Distributed Systems

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Resource and Service Management

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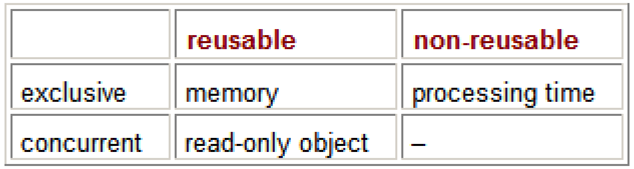
Introduction

- Resource/ Service

  Resource

  - An entity that is available in limited supply
    - Ex: memory, storage, DB connection, network connection, security token, IoT devices
  - 若此資源主要透過軟體API提供，則又稱為Service
- Roles
  - Resource user
  - Resource provider
- Categories
  - Reusable/ non-reusable
  - Exclusive/ concurrent



	reusable	non-reusable
exclusive	memory	processing time
concurrent	read-only object	–

Introduction

- Name
  - 一個參考，透過它，可以透過網路存取Resource or Service
    - 例: URI、URN

- 設置方式
  - 集中式
    - 問目錄(registry、directory)
      - Ex: DNS、LDAP
  - 分散式
    - 同伴口耳相傳
      - Ex: mDNS、SSDP

有效率，要 **maintain directory**

沒效率，但不用 **maintain directory**

Resource/ Service Discovery

- The core technology of resource/ service management
- may be client
  user能即時得知一定範圍內的其它資源/服務相關資訊的機制，包含:
  - Presence
    - 目前是否存在於「此系統」
  - Description
    - Type: 能夠提供的功能類型
    - Access point: (網路) 位置
    - Location: (實體) 位置
    - Attributes: 可以描述此節點的資訊
      - Ex: type=printer, cost = 1 per page, location=201R

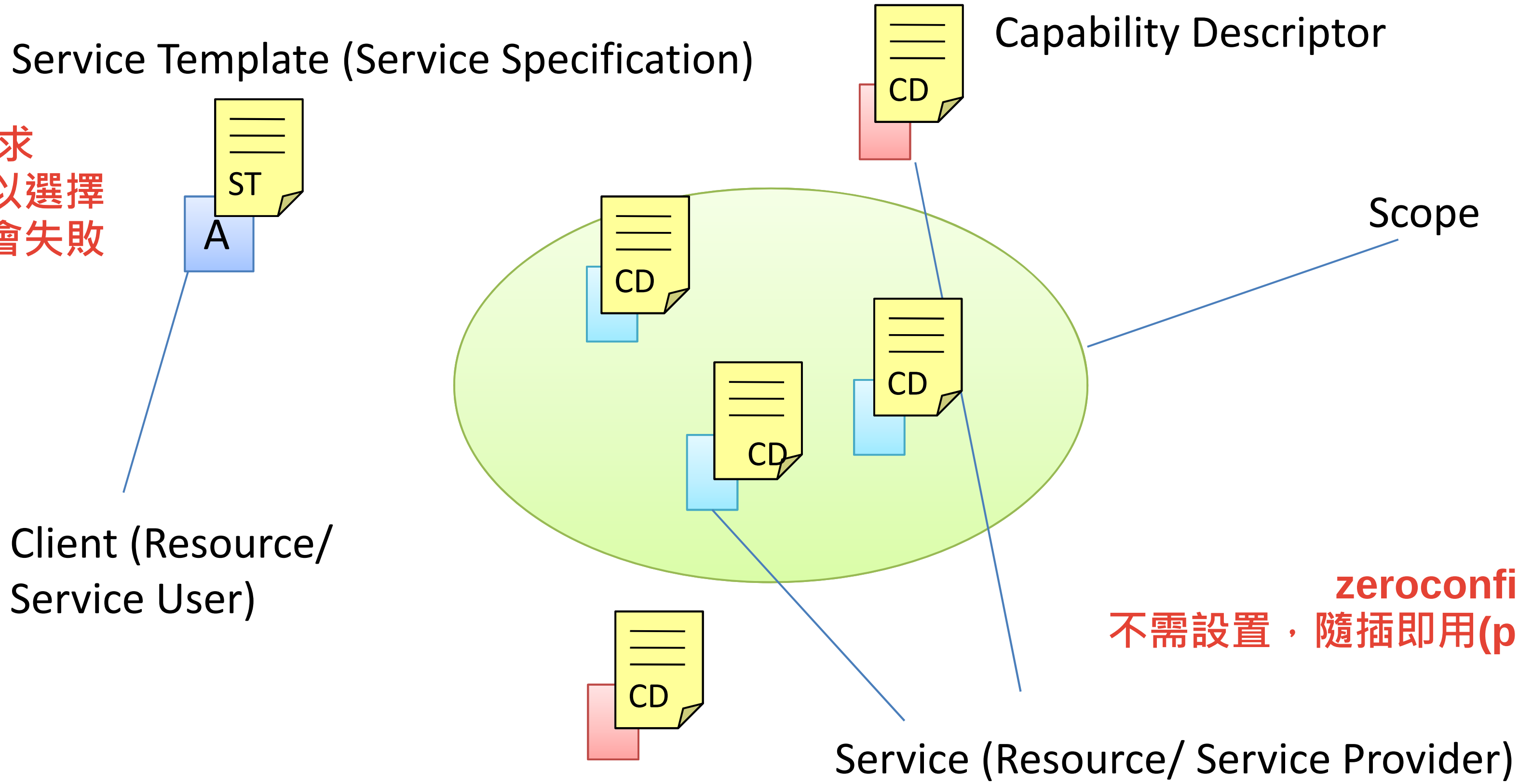
Common Characteristics of Discovery Protocols

- Presence Management 判斷誰在這個空間
  - Presence announcement and capability advertisement
  - Evicting failed or left services
- Service Lookup 想要的特定功能節點
  - Match a “specification (template)” with “capabilities”
    - By type
    - By type, and then filter by attributes
    - By semantic approaches

服務發現機制的一般性模型

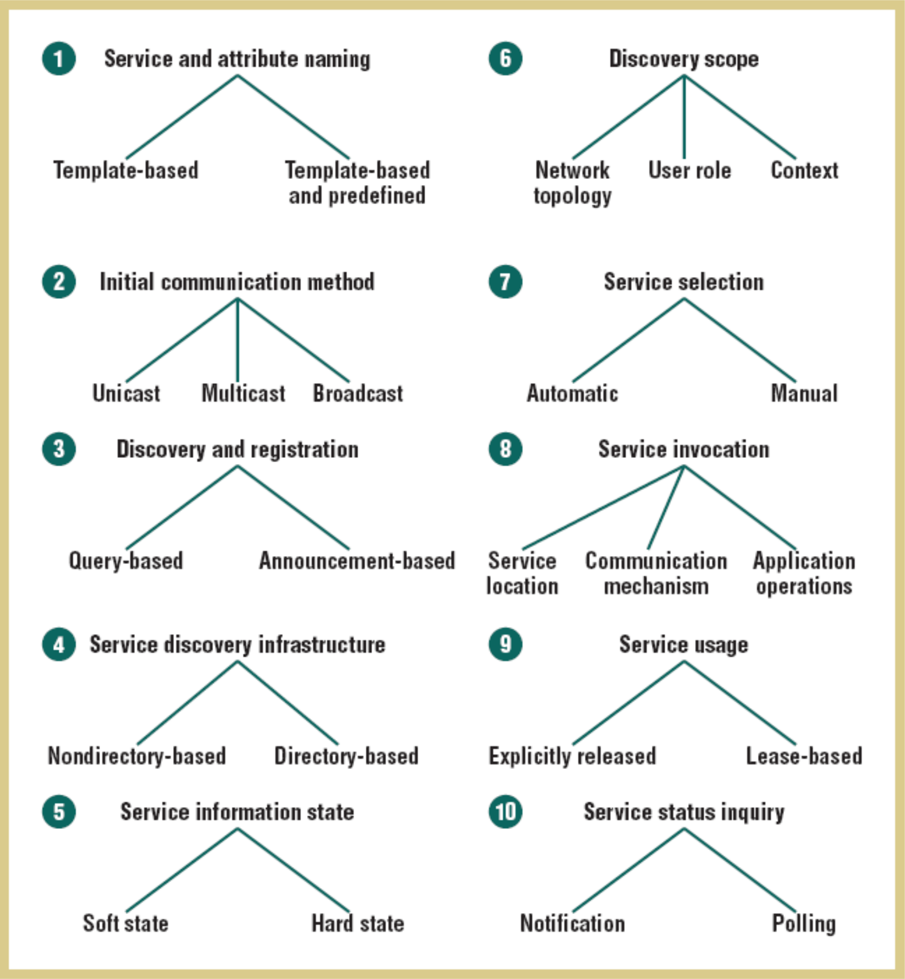
有什麼功能放在 CD

ST 是需求
供過於求可以選擇
供不應求就會失敗


Service Template (Service Specification)
ST
A
Client (Resource/ Service User)
CD
Capability Descriptor
Scope
CD
CD
CD
CD
Service (Resource/ Service Provider)

zeroconfig
不需設置，隨插即用(plug and play)

Design Issues



F. Zhu et al. Service Discovery in Pervasive Computing Environments, IEEE Pervasive Computing, 2005

Service and attribute naming

- Naming approach
  - User friendly names 頻寬足夠
    - 若不小心管理，可能會有名稱混淆或重複的問題
    - Ex: TV, stereo, air conditioner,…
    - URL、URN亦屬於此類
  - Machine friendly names 頻寬不夠的狀況
    - 使用者較難了解意義(需要透過額外機制或工具轉換)
    - Ex: UUID (BLE採用UUID)
      - 61C4D231-FE17-4AD1-B159-64F880FFC44E

Service and attribute naming

- A client searches a service by a name and attributes
  - Template-based 易寫，較低效
    - 提供特定命名格式 (URN)

      加底線是 mDNS 的格式

      . 區隔
      - mDNS/DNS-SD: light._sub._http._tcp.local 一般 IP 網路上運行的服務發現協議

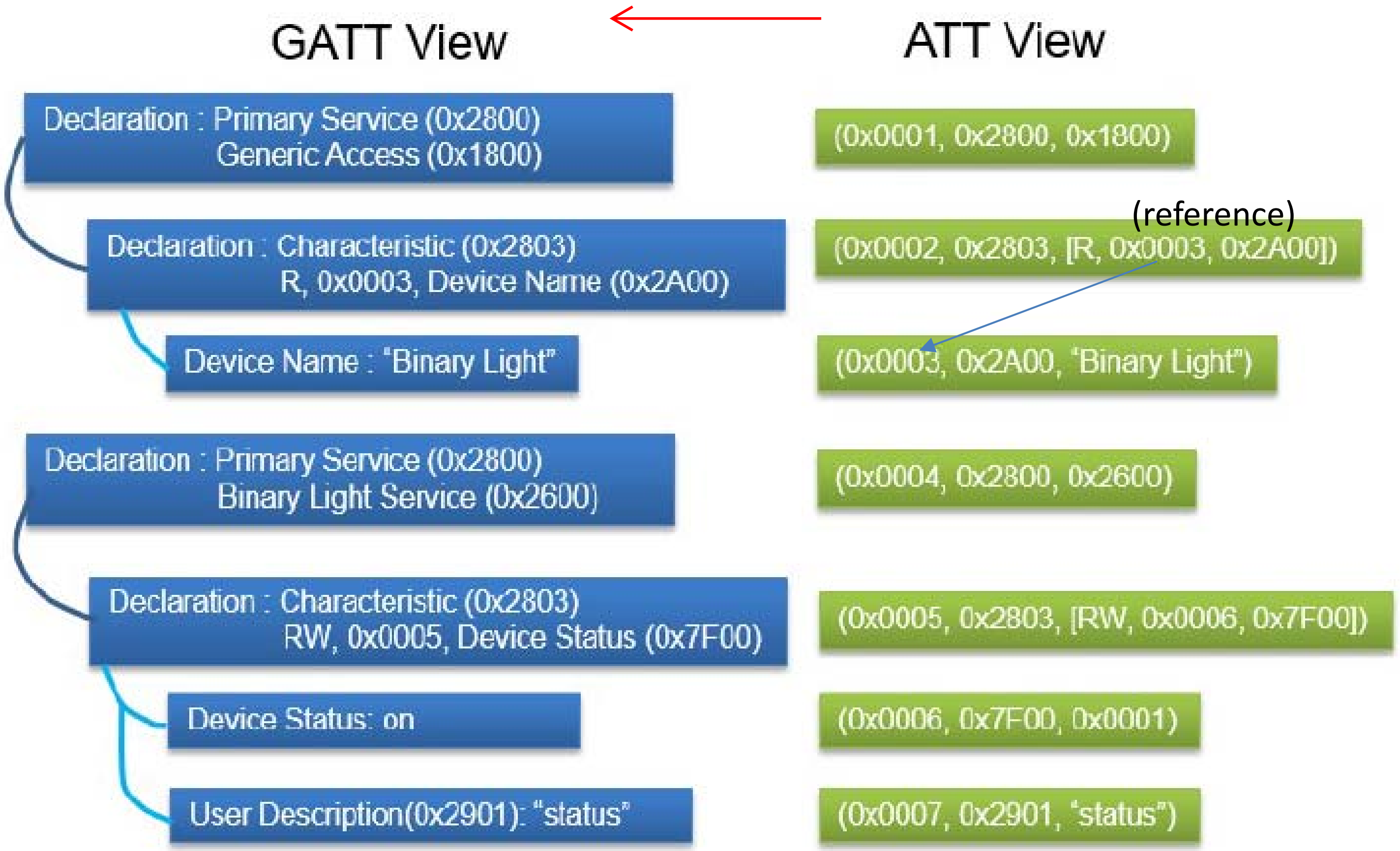
      : 區隔
      - UPnP: urn:schemas-upnp-org:device:BinaryLight:1
  - Template-based and predefined 難寫，高效
    - 除命名格式，對於常用名稱也提供標準定義
      - BLE:以規格書定義了一系列16-bit 的代碼對應到不同的Attribute types
        - GATT (Generic Attribute Profile)
        - ATT (Attribute Protocol):

          只要 maintain 一個小型 database
          就能運行服務發現

$a_k \in A, a_k = (i_k, \tau_k, v_k)$ Attribute: (handle, type, value/ref)

還原結構(對照規格書)

Attribute: (handle, type, value/ref)



GATT View

ATT View

Declaration : Primary Service (0x2800)
Generic Access (0x1800)

(0x0001, 0x2800, 0x1800)

Declaration : Characteristic (0x2803)
R, 0x0003, Device Name (0x2A00)

(reference)

(0x0002, 0x2803, [R, 0x0003, 0x2A00])

Device Name : "Binary Light"

(0x0003, 0x2A00, "Binary Light")

Declaration : Primary Service (0x2800)
Binary Light Service (0x2600)

(0x0004, 0x2800, 0x2600)

Declaration : Characteristic (0x2803)
RW, 0x0005, Device Status (0x7F00)

(0x0005, 0x2803, [RW, 0x0006, 0x7F00])

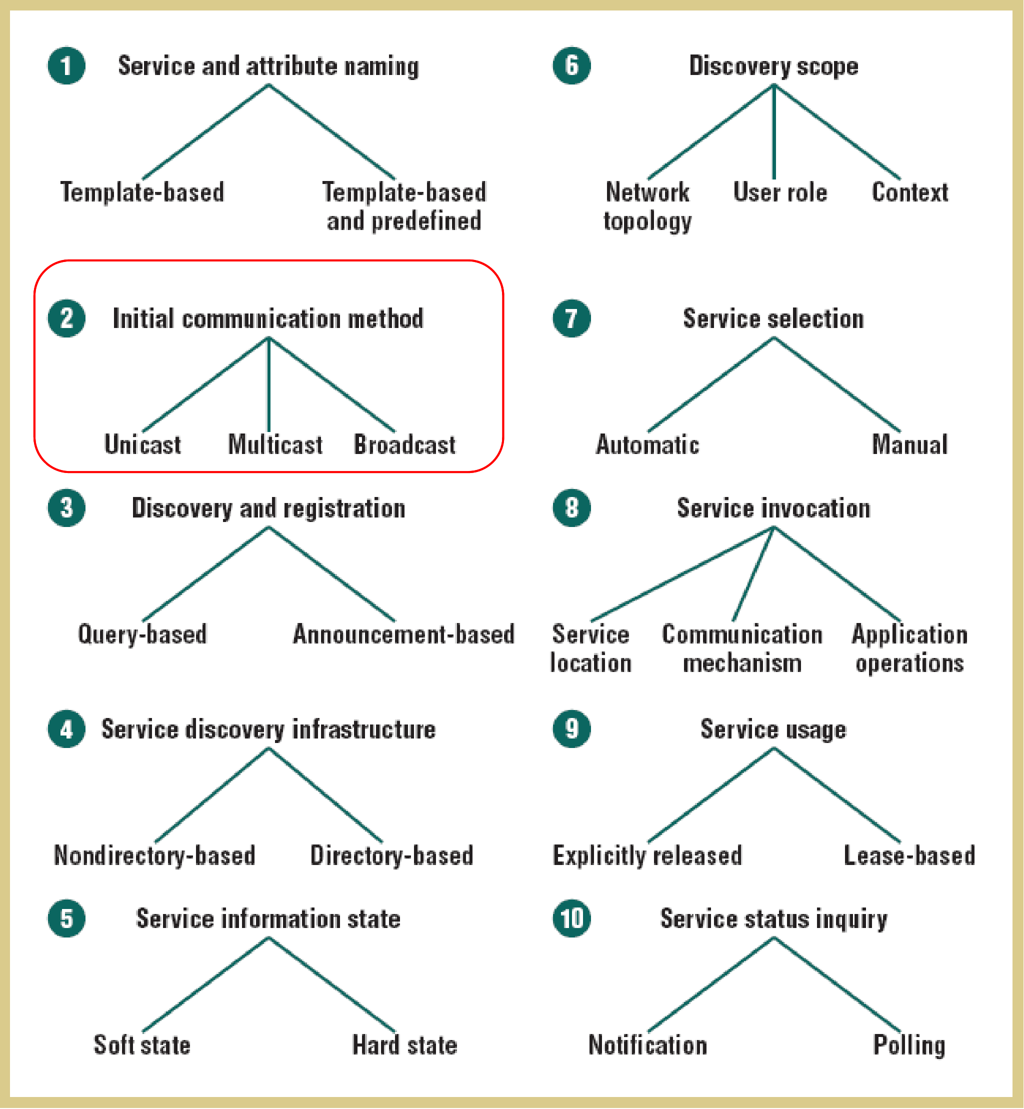
Device Status: on

(0x0006, 0x7F00, 0x0001)

User Description(0x2901): "status"

(0x0007, 0x2901, "status")

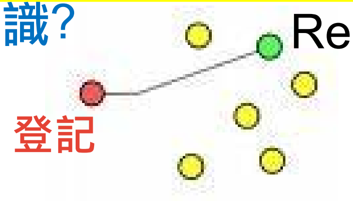
Design Issues



Initial communication method

加入群體時，如何讓大家認識?

○ **Unicast** 登記

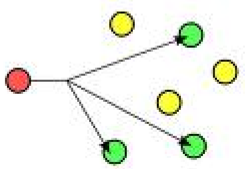


Registry/gateway

The most efficient, but need to configure network addresses with prior knowledge.

○ **Multicast** 群播

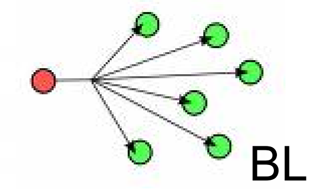
(Transport Layer)



UPnP, mDNS/DNS-SD

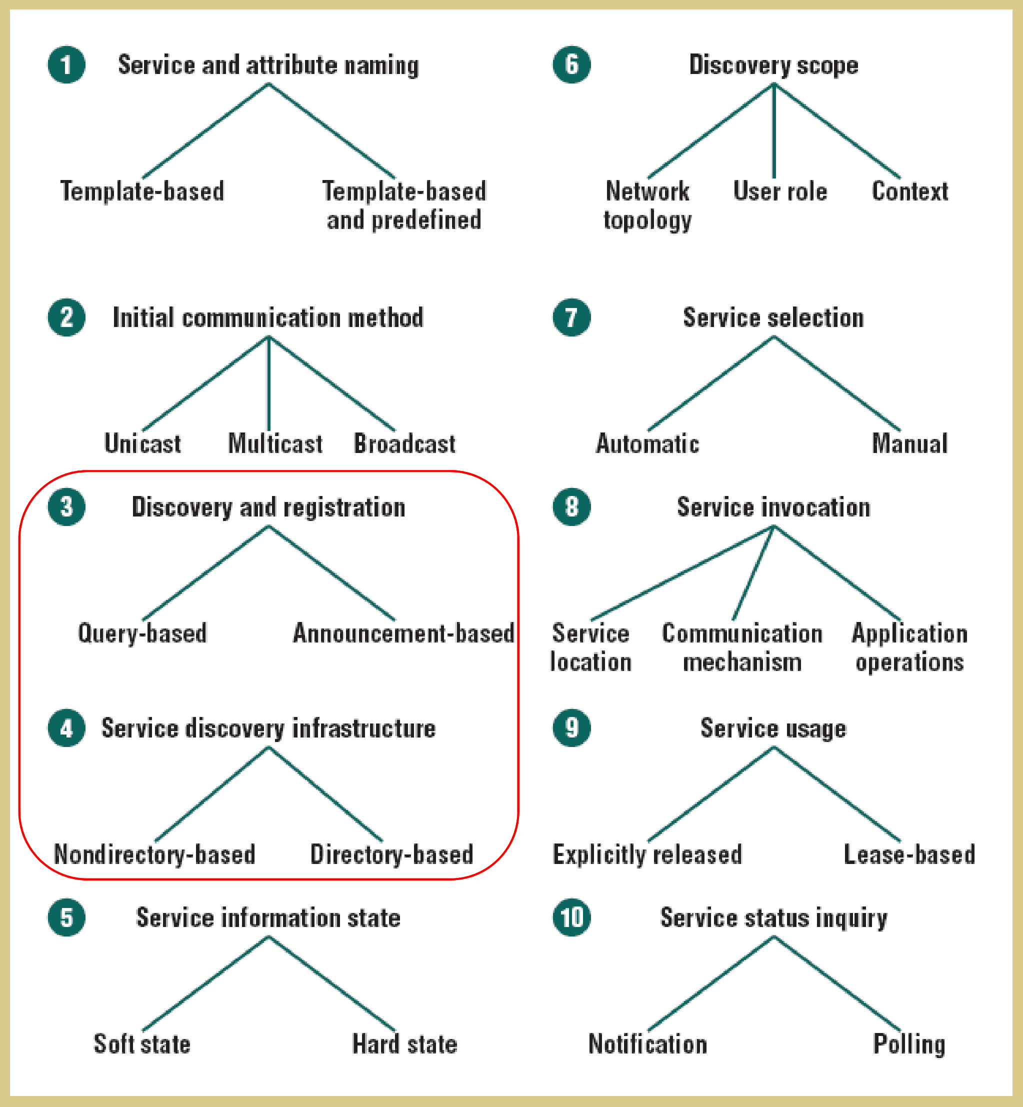
○ **Broadcast** 廣播

(Link Layer)



BLE

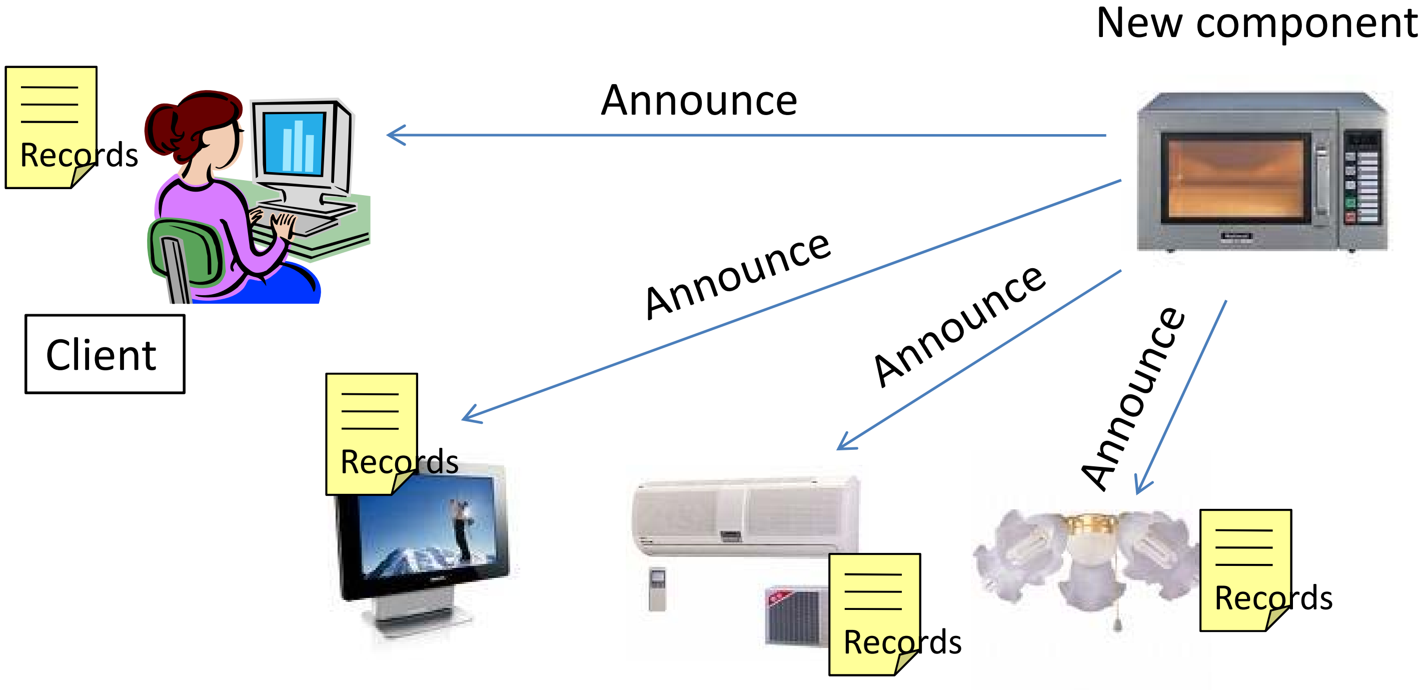
Design Issues



Discovery and registration

- **Announcement-based** Client要自己維護服務清單

Interested parties listen on a channel. When a service announces its availability and information, all parties hear the information.

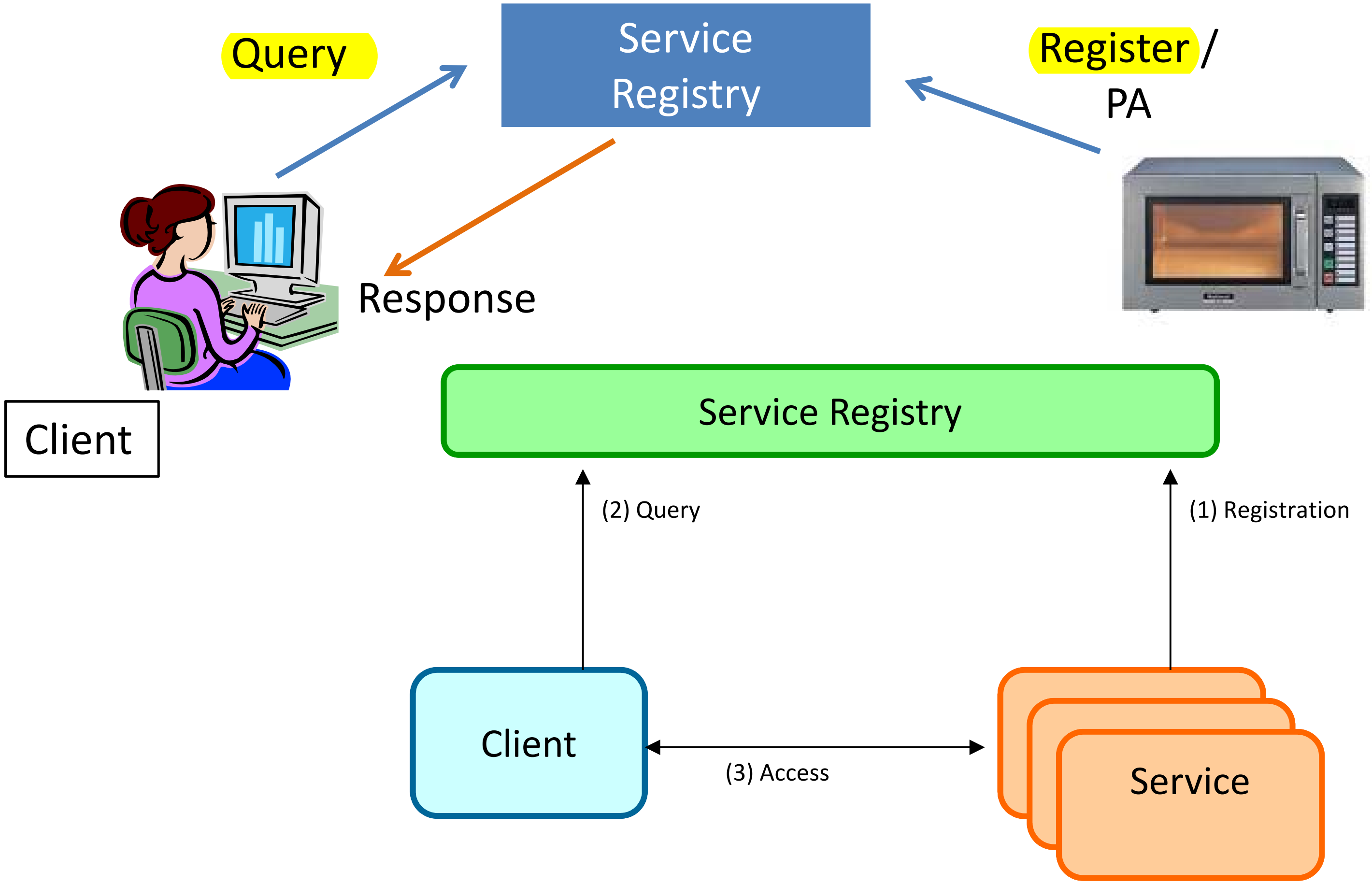


有個地方去查

額外維護一個 server

- **Query-based** 服務清單由registry (directory)統一維護

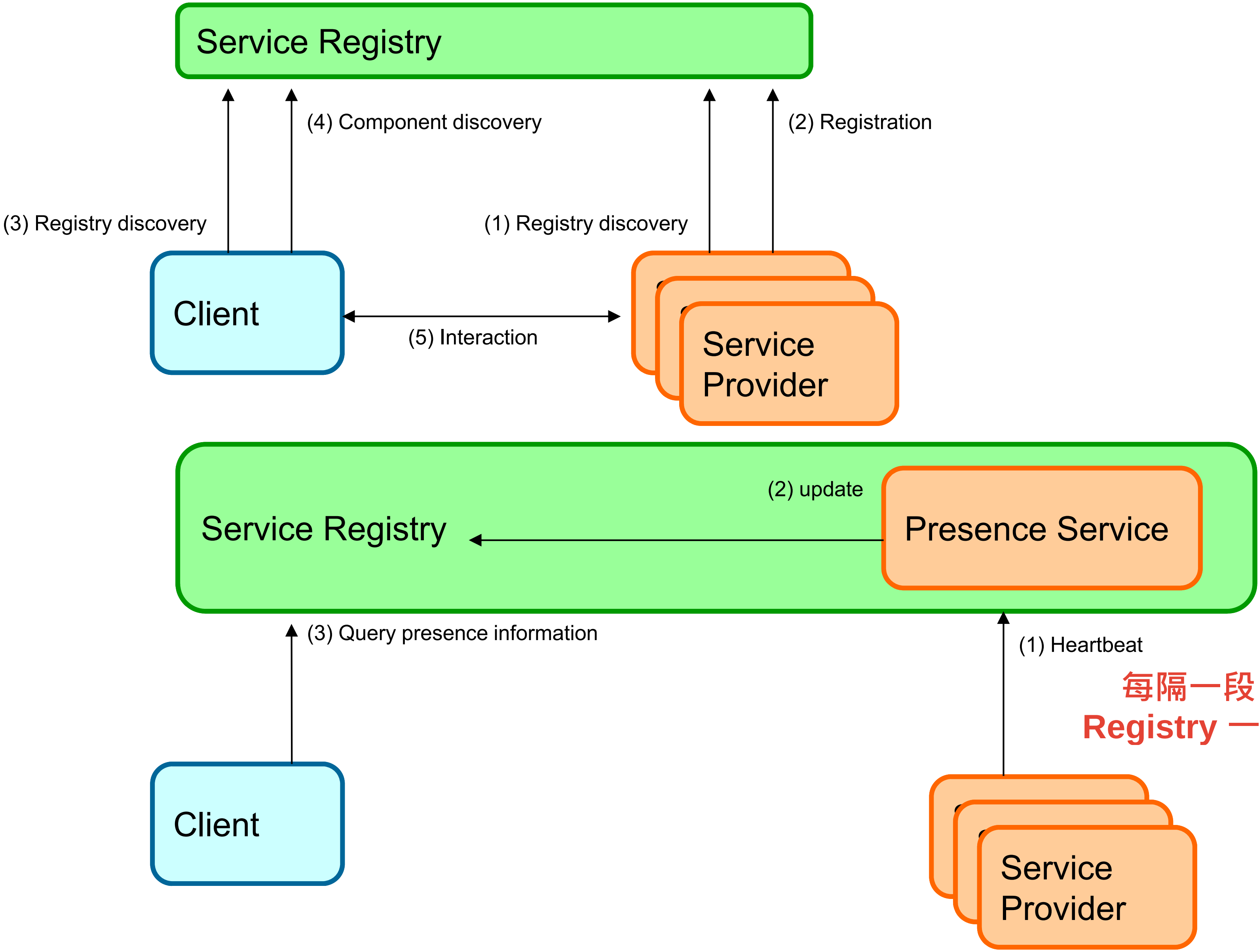
A party receives an immediate response to a query and doesn't need to process unrelated announcements. 新的東西進來要註冊



Discovery Infrastructure

- ○ Directory-based maintain registery
  - Has dedicated registries that maintain information and status of service components
  - Ex: CORBA, Web Services, Jini
- ○ Non-directory-based device 會廣播，需要的人會自己記錄
  - Rely on broadcasting or multicasting mechanisms
  - Ex: UPnP, P2P systems

Directory-based

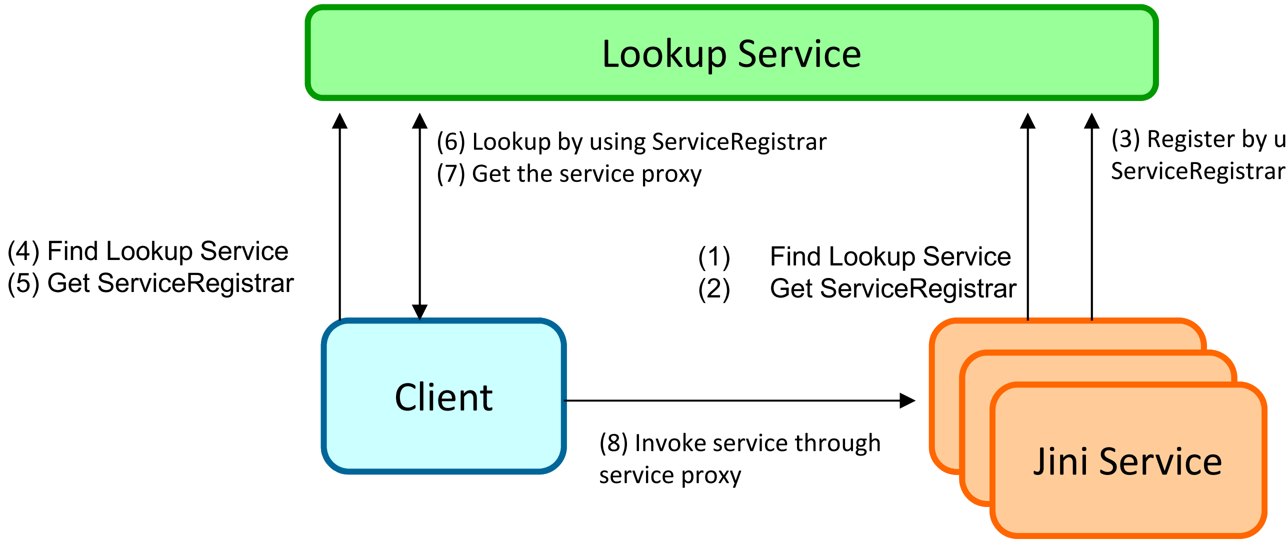


每隔一段時間要重新傳送
Registry 一段時間會刪除記錄

Case: Jini

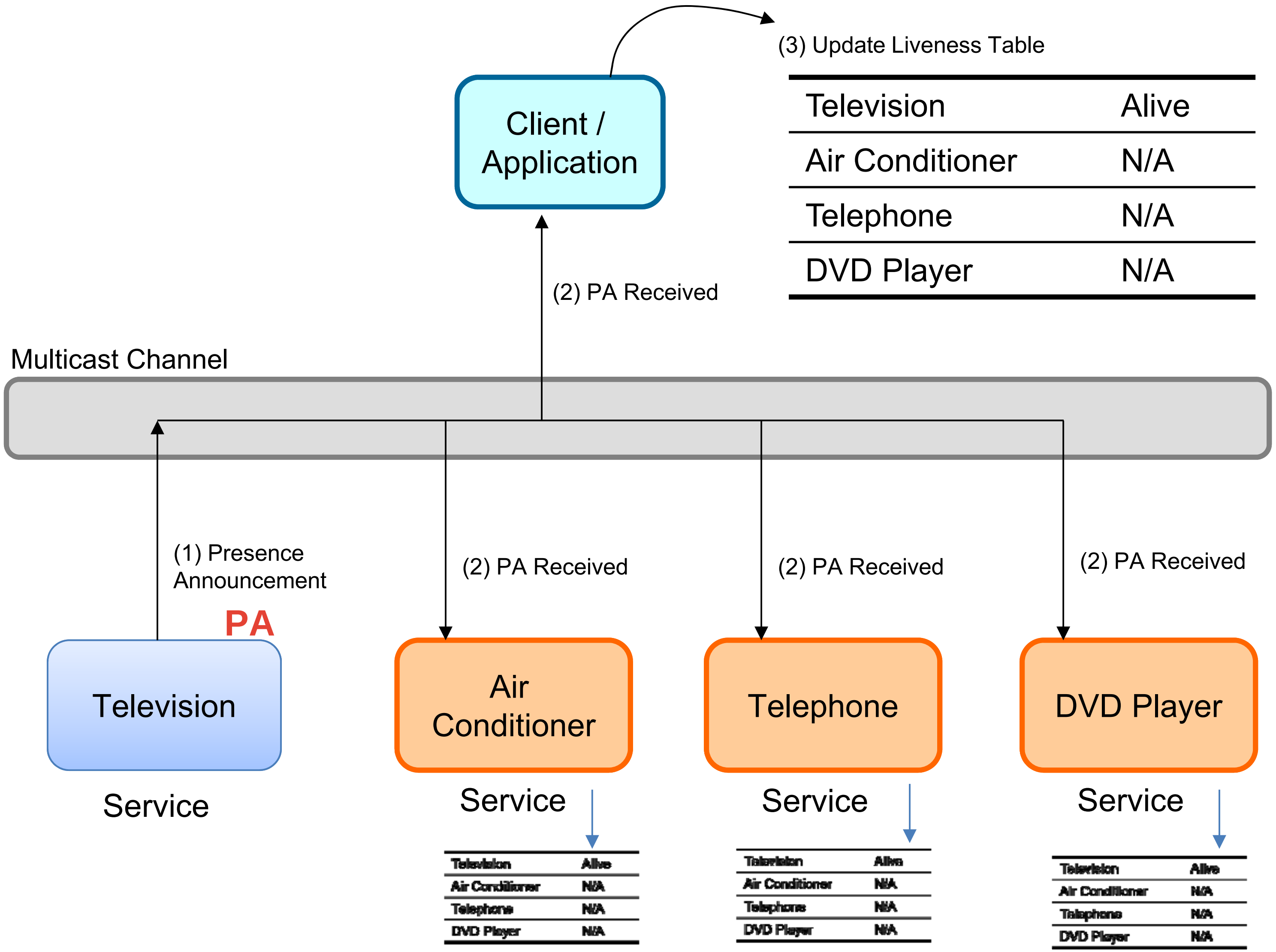
https://river.apache.org/

- a network architecture for the construction of distributed systems in the form of modular co-operating services
- Originally developed by Sun Microsystems (1998)



Lookup Service
(6) Lookup by using ServiceRegistrar
(7) Get the service proxy
(3) Register by using ServiceRegistrar
(4) Find Lookup Service
(5) Get ServiceRegistrar
(1) Find Lookup Service
(2) Get ServiceRegistrar
Client
(8) Invoke service through service proxy
Jini Service

Non-Directory-based



Television	Alive
Air Conditioner	N/A
Telephone	N/A
DVD Player	N/A

Television	Alive
Air Conditioner	N/A
Telephone	N/A
DVD Player	N/A

Television	Alive
Air Conditioner	N/A
Telephone	N/A
DVD Player	N/A

Television	Alive
Air Conditioner	N/A
Telephone	N/A
DVD Player	N/A

SSDP Announcement

簡單服務發現協定

NOTIFY * HTTP/1.1

NT: urn:schemas-upnp-org:device:DimmableLight:1

USN: uuid:ecd54de1-9008-4df5-b5bb-a0722612afdc::

urn:schemas-upnp-org:device:DimmableLight:1

NTS: ssdp:alive

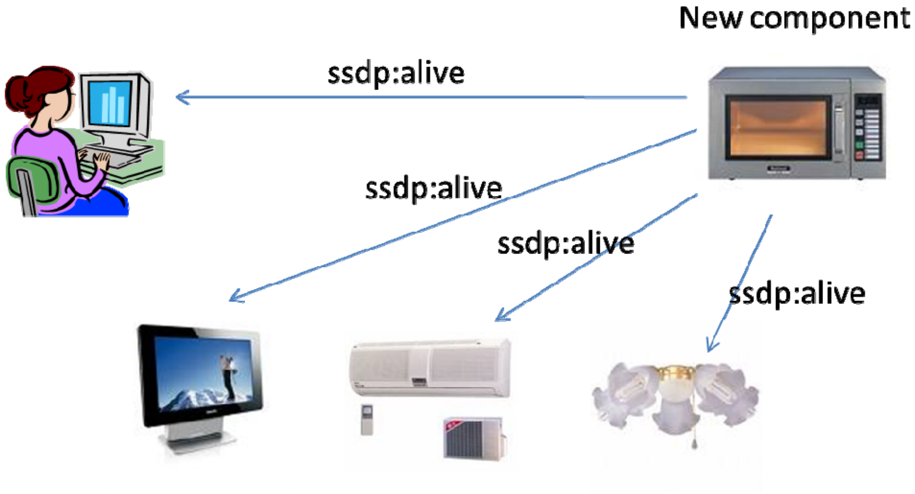
SERVER: Windows NT/5.0, UPnP/1.0

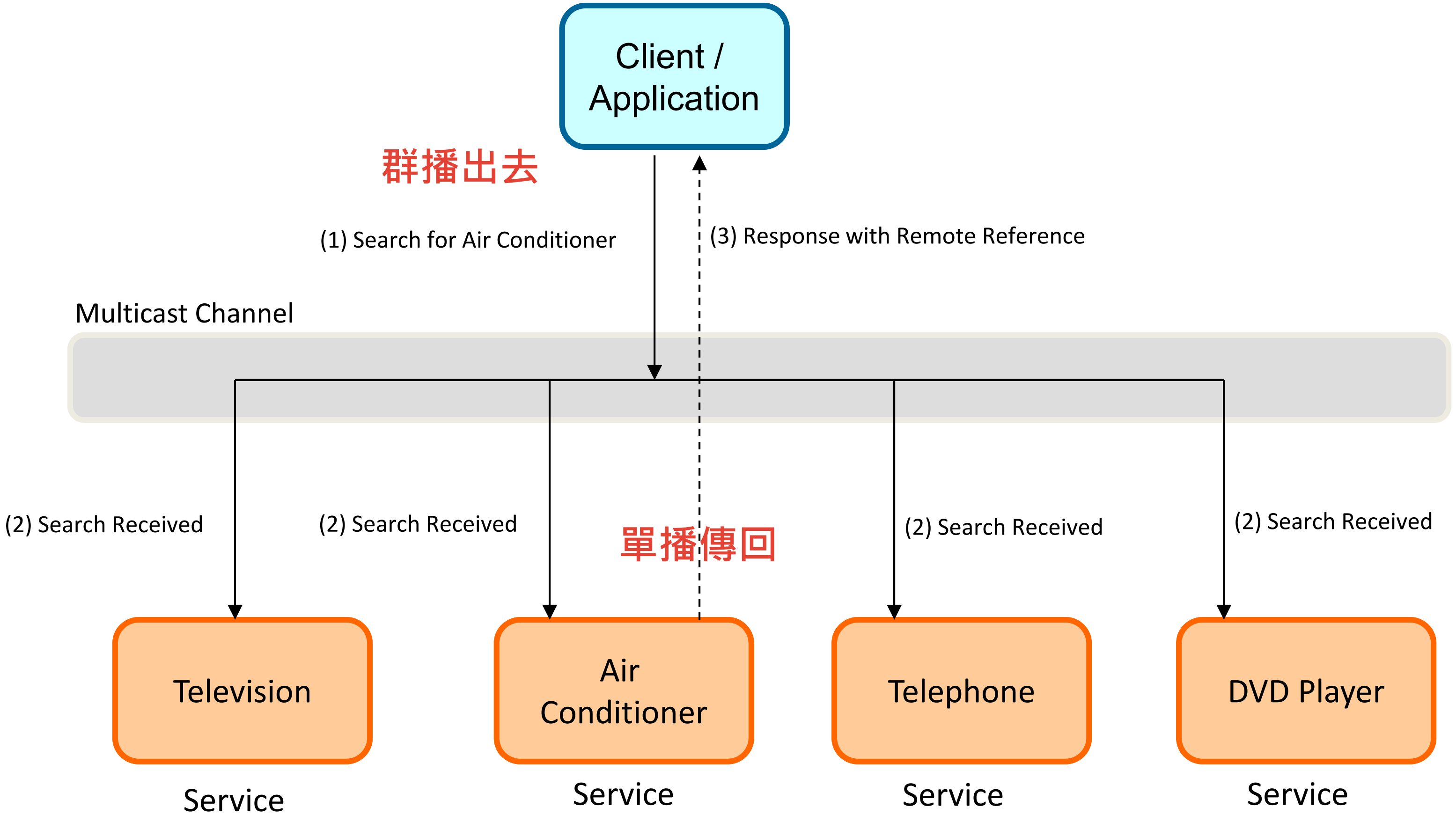
LOCATION: http://192.168.4.37:1810/

HOST: 239.255.255.250:1900 群播位址

CACHE-CONTROL: max-age=900 有效期間

Content-Length: 0




Client / Application
群播出去
(1) Search for Air Conditioner
(3) Response with Remote Reference
Multicast Channel
(2) Search Received
(2) Search Received
單播傳回
(2) Search Received
(2) Search Received
Television
Air Conditioner
Telephone
DVD Player
Service
Service
Service
Service

SSDP Query

M-SEARCH * HTTP/1.1

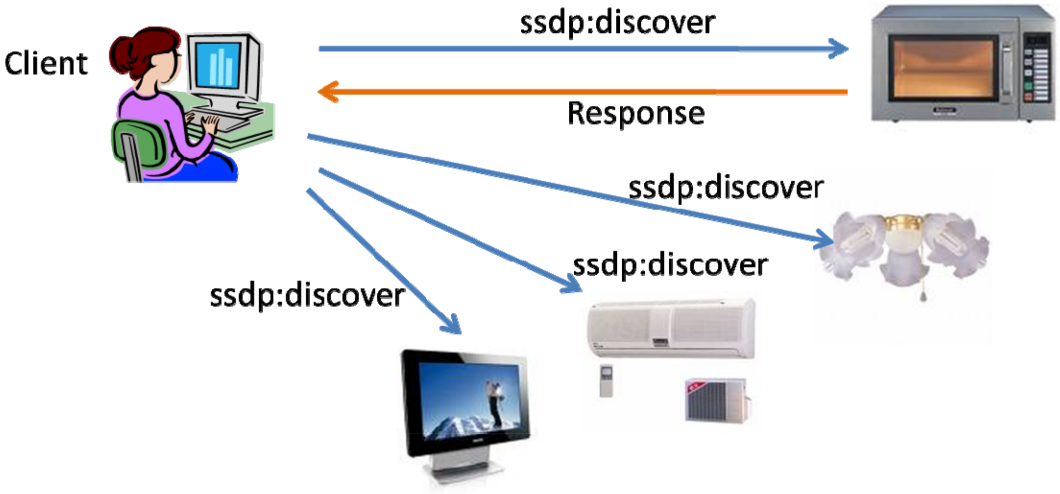
ST: urn:schemas-upnp-org:device:MediaRenderer:1　要搜尋的目標種類

MX: 10　最多等幾秒回應

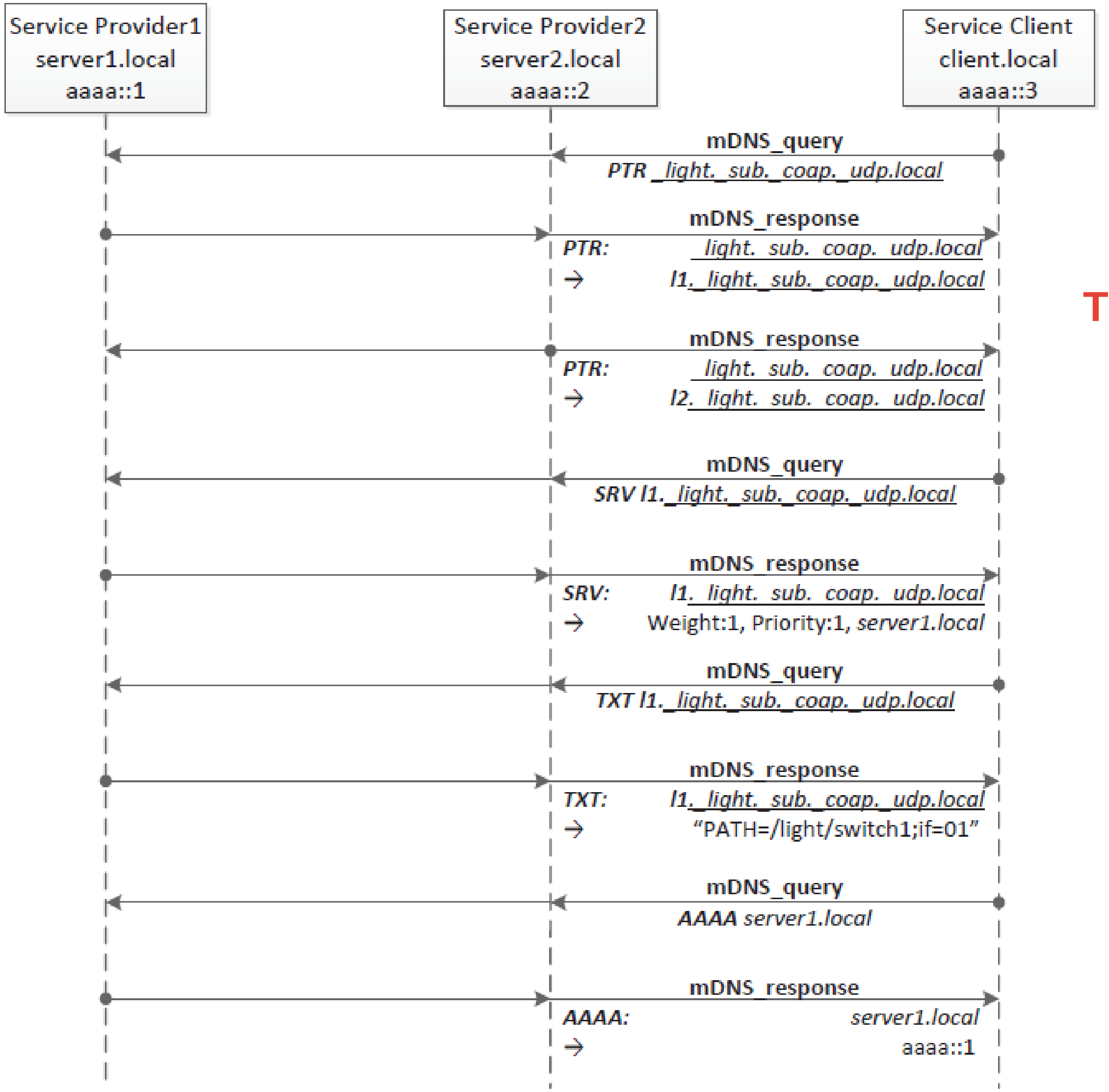
MAN: "ssdp:discover"

HOST: 239.255.255.250:1900　群播位址

Content-Length: 0

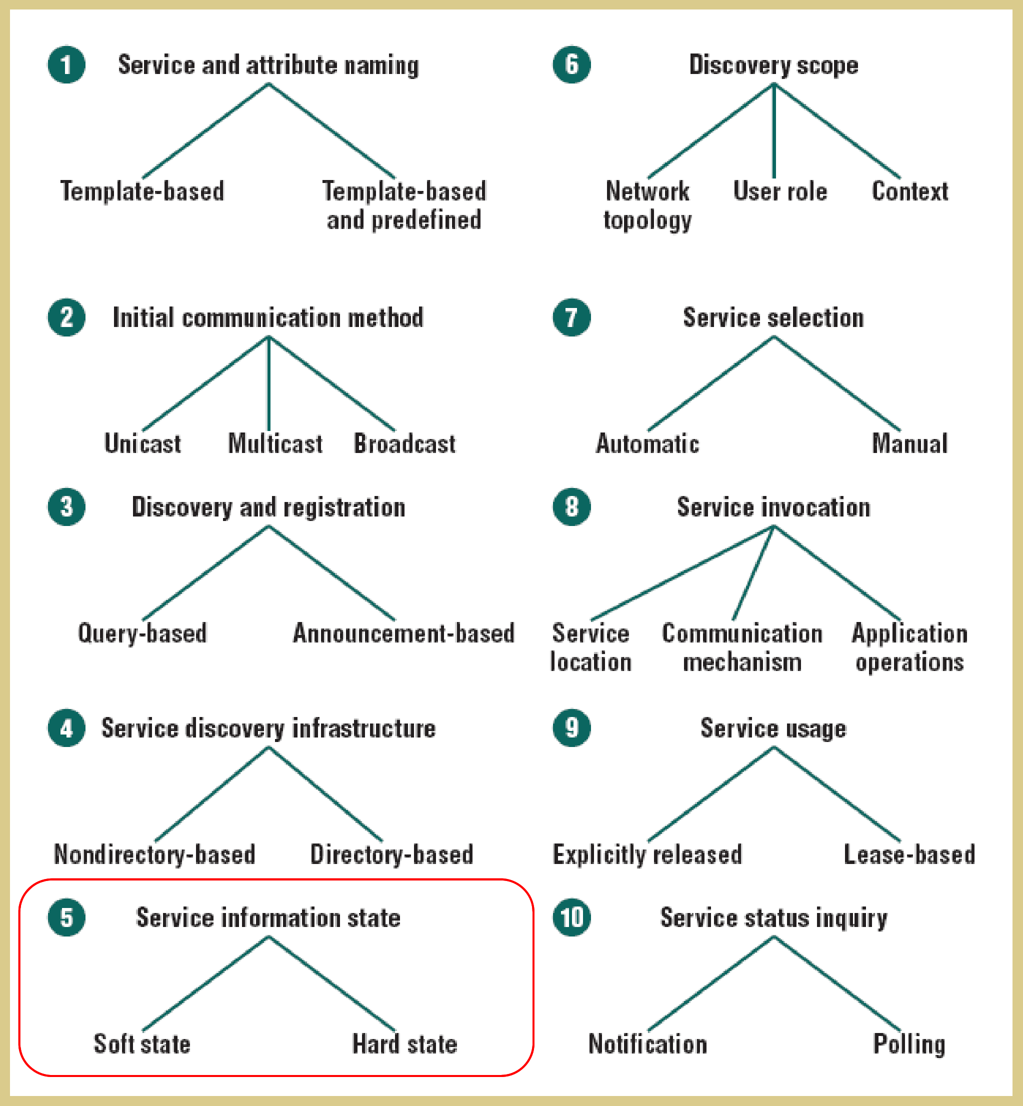


mDNS/DNS-SD


Service Provider1
server1.local
aaaa::1
Service Provider2
server2.local
aaaa::2
Service Client
client.local
aaaa::3
mDNS_query
PTR _light._sub._coap._udp.local
mDNS_response
PTR: _light._sub._coap._udp.local
→ l1._light._sub._coap._udp.local
mDNS_response
PTR: _light._sub._coap._udp.local
→ l2._light._sub._coap._udp.local
mDNS_query
SRV l1._light._sub._coap._udp.local
mDNS_response
SRV: l1._light._sub._coap._udp.local
→ Weight:1, Priority:1, server1.local
mDNS_query
TXT l1._light._sub._coap._udp.local
mDNS_response
TXT: l1._light._sub._coap._udp.local
→ "PATH=/light/switch1;if=01"
mDNS_query
AAAA server1.local
mDNS_response
AAAA: server1.local
→ aaaa::1

PTR 階段：知道服務類型
SRV 階段：詳細資訊
TXT：質性資訊(key = value)
AAAA： ip

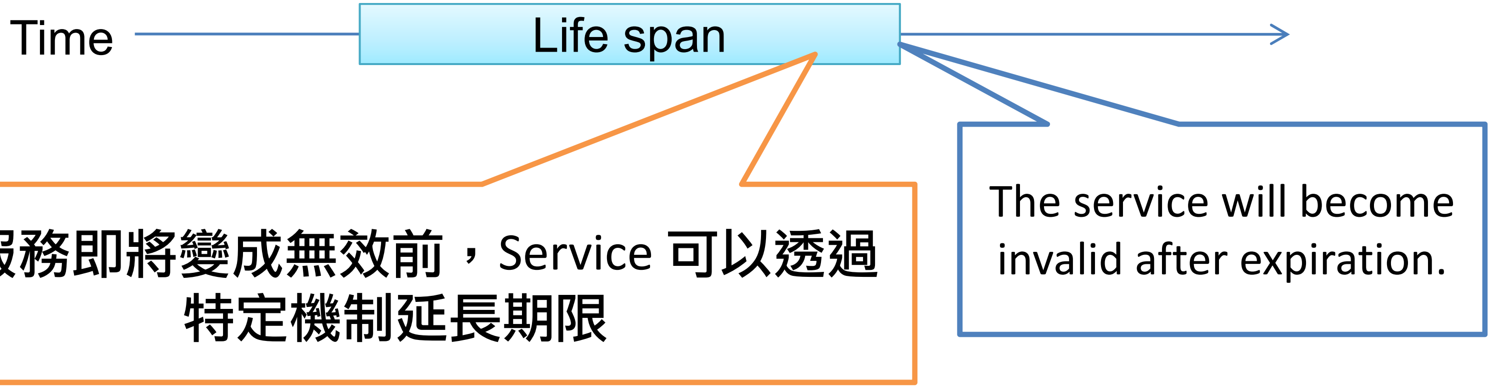
Design Issues



Information state

○ **Soft state**

服務宣告一個短期間，在此一短期間之後，服務就當做無效



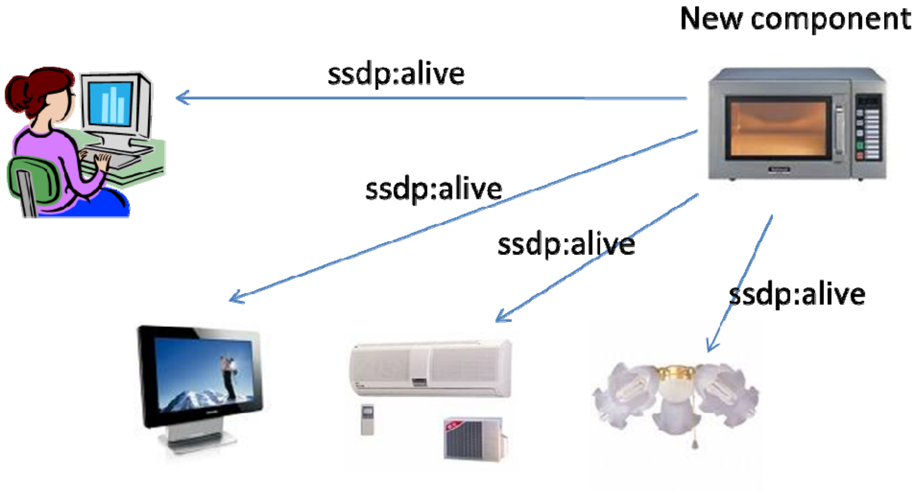
在服務即將變成無效前，Service 可以透過特定機制延長期限

The service will become invalid after expiration.

SSDP Announcement

```
NOTIFY * HTTP/1.1
NT: urn:schemas-upnp-org:device:DimmableLight:1
USN: uuid:ecd54de1-9008-4df5-b5bb-a0722612afdc::
        urn:schemas-upnp-org:device:DimmableLight:1
NTS: ssdp:alive
SERVER: Windows NT/5.0, UPnP/1.0
LOCATION: http://192.168.4.37:1810/
HOST: 239.255.255.250:1900
CACHE-CONTROL: max-age=900
Content-Length: 0
```

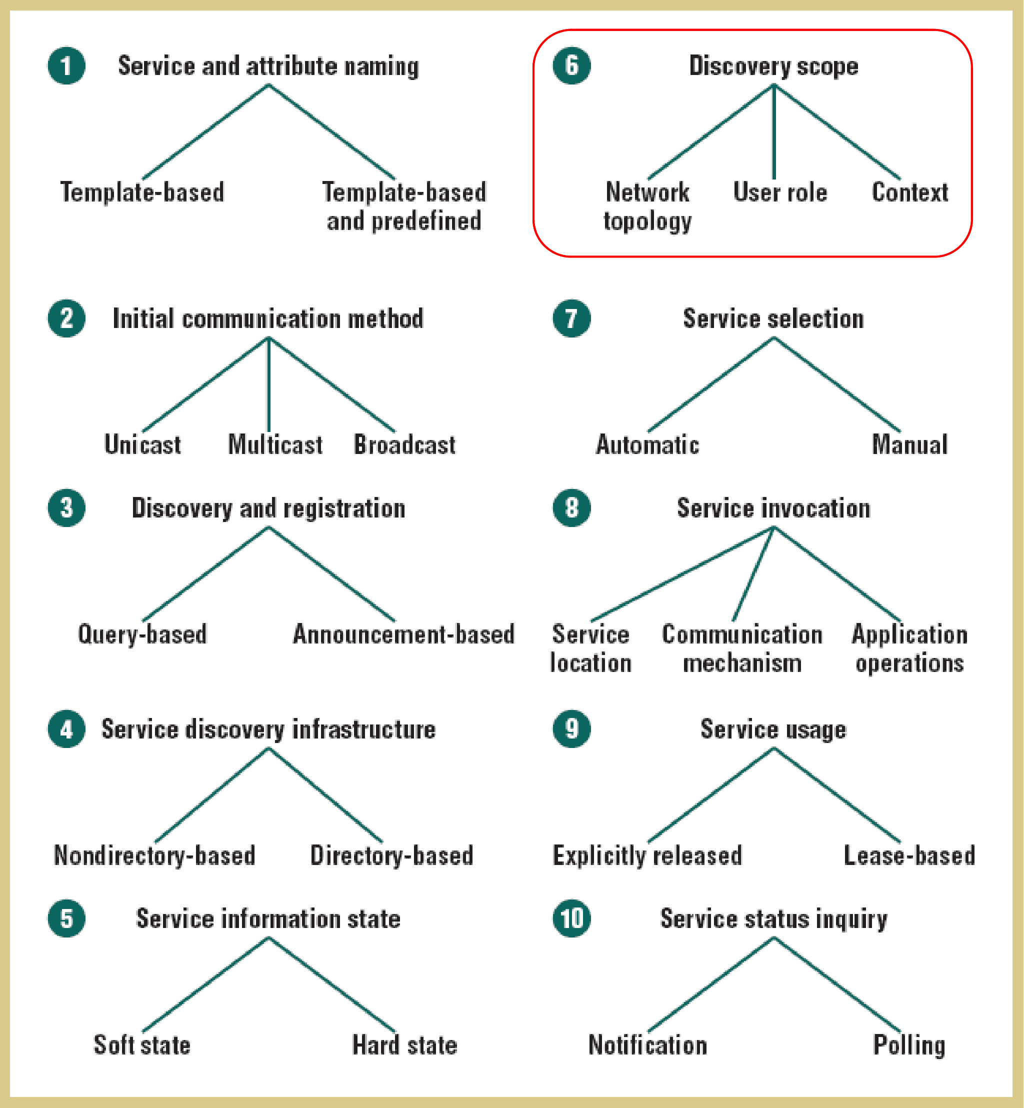
有效期間



- **Hard state**

  必須明確詢問，以確認服務的離開或關閉

Design Issues



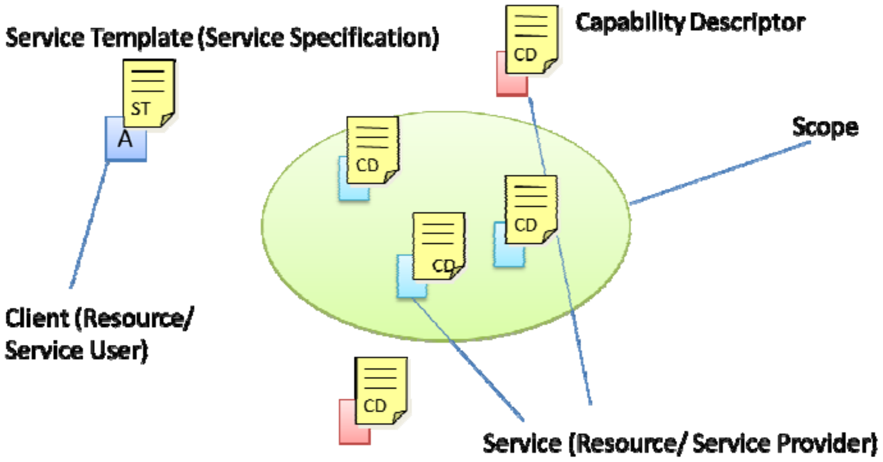
Discovery scope

- **Network topology**

  Ex: LAN

- **User role**

  Lets users control the target domain, but it requires prior knowledge of the target service and its domain

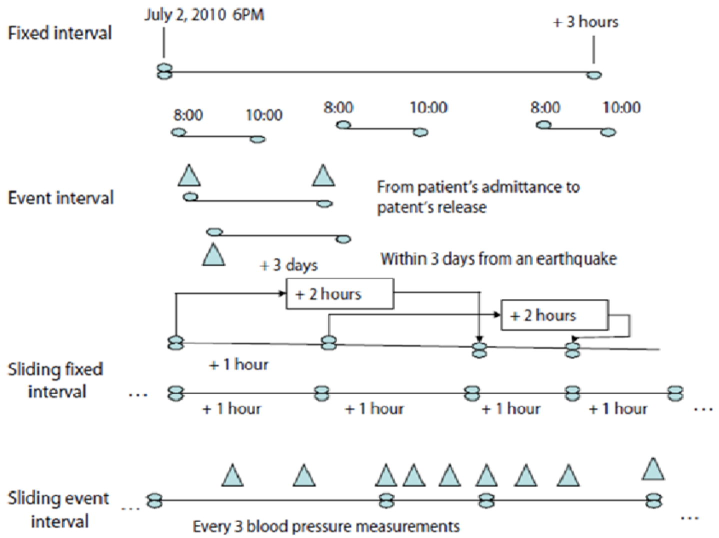

Service Template (Service Specification)
ST
A
Capability Descriptor
CD
CD
CD
CD
CD
Scope
Client (Resource/ Service User)
Service (Resource/ Service Provider)

此處 skip

- ## Context

Temporal, spatial, and user activity information can also help define the discovery scope

和context無關的就不加以搜尋

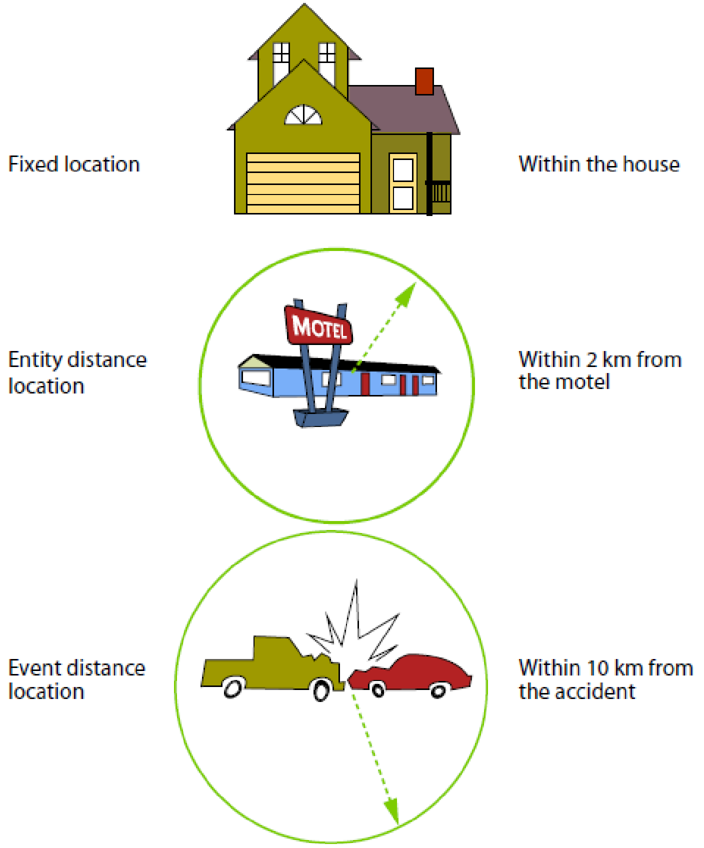


以絕對時間區分

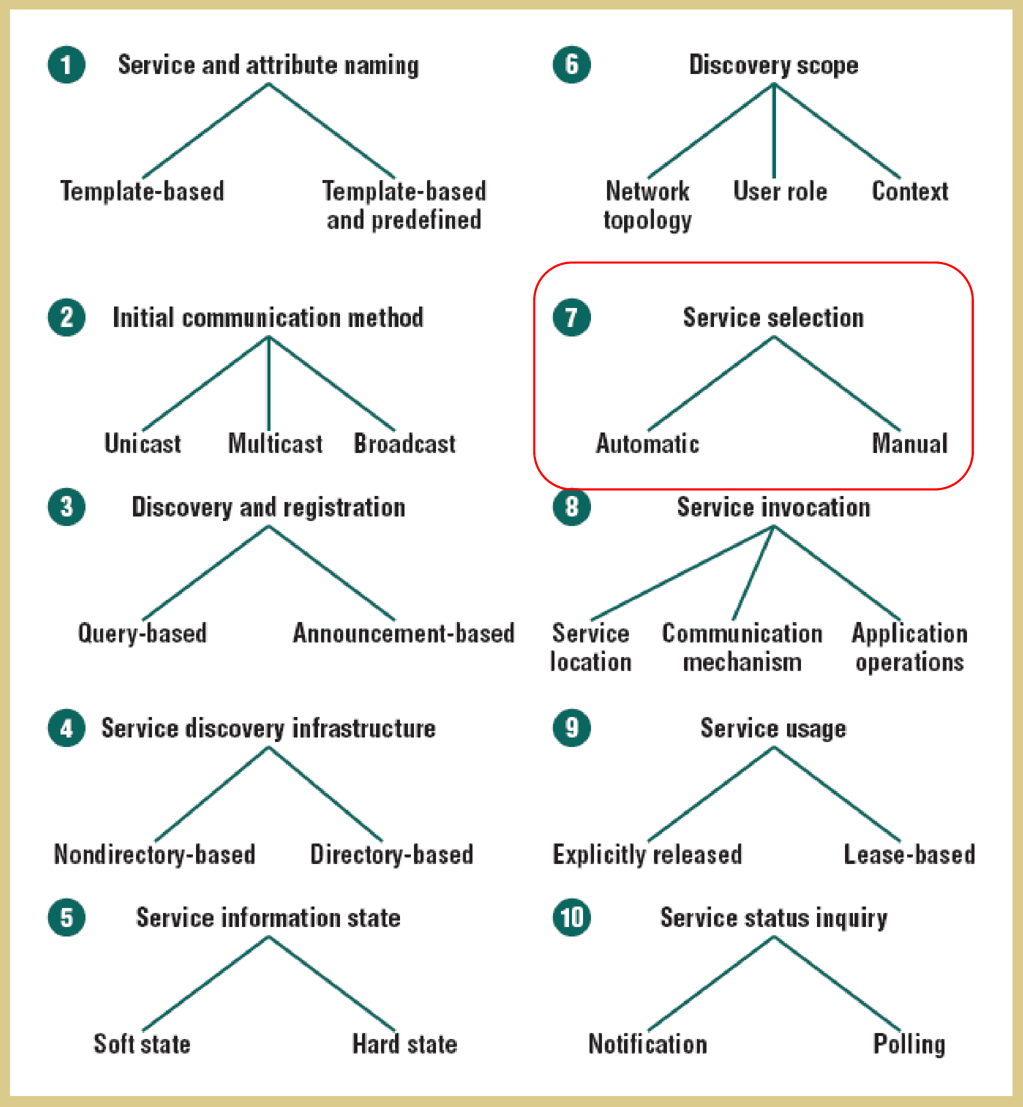
以事件發生區分

以相對時間區分

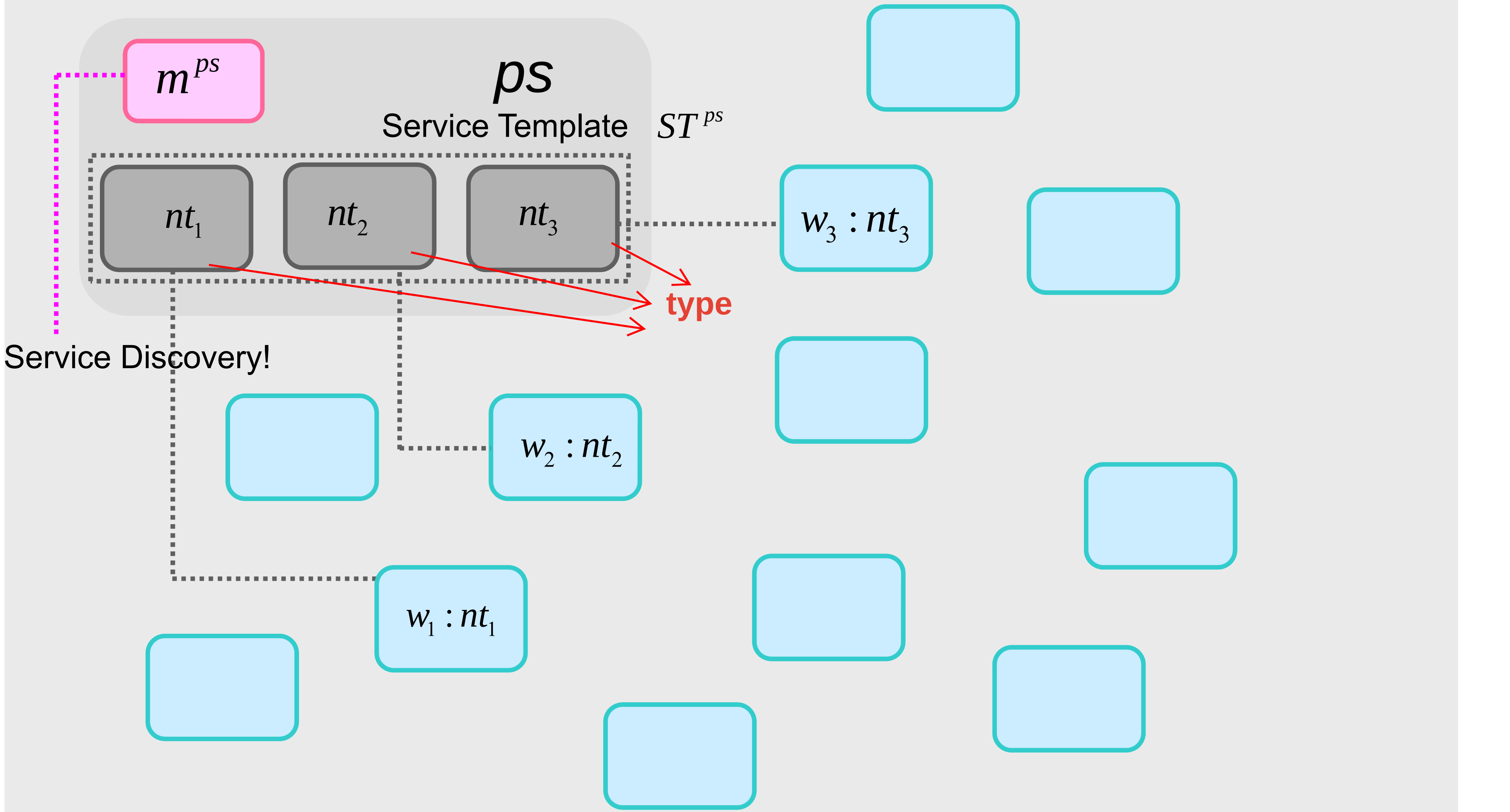
以事件發生次數區分



Design Issues



Example

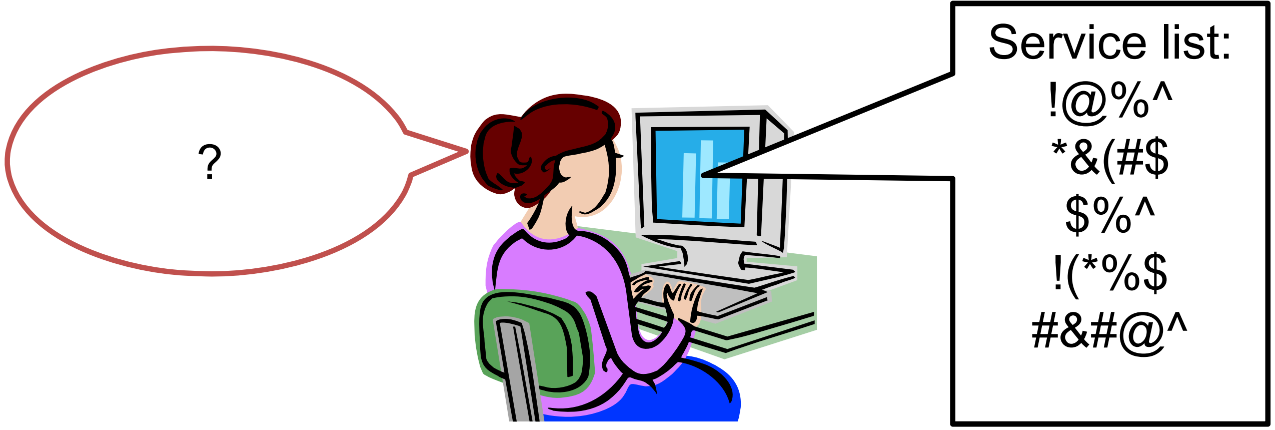

m^{ps}
ps
Service Template
ST^{ps}
nt_1
nt_2
nt_3
type
$w_3 : nt_3$
Service Discovery!
$w_2 : nt_2$
$w_1 : nt_1$

供過於求時，要選哪個

Selection

○ **Manual** user 選擇

Gives user total control. Tedious and user might not know enough information.



Service list:
!@%^
*&(#$
$%^
!(*%$
#&#@^

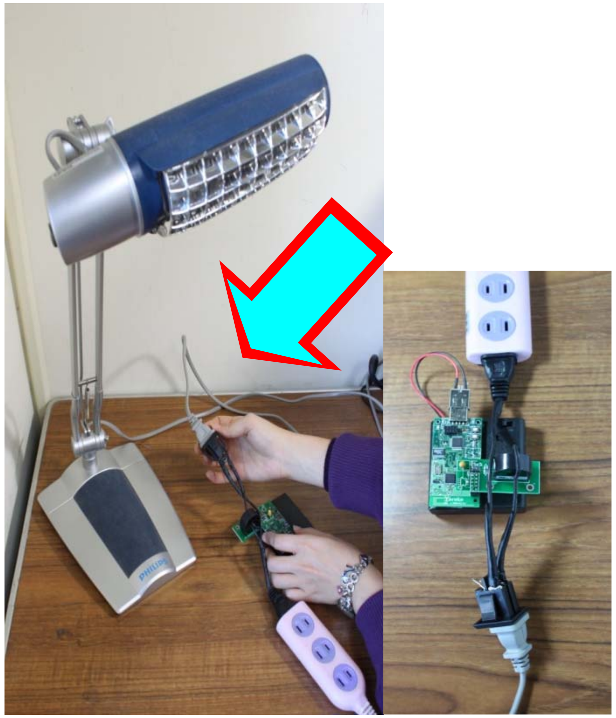
○ **Automatic** 固定配置

The service discovery protocols select the service.

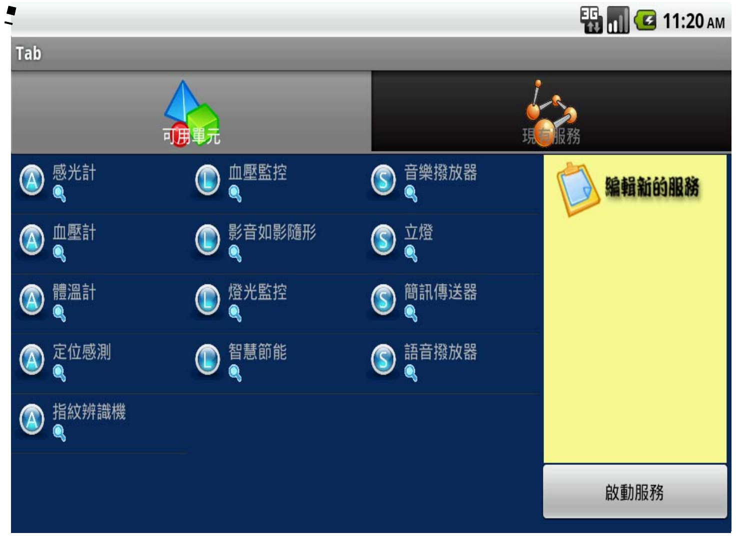
裝置發現及整合

Step1:將基地台插入服務主機

Step2:串接控制裝置於家電上



Step3:手持人性化介面上出現新家電



11:20 AM

Tab

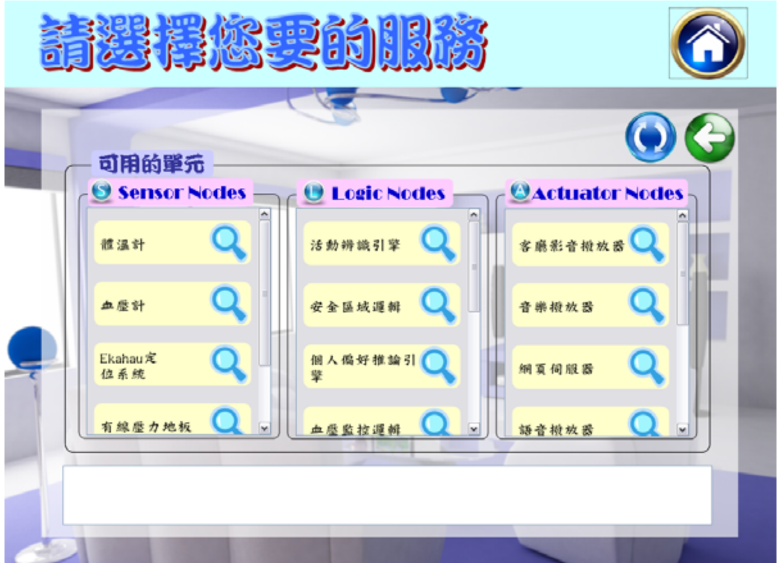
可用單元 | 現[illegible]服務

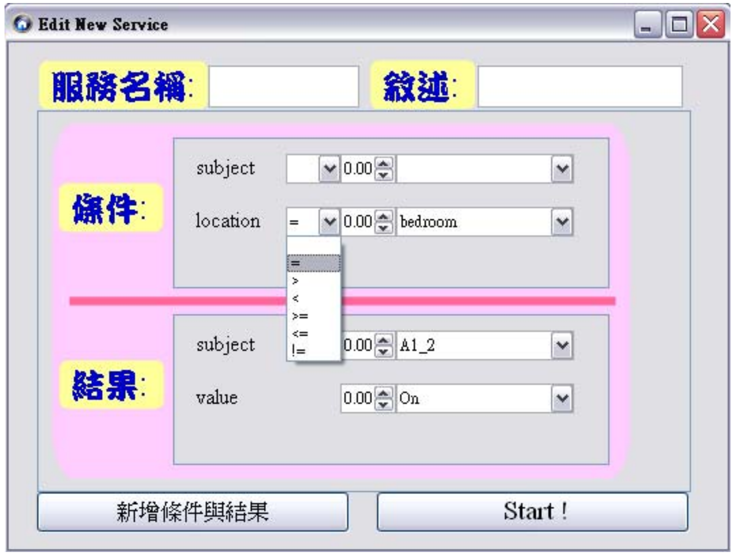
感光計
血壓監控
音樂撥放器
血壓計
影音如影隨形
立燈
體溫計
燈光監控
簡訊傳送器
定位感測
智慧節能
語音撥放器
指紋辨識機

編輯新的服務

啟動服務

Automatic Service Composition




Edit New Service

服務名稱:

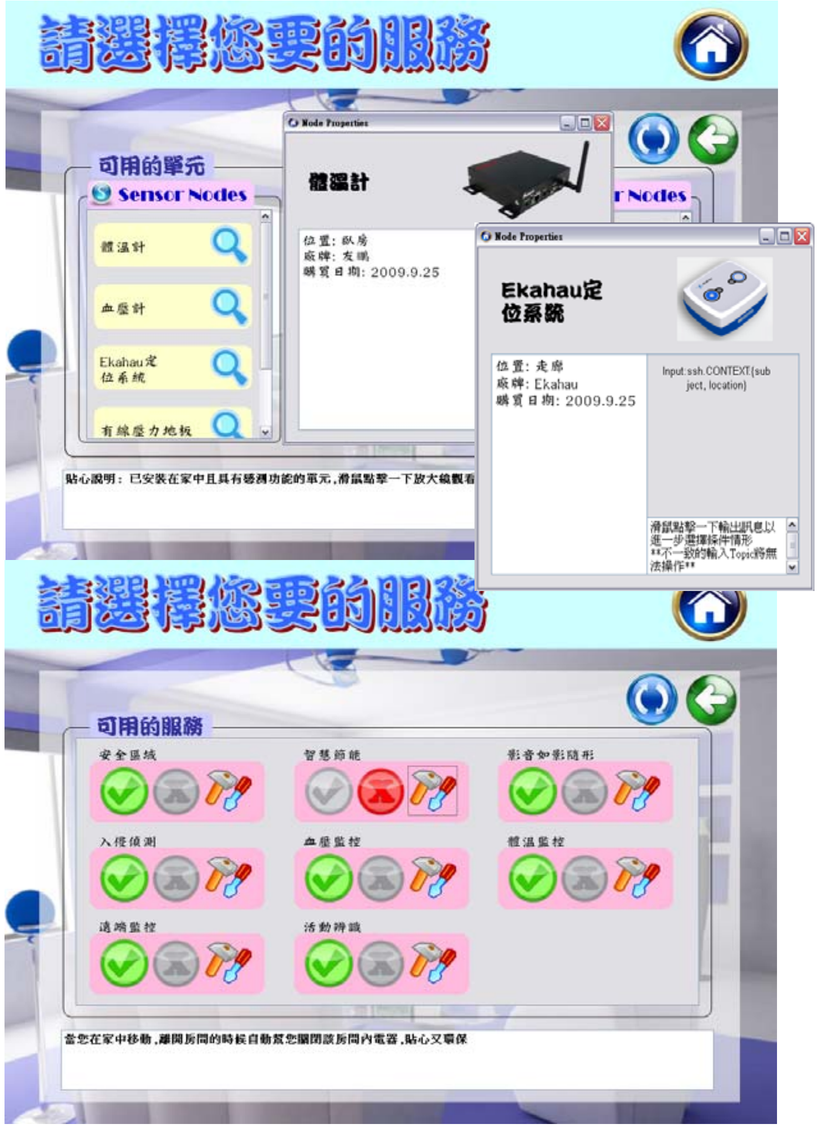
敘述:

條件:

subject		0.00	
location	=	0.00	bedroom

結果:

subject	0.00	A1_2
value	0.00	On



貼心說明：已安裝在家中且具有感測功能的單元,滑鼠點擊一下放大鏡觀看

Node Properties

體溫計

位置: 臥房
廠牌: 友鴻
購買日期: 2009.9.25

Node Properties

Ekahau定位系統

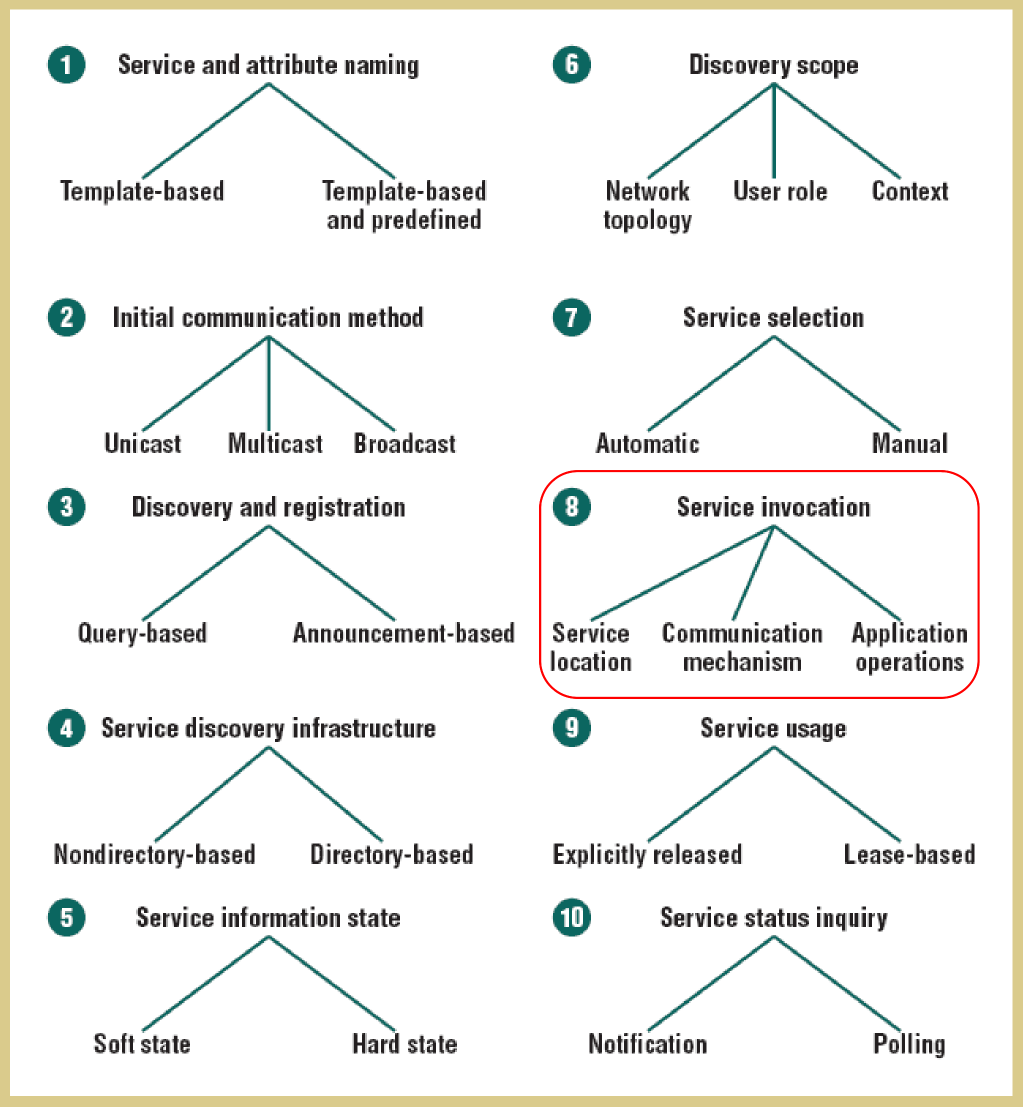
位置: 走廊
廠牌: Ekahau
購買日期: 2009.9.25

Input:ssh.CONTEXT(subject, location)

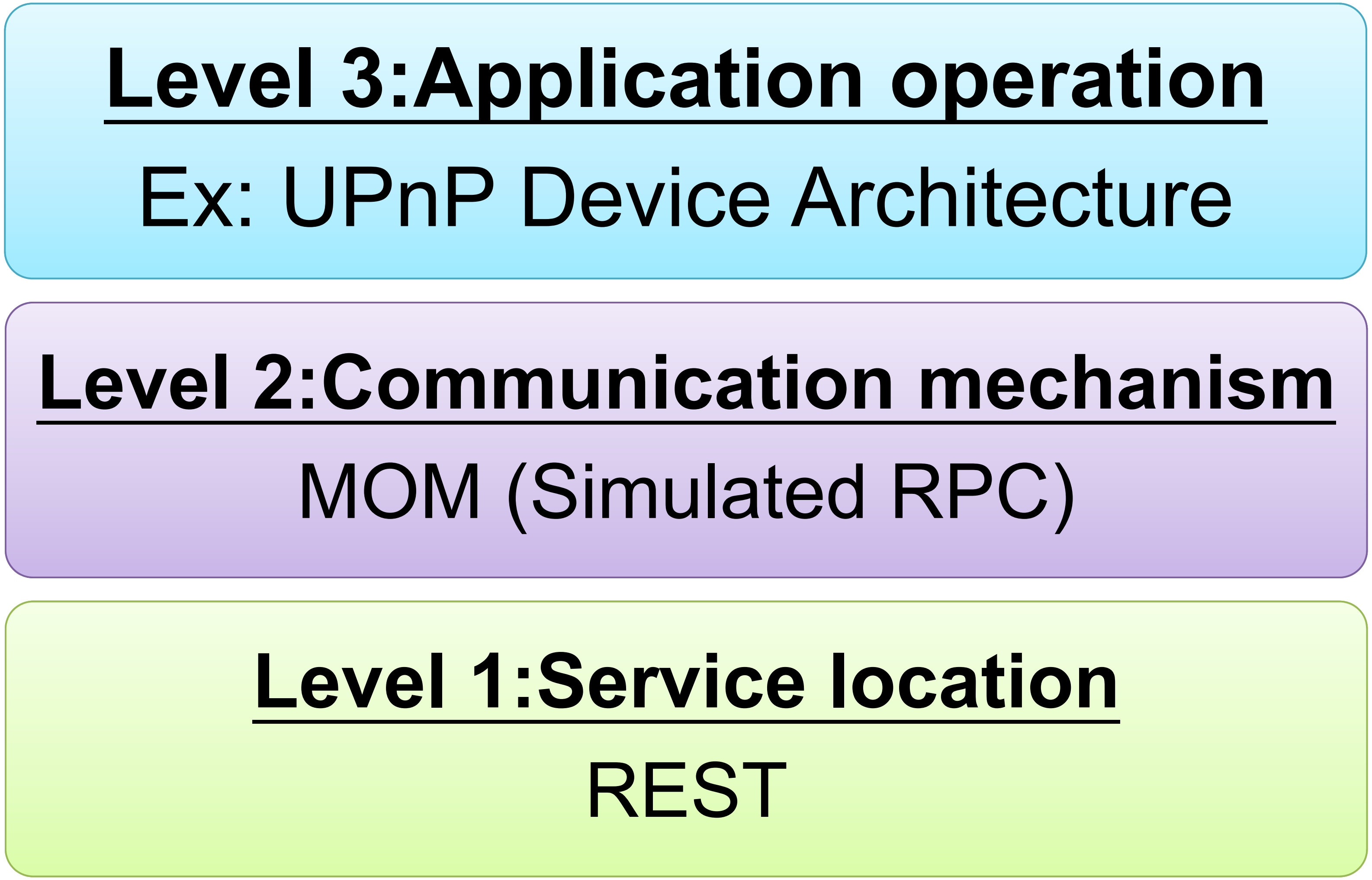
滑鼠點擊一下輸出訊息以進一步選擇條件情形
不一致的輸入Topic將無法操作

當您在家中移動,離開房間的時候自動幫您關閉該房間內電器,貼心又環保

Design Issues



Service invocation



Level 3:Application operation

Ex: UPnP Device Architecture

Level 2:Communication mechanism

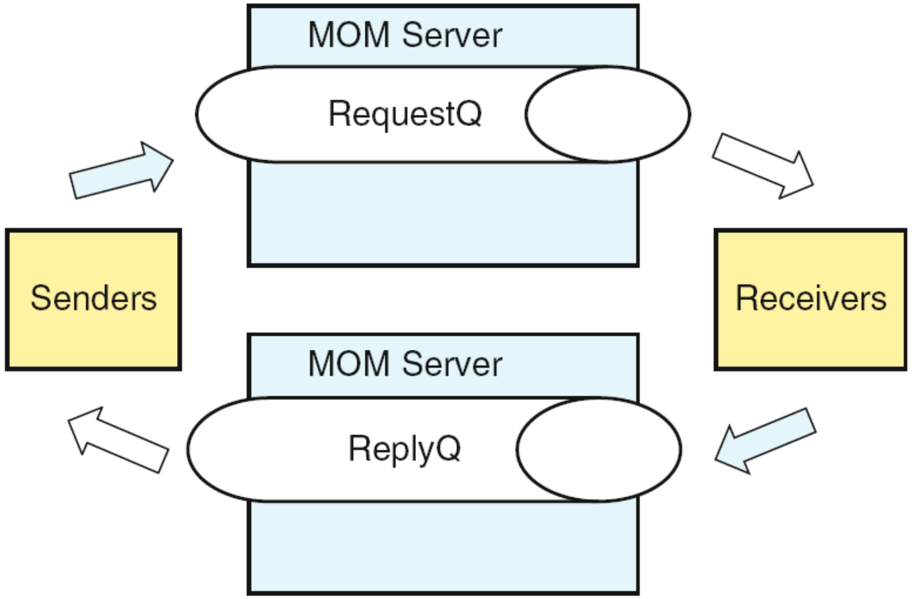
MOM (Simulated RPC)

Level 1:Service location

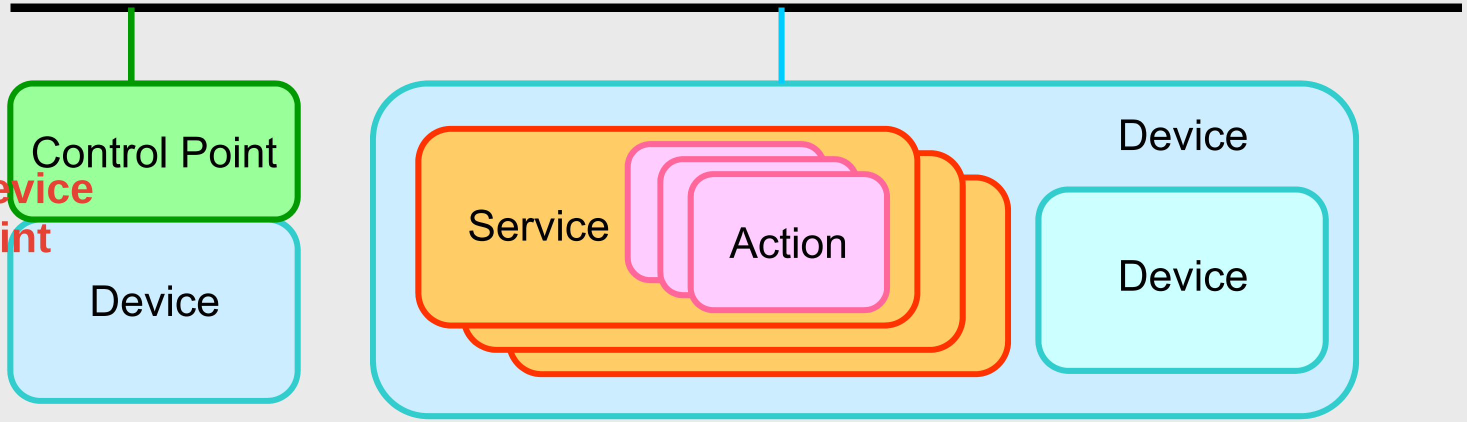
REST

Level 2: Communication Mechanism

- Ex: Simulated RPC in MOM
  - MOM can also be used for synchronous communications
  - Frequently used in enterprise systems to replace conventional



Level 3: Application Operation



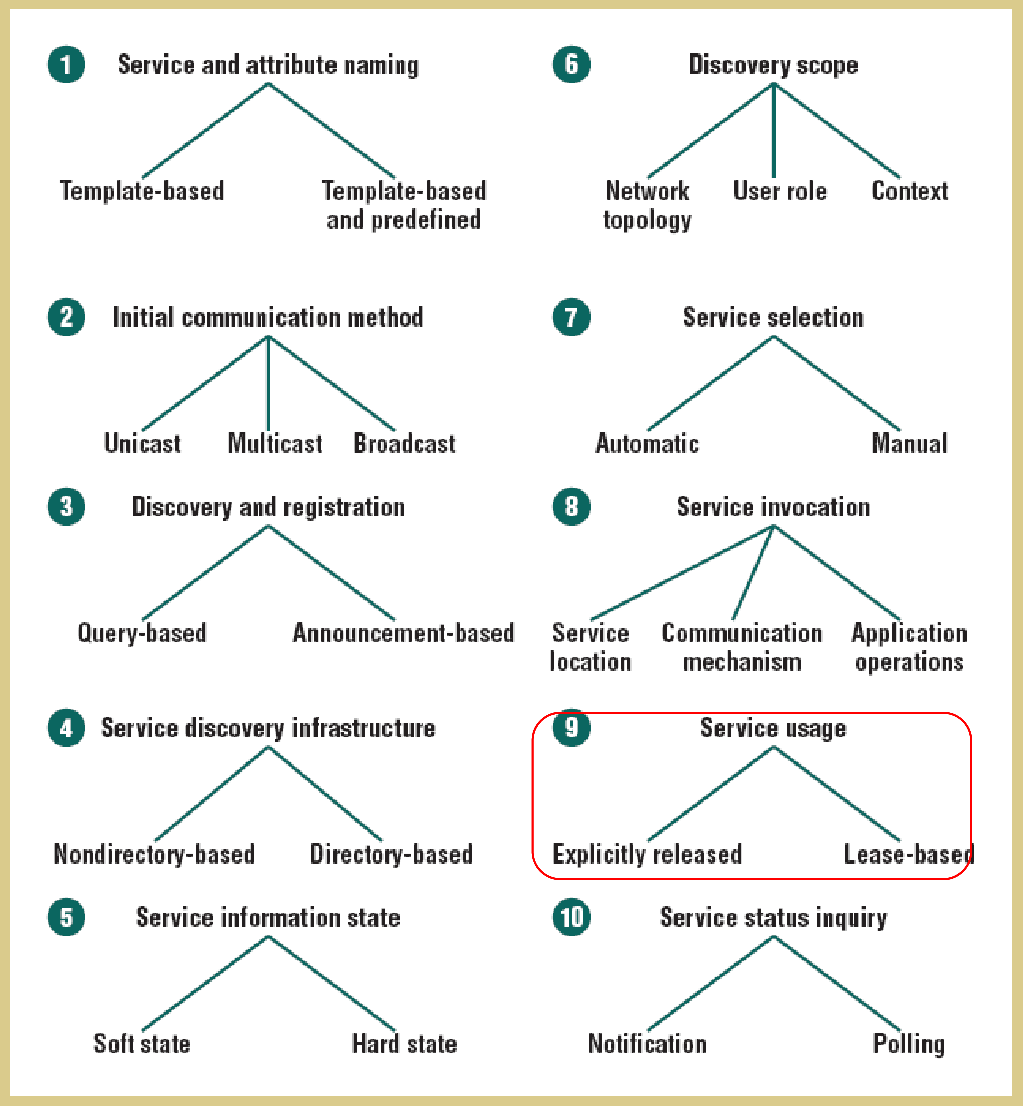
可以呼叫別人的 device
叫做 control point

Level 3: Application Operation

```
POST /_urn-schemas-upnp-org-service-ConnectionManager_control HTTP/1.1
SOAPACTION: "urn:schemas-upnp-org:service:ConnectionManager:1#
                    GetProtocolInfo"
CONTENT-TYPE: text/xml; charset="utf-8"
HOST: 192.168.4.100:1123
Content-Length: 294

<?xml version="1.0" encoding="utf-8"?>
<s:Envelope s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"

xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
  <s:Body>
    <u:GetProtocolInfo xmlns:u="urn:schemas-upnp-
org:service:ConnectionManager:1" />
  </s:Body>
</s:Envelope>
```

```
HTTP/1.1 200 OK
EXT:
CONTENT-TYPE: text/xml; charset="utf-8"
SERVER: Windows NT/5.0, UPnP/1.0
Content-Length: 638

<?xml version="1.0" encoding="utf-8"?>
<s:Envelope s:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
               xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
  <s:Body>
    <u:GetProtocolInfoResponse xmlns:u="urn:schemas-upnp-org:service:ConnectionManager:1">
      <Source />
      <Sink>http-get:*:audio/mpegurl:*,http-get:*:audio/mp3:*,http-get:*:audio/mpeg:*,http-get:*:audio/x-ms-wma:*,http-get:*:audio/wma:*,http-get:*:audio/mpeg3:*,http-get:*:video/x-ms-wmv:*,http-get:*:video/x-ms-asf:*,http-get:*:video/x-ms-avi:*,http-get:*:video/mpeg:*</Sink>
    </u:GetProtocolInfoResponse>
  </s:Body>
</s:Envelope>
```

Service discovery design issues

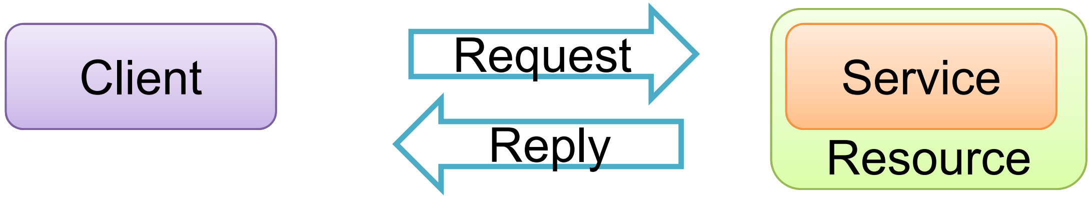


此 part skip

Usage

○ **Explicitly released**

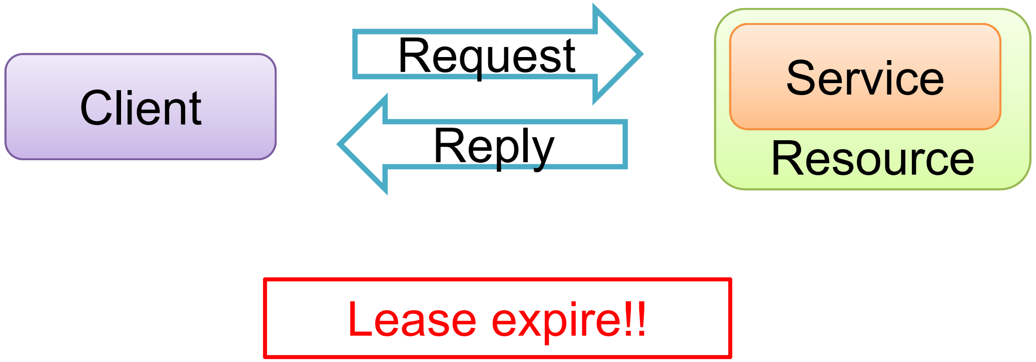
A client must explicitly release a service's resource once service usage is granted.



When a client crashes,
the resource can't be released !!

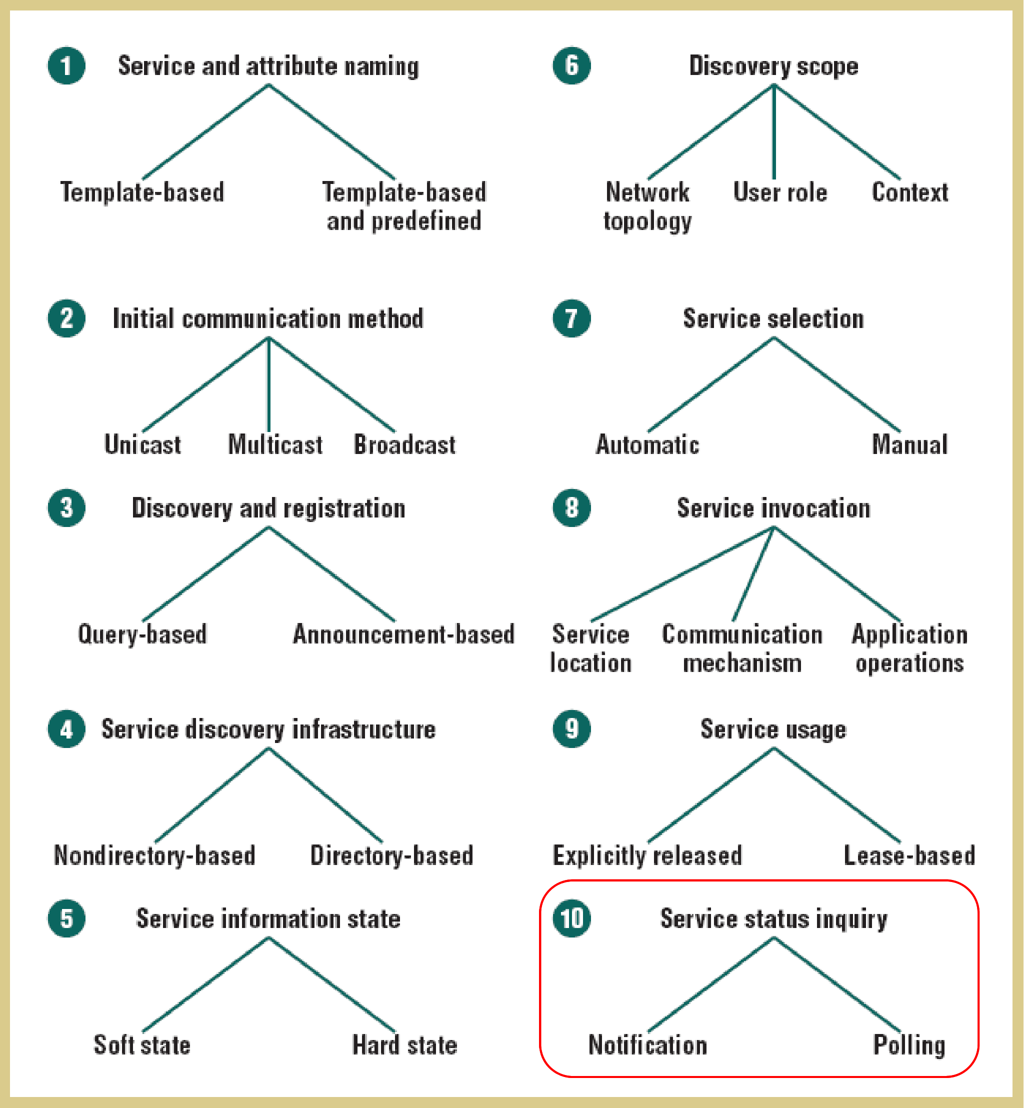
- **Lease-based**

A client and a service negotiate a service usage period, which the client can later cancel or renew. Resources will be reclaimed when leases expire.



Lease-based service usage handles dynamic conditions better in pervasive computing environments.

Design Issues



Status Inquiry

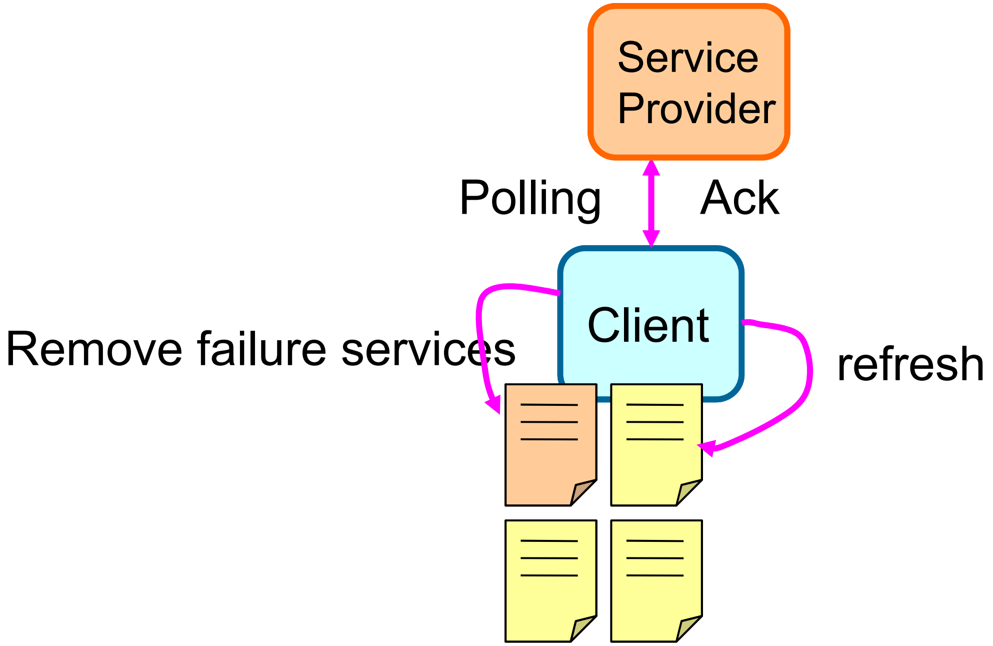
必考

- **Polling**

SP 一直發出搜尋指令，如果裝置存在就會 respond

A client can keep up with a service’s events or status by polling it periodically.

(Case: SSDP M-Search)



必考

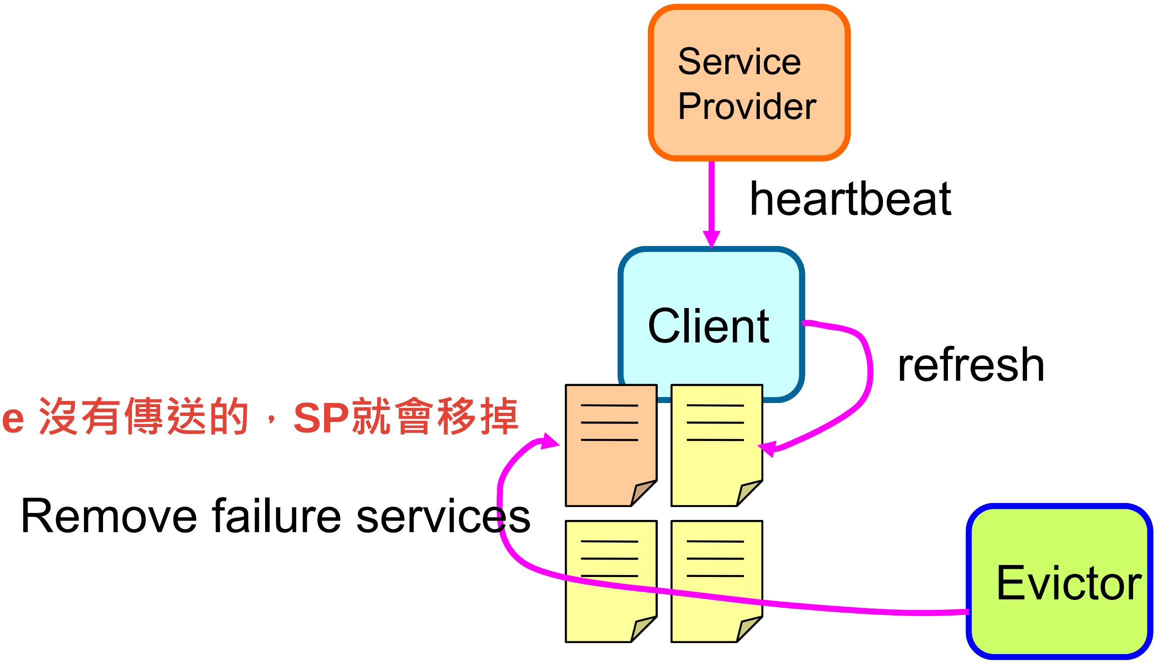
○ Notification (Heartbeat)

(Case: SSDP Notify)

裝置固定時間單向傳送訊息給 SP

Heartbeat

Device 沒有傳送的，SP就會移掉



Device 多久時間回傳一次 => Eviction Period(EP)
如果 Device 已經死了，SP 要什麼時候知道

EP：每次檢查 Heartbeat 的時間
HBP： Heartbeat 的間隔

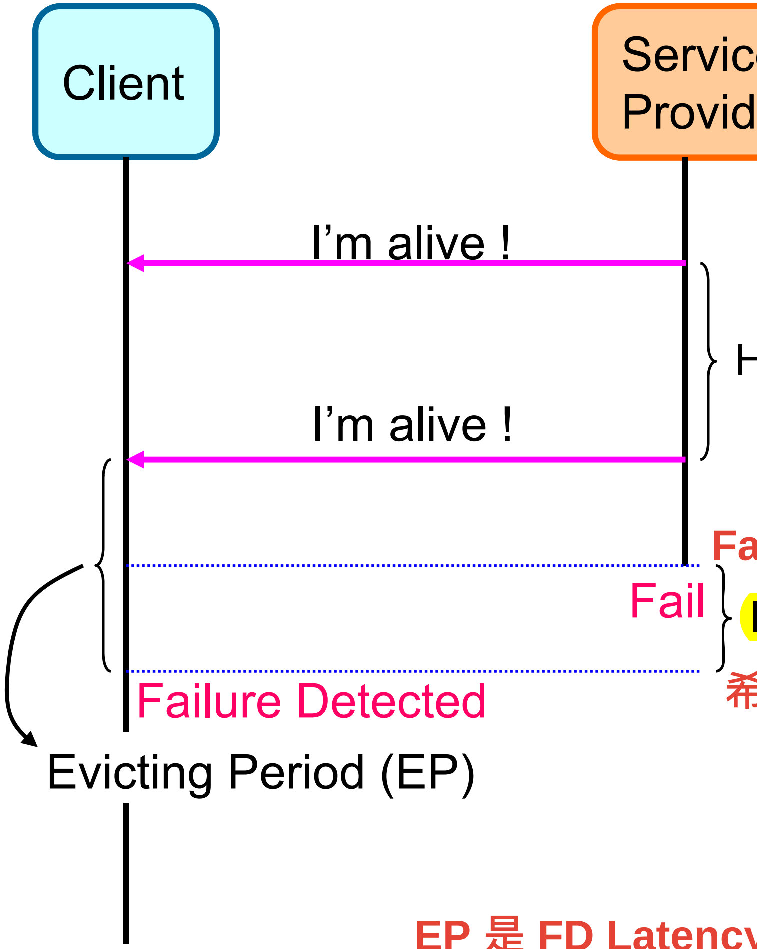
Heartbeat

EP > FD Latency

EP >= HBP

When EP < HBP :
the provider is constantly considered failed!

EP：SP檢查 Client，會刪除的時間
HBP：Client 回傳的時間

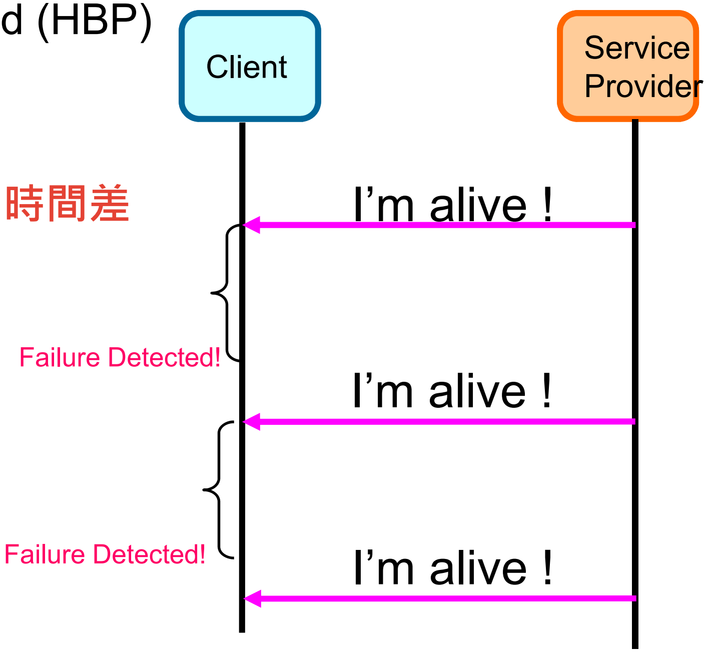


Heartbeat Period (HBP)

Fail 到 Detect 的時間差

FD Latency

希望越小越好

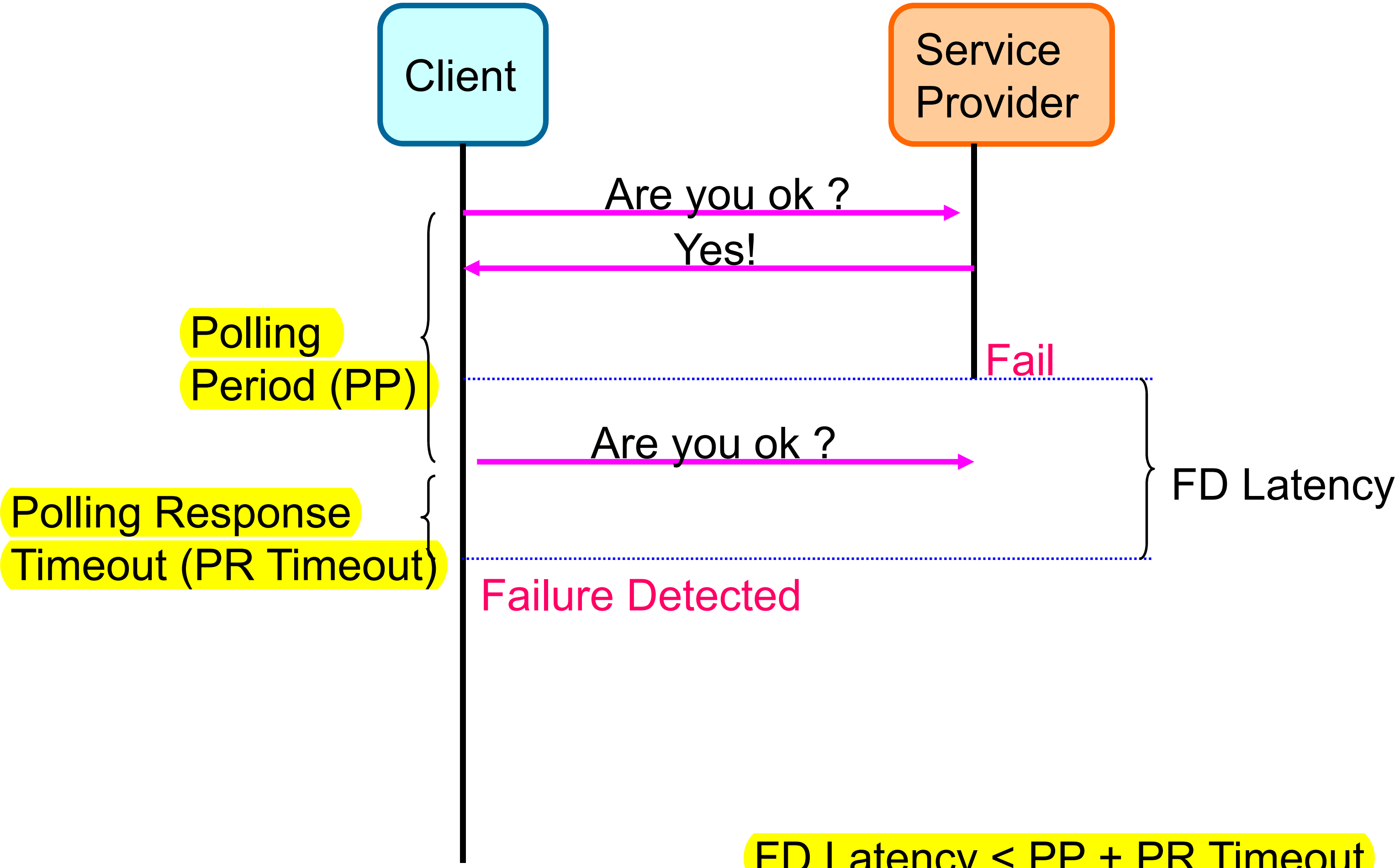


EP 是 FD Latency 的上限

必考

Polling

必考



FD Latency < PP + PR Timeout

Polling雖然一次要二個network access，但可以由Client自行控制頻率

FD Latency is Significant!

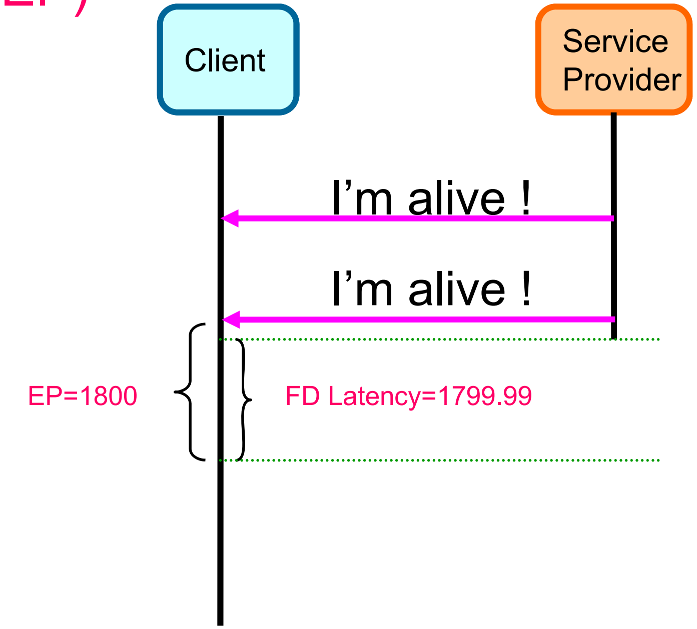
○ The FD Latencies of existing Discovery Protocols are high :

EP 不會太久
希望不要太常點名

Example:

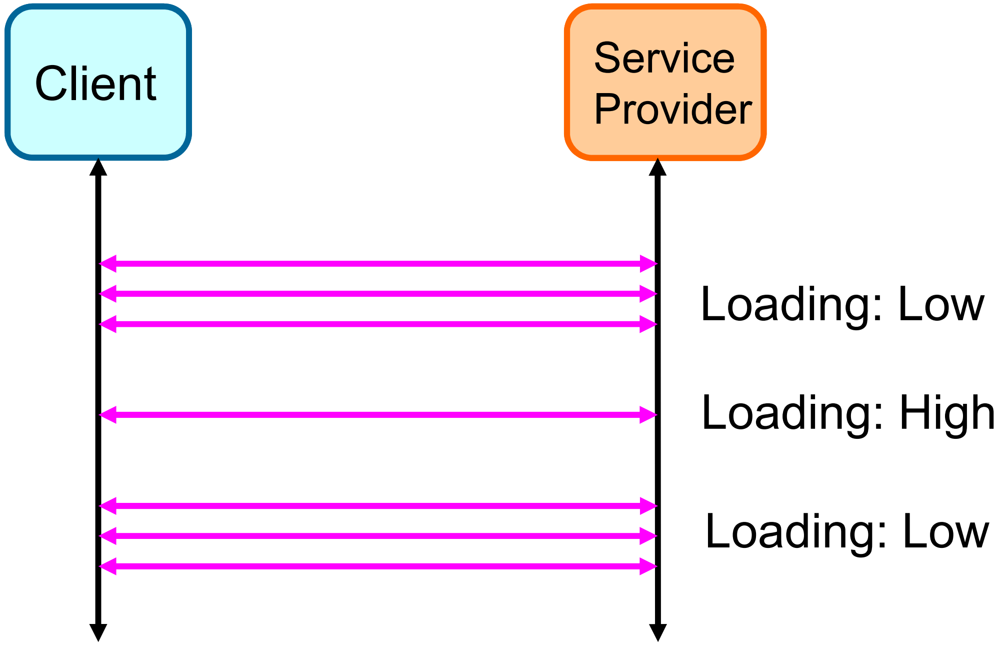
For Heartbeat, FD Latency < Eviction Period (EP)

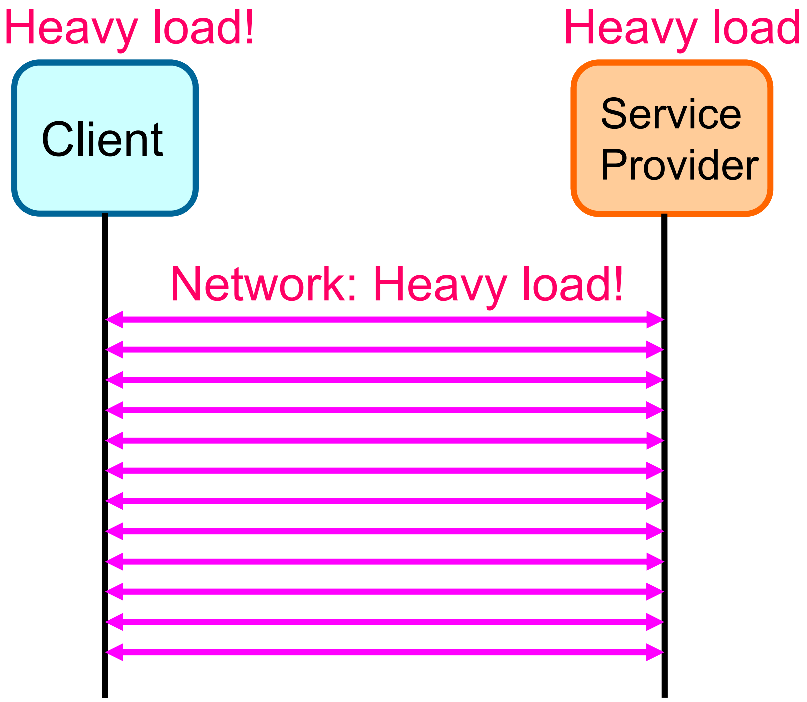
- SSDP / UPnP: EP=1800s (0.5 hrs)
- Rendezvous: EP=7200s (2hrs)
- SLP: EP=64800s (18hrs)
- Jini: EP=120s (2min)



The Trade-Offs

- If the EP or PP too short may cause:
  - Network flooding
  - Heavy loading of services


Client
Service Provider
Loading: Low
Loading: High
Loading: Low


Heavy load!
Heavy load
Client
Service Provider
Network: Heavy load!