End-to-end IP Service Quality and Mobility

- Lecture #10 -

Special Course in Networking Technology

S-38.215

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Planned contents & draft schedule

1.	Introduction	Jan 13th
2.	Characteristics of mobile applications	Jan 20th
3.	Service quality requirement characterizations	Jan 27th
4.	Challenges of mobile environment	Feb 3rd
5.	Mobility and QoS in GPRS	Feb 10th
6.	Mobility and QoS in 3GPP systems	Feb 17th
7.	Mobility and QoS with Mobile IP	Feb 24th
8.	Mobile IP QoS enhancements	Mar 3rd
9.	Edge mobility and SIP	Mar 10th
10.	**Inter-system mobility**	Mar 17th
11.	End-to-end QoS management	Mar 31st
12.	Summary	(Apr 7th)

Dates in parentheses to be confirmed

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Agenda

- Motivation for inter-system mobility.
- Inter-system mobility concepts
- Technical requirements.
- Effect on end-to-end service quality.
- Summary

Goals of the lecture

- Understand which issues need to be taken into account for inter-system mobility.
- Understanding means of analysing inter-system mobility.
- Rôle of the endpoint.
- Rôle of the access network operator.
- Understanding the generic effect of inter-system mobility on end-to-end service quality.

Inter-system mobility

- Inter-system mobility means the ability to switch between access technologies during sessions.
  - Criterion: switching between technologies can be made automatic.
  - However, switching between technologies does not need to be automatic.
- Reasons for inter-system mobility:
  - Throughput.
  - Price.
  - Load balancing.
  - Service quality support.

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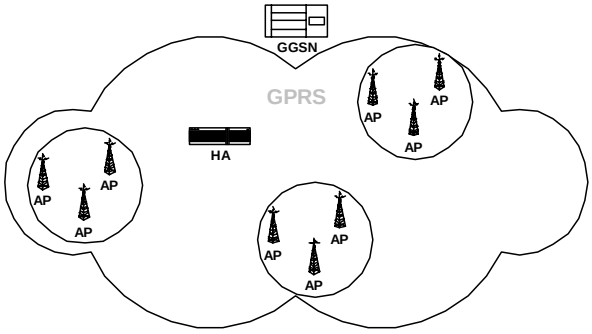
GPRS/WLAN example

•GPRS provides wide area coverage.
•WLAN “hot spots” provide lower price (€/bit) for data transfer.
•User can activate manually one of the accesses for a session => “**inter-system nomadicity**”.
•Switching between access technologies within a session => **inter-system mobility**.



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Inter-system mobility concepts

- Capabilities of the endpoint.
- Inter-system mobility support scheme.
- Commensurability of service quality support in access technologies.
  - Effect on mobility support.
- Criterion for switching between access technologies.
- Effect on end-to-end service quality.

Capabilities of the endpoint

- Supported macromobility schemes: none/MIP/SIP.
- Supported access technologies: GPRS / 3GPP / 802.11 / …
  - Multiple access technologies can / can not be active simultaneously.
- TCP/IP support for multiple access technologies.
  - Multiple bindings.
- Application level support.
  - Can optimal use be made of currently available access technologies?
- Does the user need to be made aware of switching of access technologies?

Capabilities of the endpoint / 2

- Service quality support capabilities of the endpoint
  - Ability of dejittering buffer to compensate
    - Missing / partial service quality support for real-time traffic.
    - Effect of handovers.
- Micromobility support (when applicable):
  - Support for HMIP.
  - Support for smooth handovers.
  - Support for bicasting.
  - Support for CAR-type scheme for inter-operator handovers?

Inter-system mobility support scheme

- **MIP**:
  - Requires HA.
  - (MIPv4: requires FA for FA-CoA).
  - Requires MIP support from mobile node.
  - Micromobility: MN / network support.
  - IP layer mobility.
- **SIP**:
  - Requires SIP proxy & RS.
  - Requires SIP support in MN.
  - Services need to be made known to SIP proxy.
  - Service mobility.

Service quality support commensurability

- Degree of service quality support in different access technologies:
  - Availability.
  - Service instantiation time.
  - Latency.
    - Delay variation.
  - SDU loss.
    - Loss correlation.
  - Throughput consistency.
- Criteria for assessing service quality support need to be the same for all access technologies.

Commensurability / 2

- Commensurability of service quality support can be divided into two separate cases:
  - One of the access technologies does not support full intra-system mobility.
  - Both support full intra-system mobility.
- Full intra-system mobility in one of the access technologies only:
  - Session can be maintained during inter-technology handovers.
  - Mobility support (between L2 or IP PoAs) partial in some of the access systems.
  - Easier to implement than full inter-system mobility.

Criterion for inter-system handover

- When does one switch from access technology A to access technology B?
- When does one switch back from access technology B to access technology A?
- Two high-level strategies:
  - All services use the same access technology.
  - Some services use A, others B.
    - Depends on endpoint capabilities!
- Even when different services use different technologies, criteria for access technology selection may be needed.
- When all services use the same access technology, inter-service dependencies arise.

Inter-system handover/2

- Simple example rules for inter-system handovers.
- Case 1: only one access technology can be activated at a time.
  - Assume higher bandwidth and cheaper price for WLAN access, but no service quality support for streaming.

```
If (using data services AND using GPRS AND WLAN
   hotspot available) then
Begin
   If NOT (streaming sessions active) then
    handover(GPRS, WLAN)
End
```

Inter-system handover/3

- Case 2: WLAN and GPRS can be simultaneously active.
  - WLAN assumed to be cheaper and to have higher throughput.
  - No streaming service quality support in WLAN assumed.
  - Decision as to whether to handover data session X from GPRS to WLAN.

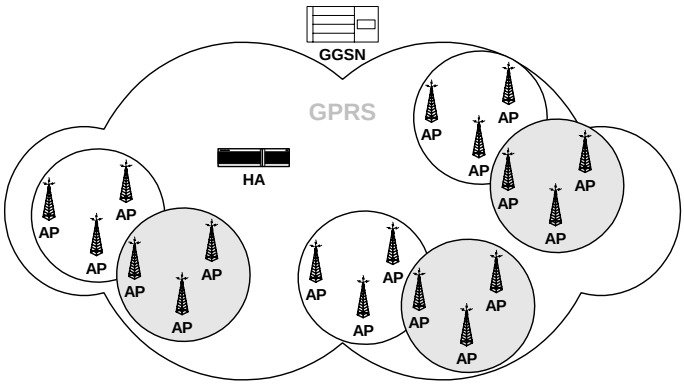
If (using data services AND data session X using GPRS AND WLAN hotspot available) then

handover(GPRS, WLAN, session X)

Inter-system handover/4

- General case:
  - Multiple access network operators.
  - Some operators have multiple access technologies
    - May provide optimised inter-technology handover performance.
    - May provide consistent service quality support across access technologies.
  - Differing service quality support in different access technologies
    - May vary from operator to operator.
  - Price per service support class may depend on the operator.
  - Differing support for intra-access technology mobility.

Example



Inter-system handover control algorithm

- May be executed by network or by endpoint.
- Need to take into account the capabilities of the endpoint.
- Need to take into account service quality requirements.
  - Service instantiation time.
  - Inter-system handover performance.
    - Service quality support instantiation performance.
    - Also in reverse direction!
  - Intra-system handover performance.
  - Delay and packet loss performance.
- May take into account price.
  - How to obtain price information?

Generic h/o control algorithm example

```
If (new operator found)
Begin
    if (price(new, applications) < price(current, applications)
        AND qos(new, applications) >=
        requirement(applications)) then
                handover_operator(current, new,
    applications)
End
```

- **Note**: price comparison and service quality comparison may require iteration.
- **Note2**: If multiple access technologies available for both operators, applications may be mapped differently onto them.

Generic h/o control / 2

```
Proc price(new, applications, QoS)
Begin
    done = false
    while (done)
    begin
        price = find_lowest_price(technology, applications)
        if (good_enough_qos(applications, QoS))
                done = true
        else
                discard_combination()
    end
End
```

Multiple registrations

- SIP allows for multiple registrations for a single user.
  - If terminal support multiple simultaneous link layer connections, multiple registrations can potentially be used for implementing smoother inter-system handover.
  - Applications need to support this.
  - Services must be known to SIP.
- Another alternative: bicasting.

Effect on end-to-end service quality

- End-to-end service quality support level may be defined in a SLA or signalled.
  - Cf. CAR discovery schemes.
- If service provider is different from the access provider, it may have different SLAs towards different operators.
- An access operator may have different SLAs towards different service providers.
  - If service belongs to one of the access network operators, service quality support may not be as closely integrated into services when access operator changes.

End-to-end service quality/2

- Service availability.
  - Total service instantiation time.
  - Paging for dormant terminal.
- Service continuity.
  - Commensurability of service quality support across technologies vs. terminal capabilities.
  - Effect on temporally correlated vs. statistical characteristics.
    - Latency vs. delay variation.
    - Packet loss percentage vs. loss correlation.
    - Overall throughput vs. throughput consistency.

Summary

- Reasons for inter-system mobility.
- Inter-system mobility concepts.
  - Service quality commensurability.
  - Endpoint support.
  - Network support.
  - Handover criteria.
- Effect on end-to-end service quality.