Mobility Management (Transport Layer)
Lecture overview

This lecture will explain the concepts and issues in supporting Internet mobility at the transport layer. Mobility extensions of TCP and SCTP will be discussed.
Prerequisite knowledge

- **TCP**
- **SCTP**
- **Text books (late editions of introductory networking)**
  - e.g., Forouzan, TCP/IP Protocol Suite, 3rd or 4th Ed
Topics to be covered

- Layers of TCP/IP protocol suite
- Pros and cons of network-layer mobility
- Transport layer mobility
- Mobility extension of TCP
- Mobility extension of SCTP
Protocol Layers
TCP/IP has 3 loosely-connected protocol layers running on top of physical networking technologies.
Two key requirements of IP mobility

1. **Reachability**: A mobile user must remain reachable at all times via some permanent identifier regardless of its current location (subnet of attachment)

2. **Continuity**: an ongoing communication should not break when the mobile user moves (across subnet boundaries)
Mobile communication with TCP/IP (problems)

- None of the layers was designed for mobility
- **Mobile devices change IP address while crossing subnets**
  - does not remain reachable anymore
- **IP address change breaks transport layer connections**
  - continuity is not protected
- **Application terminates when transport connection breaks**
  - service continuity disrupted
Mobile communication with TCP/IP
possible solutions

- TCP/IP must evolve to support mobility
  - tracking capability must be added to support reachability
  - must support IP handover to deal with IP address change
- Question: which layer(s) should do the job?
- Answer: technically, mobility problem can be solved at any layer, but there will be pros and cons
- So far, we’ve studied network layer solution (mobile IP)
- This lecture will explore transport layer solutions
Mobile IP

**Pros**

- **Solves mobility at the root**
  - IP is the lowest layer in TCP/IP
  - ➞ blanket mobility support to rest of the stack
- **In-built tracking support**
  - via permanent IP address and HA
- **No change to network core**
  - only edge routers (eg home agent) are affected
- **Location privacy** (no route optimisation)
Mobile IP

Cons

- High latency due to triangular routing
  - no route optimisation
- Handoff delay due to registration process
- Need for infrastructure support
  - HA (and FA)
- Hiding mobility from transport layer has its problems
  - may upset congestion control functions
Transport Layer Mobility
What transport layer has to do to support mobility (when network layer does not)

- **Maintain connection continuity** *(IP handoff)*
  - prevent connect break when IP address changes
- **Support reachability** *(IP tracking)*
  - Also known as location management
Supporting reachability

IP tracking or location management

- Transport layer cannot support reachability
  - it must rely on other (network or application) layers

- Application layer is well suited for tracking
  - eg dynamic DNS

Note that reachability support is needed only for communication scenarios where other hosts originate communication to the mobile host (eg, IP Telephony).
Maintaining continuity

IP handoff

- TCP/IP was designed for fixed hosts
  - hosts were not meant to change IP address in the middle of a transport connection
- Traditionally, IP addresses of communicating parties are statically bound to a transport connection
  - binding cannot be changed until transport connection terminates ➔ cannot support handoff
- Dynamic binding required to support handoff
TCP uses a 4-tuple to identify a connection

Mobile initiates a TCP connection to a fixed server to download a web object using HTTP
- TCP connection: (131.5.3.6/16,80,129.3.4.24/16,2110)

Mobile moves and attaches to a different subnet while downloading
- new IP address: 129.3.5.1/16

Mobile has no way of telling server that it has changed IP address

Server continues to send packets to 129.3.4.24/16
- All packets are lost, TCP times out repetitively, and connection is terminated eventually (after 16 timeouts)
Mobility extension of TCP
Dynamic binding in TCP

- Original TCP does not support dynamic binding
  - no recent standard either
- But it is technically possible and can be accomplished in several ways
- Let’s study one method - TCP connection migration
TCP connection migration concept

- TCP is modified to accept request from mobile to change its IP address in the connection ID
- Connection migrates to new IP address
  - other parameters of the connection remain unchanged (eg. no change in congestion control state)
Two new options proposed (similar to SACK options)
- migration-permitted option (3 bytes for insecure version)
- migration option (19 bytes) [ReqNo monotonically increasing; Request is a 64-bit hash similar to Token]

Migration-permitted option

| Kind:15 | Len=3 | Curve=0 |

Migration option

<table>
<thead>
<tr>
<th>Kind:16</th>
<th>Len=19</th>
<th>ReqNo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Token</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Token (cont.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request (cont.)</td>
<td></td>
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</tbody>
</table>
TCP connection migration  
how does it work

- Mobile uses migration-permitted option with SYN during connection establishment and negotiates a TOKEN
- From now on, the connection can be identified by the TOKEN
- When mobile moves to different subnet, it uses migration option and sends a SYN to its peer
- Upon receiving a SYN with migration option, peer replaces old destination IP address with new one in the 4-tuple
  - new IP address is carried in the IP packet header
TCP connection migration
an example

mobile
SYN with mig-permitted option
SYN ACK (carries a TOKEN)
ACK

mobile changes address (enters new subnet)

fixed server

SYN with migrate option
SYN ACK
ACK

Initial connection establishment with 3-way handshake
Replaces old IP address with new one in 4-tuple
Mobility extension of SCTP
SCTP Introduction

- Third transport protocol (after TCP & UDP)
- Internet standard RFC 2960 (released in 2000)
- Introduced mainly to support multimedia
- Two main features are
  - multistreaming (multiple streams in multimedia)
  - multihoming (enhanced reliability)
- A connection in SCTP is called association
Multistreaming

- Single association maintains multiple streams
- Example application: for video IP telephony, voice and video can be sent using different stream identifiers
- Transmission problems in one stream does not affect the other
  - Video may suffer problem, but voice can proceed
Multihoming

- A host may be connected to multiple subnets for reliability reason
- Multiple subnet = multiple IP addresses
- SCTP allows a host to bind multiple IP addresses to a single association
- Must nominate one as primary address
- Primary address is used for all communication
- Other addresses used only if primary address fails
**SCTP packet format**

- 12-byte general header followed by payload
- Payload contains a set of blocks called *chunks*
- Two types of chunks: control and data
- *Control chunks* precedes data chunks
Chunk layout

First 3 fields are common to all chunks; information field depends on the type of chunk.

<table>
<thead>
<tr>
<th>Type (8-bit)</th>
<th>Flag</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Chunk information (multiple of 4 bytes)</td>
</tr>
</tbody>
</table>
Chunk types

- $2^8 = 256$ types are possible
- Only a few (less than 20) defined so far
  - 0 DATA user data
  - 1 INIT sets up an association (similar to TCP SYN)
  - 2 INIT ACK
  - 7 SHUTDOWN
  - 8 SHUTDOWN ACK
  - and so on
- Plenty of scope to introduce new types
  - we'll study new types to support handover
Identifying an association

- SCTP uses a verification tag (VT) to identify an established association
- VT is negotiated during association establishment
- We will see later that a tag-based identification (instead of address-based identification used in TCP) becomes handy for handover management
  - VT is similar to the *token* concept in TCP migration
An Internet Draft proposing three new capabilities to SCTP

1. Dynamic addition of IP addresses to an existing association
2. Dynamic deletion of IP addresses to an existing association
3. Request to set primary address
Two new chunk types are proposed
1. 0xC1 ASCONF address conf change chunk
2. 0x80 ASCONF-ACK

ASCONF contains a set of parameters
- each parameter contains a request for addition, deletion or change of primary address
ADDIP extension
parameter types

- 3 new parameter types to be used in ASCONF
  1. 0xC001 Add IP address
  2. 0xC002 Delete IP address
  3. 0xC004 Set primary address
Soft vs hard handover

- **Soft handover: make-before-break**
  - do not lose connectivity with current address until switched (handed over) to new address
  - handover is smooth (no data loss)
  - requires overlapping wireless cells

- **Hard handover: break-before-make**
  - connectivity lost before registering new address
  - has to happen when coverage overlaps do not exist
Handover management in SCTP using ADDIP extension

- ADDIP extension allows soft handover
  - mobile moves to overlapping zone
  - obtains new IP address
  - adds new address to SCTP association by sending ASCONF chunk to server
  - changes primary address to new address by sending ASCONF chunk to server
  - Deletes old address from SCTP association by sending ASCONF chunk to server
Soft handover (with SCTP) illustrated

1. **Mobile enters overlapping zone, obtains new IP address, and adds new IP address to SCTP association as the secondary address using ASCONF chunk (0xC001)**

2. **Mobile hands off to new subnet → switch primary address to new address using ASCONF chunk (0xC004)**

3. **Mobile leaves overlapping zone and deletes old IP address using ASCONF chunk (0xC002)**
Rule for switching primary address

- When to switch to the new address?
- Possible rules:
  - as soon as new address is detected (low handover latency; suitable for fast moving mobile)
  - signal strength based (similar to cellular)
  - Other (eg, remain connected to WLAN as long as possible before switching to 3G)
Transport layer mobility
pros and cons

- **Pros**
  - no triangular routing (low latency)
  - no changes in network infrastructure (e.g. no HA)
  - soft handover possible (with SCTP)

- **Cons**
  - mobile is not reachable (unless other layers involved)
  - changes required in transport layer software
  - location privacy not protected
Reading material

2. IETF RFC 2960 [original SCTP, 2000]
3. IETF draft-ietf-tsvwg-addip-sctp-12.txt [ADDIP extension to SCTP, 2005]
4. IETF draft-sjkoh-msctp-01.txt [handover management using ADDIP extension, 2005]