquiry

- Used by clients to keep up with service events or status by polling or service event notifications.
- Two types of service status inquiry: **Polling** and **Service Event Notifications**
  - **Notification**
    - Clients register with a service and the service notifies client of something interesting such as a expiration date or upgrade to software
  - **Polling**
    - Used services generate events frequently or change status quickly

Security and Privacy

- Service discovery protocols must provide security and privacy to protect devices, services, and users
- Harder to implement changes due to changing environment
- Only current solution to environment changes is have people with special skills
- Scope of possible intrusion is increased due to wireless networks in a pervasive computing environment
- Clients, services, and directories should exchange sensitive information with legitimate parties
- What is legitimacy?
  - Refers to both valid and credentials and access privileges on services
- Isn’t always easy to acquire

Security and Privacy cont'd

- One way to verify legitimacy is to progressively exchange credential and information
- Compared to service discovery functionality, support for security and privacy in existing service discovery protocols is still in its infancy stages
- Because of different protocols being used, pervasive computing requirements cannot be met
- But with some revisions in discovery protocols and new protocols, we are able to support more security features
- With further research or possibly assimilating these protocols into maybe a "suite", we can increase security and privacy

Conclusion

- Service discovery for unfamiliar protocols needs to be addressed more
- In order to compute at anytime or anywhere, these discovery protocols must work in unfamiliar computer environments
- These must become more intelligent to compensate for user’s lack of knowledge, special skills, and unwillingness to trust the environment

References

- Zhu, Mutka, and Ni. *Service Discovery in Pervasive Computing Environments.* IEEE ppg. 2005 81-90.