Indirection

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Indirection:

rather than reference an entity directly, reference it (indirectly) via another entity, which in turn can or will access the original entity

“Every problem in computer science can be solved by adding another level of indirection”

-- Butler Lampson
**Multicast: one sender to many receivers**

- **Multicast**: act of sending datagram to multiple receivers with single “transmit” operation
- **Question**: how to achieve multicast?

![Multicast network](image)

Network multicast
- routers actively participate in multicast, making copies of packets as needed and forwarding towards multicast receivers

**Internet Multicast Service Model**

- **Multicast group concept**: use of *indirection*
  - Host addresses IP datagram to multicast group
  - Routers forward multicast datagrams to hosts that have “joined” that multicast group
Multicast via Indirection: why?

- Naming and forwarding in IP tailored for point-to-point communication
- Indirection
  - Provides flexible naming
  - Decouples sender from receivers (and their joins and leaves)

Mobility and Indirection

How do you contact a mobile friend?

Consider friend frequently changing addresses, how do you find her?

- search all phone books?
- call her parents?
- expect her to let you know where he/she is?

I wonder where Alice moved to?
**Mobility and indirection:**

- **Situation:**
  - Mobile node moves from network to network
  - Correspondents want to send packets to mobile node

- **Two approaches:**
  - *Indirect routing:* communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *Direct routing:* correspondent gets foreign address of mobile, sends directly to mobile

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**Mobility: Vocabulary**

- **home network:** permanent “home” of mobile (e.g., 128.119.40/24)
- **home agent:** entity that will perform mobility functions on behalf of mobile, when mobile is remote
- **permanent address:** address in home network, can always be used to reach mobile (e.g., 128.119.40.186)

Mobility: more vocabulary

- **permanent address**: remains constant (e.g., 128.119.40.186)
- **visited network**: network in which mobile currently resides (e.g., 79.129.13/24)
- **care-of-address**: address in visited network (e.g., 79.129.13.2)
- **wide area network**
- **foreign agent**: entity in visited network that performs mobility functions on behalf of mobile.
- **correspondent**: wants to communicate with mobile

Mobility: registration

1. mobile contacts foreign agent on entering visited network
2. foreign agent contacts home agent home: “this mobile is resident in my network”

- **End result**:
  - Foreign agent knows about mobile
  - Home agent knows location of mobile
Mobility via Indirect Routing

1. Correspondent addresses packets using home address of mobile.
2. Home agent intercepts packets, forwards to foreign agent.
3. Foreign agent receives packets, forwards to mobile.
4. Mobile replies directly to correspondent.

Indirect Routing: comments

- Mobile uses two addresses:
  - Permanent address: used by correspondent (hence mobile location is transparent to correspondent)
  - Care-of-address: used by home agent to forward datagrams to mobile
- Foreign agent functions may be done by mobile itself
- Triangle routing: correspondent-home-network-mobile
  - Inefficient when correspondent, mobile are in same network
Indirect Routing: moving between networks

- Suppose mobile user moves to another network
  - Registers with new foreign agent
  - New foreign agent registers with home agent
  - Home agent updates care-of-address for mobile
  - Packets continue to be forwarded to mobile (but with new care-of-address)

- Mobility, changing foreign networks transparent: ongoing connections can be maintained!

Mobility via Direct Routing

1. Correspondent requests, receives foreign address of mobile
2. Correspondent forwards to foreign agent
3. Foreign agent receives packets, forwards to mobile
4. Mobile replies directly to correspondent

Diagram showing the path of packet flow between networks.
Mobility via Direct Routing: comments

- Overcomes triangle routing problem
- Non-transparent to correspondent: correspondent must get care-of-address from home agent
  - What happens if mobile changes networks?

Mobile IP

- RFC 3220
- Has many features we’ve seen:
  - Home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)
- Three components to standard:
  - Agent discovery
  - Registration with home agent
  - Indirect routing of datagrams
Mobility via indirection: why indirection?

- Transparency to correspondent
- “Mostly” transparent to mobile (except mobile must register with foreign agent)
- Transparent to routers, rest of infrastructure
  - Practical concern: if egress filtering is in place in foreign networks (since source IP address of mobile is its home address): spoofing?