Multimedia Mobile Applications on Heterogeneous Networks

Meeting Web-Minds

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UNITA' DI RICERCA CINI NAPOLI

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Mobility on Heterogeneous Networks

Wireless and mobile networks represent an enabling technology for ubiquitous access to information systems and services. A really ubiquitous and seamless access demands the following requirements:

- Access must be guaranteed when moving through subnets based on **different technologies**: Ethernet LANs, IEEE 802.11 WLANs, and 2.5/3G cellular data networks (for geographic access).

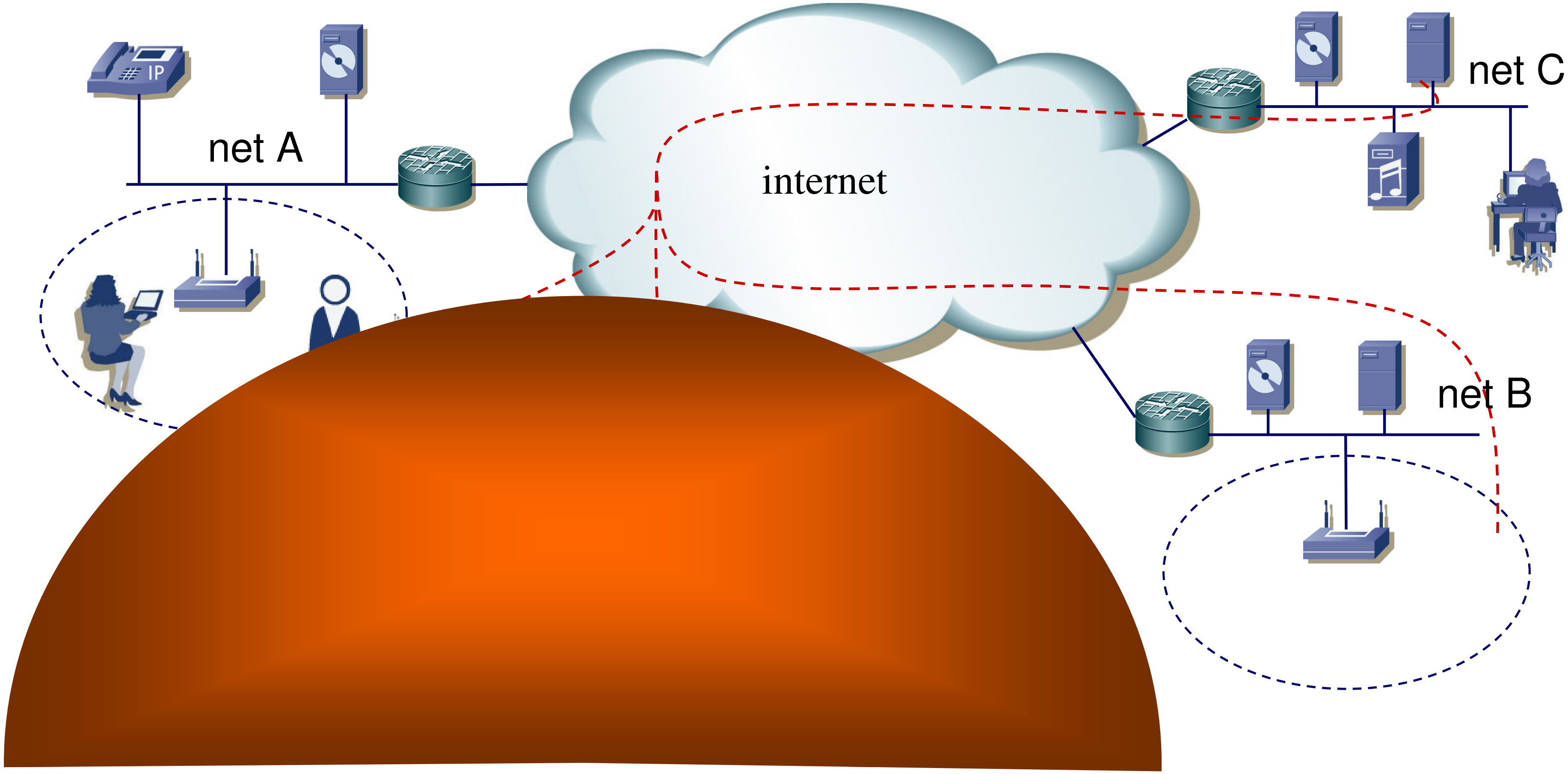
- **No** additional **configuration** effort should be required to final users.

- Sessions must be **seamlessly maintained** through different subnets.

- Handoff must be **fast enough** not to cause service disruption.

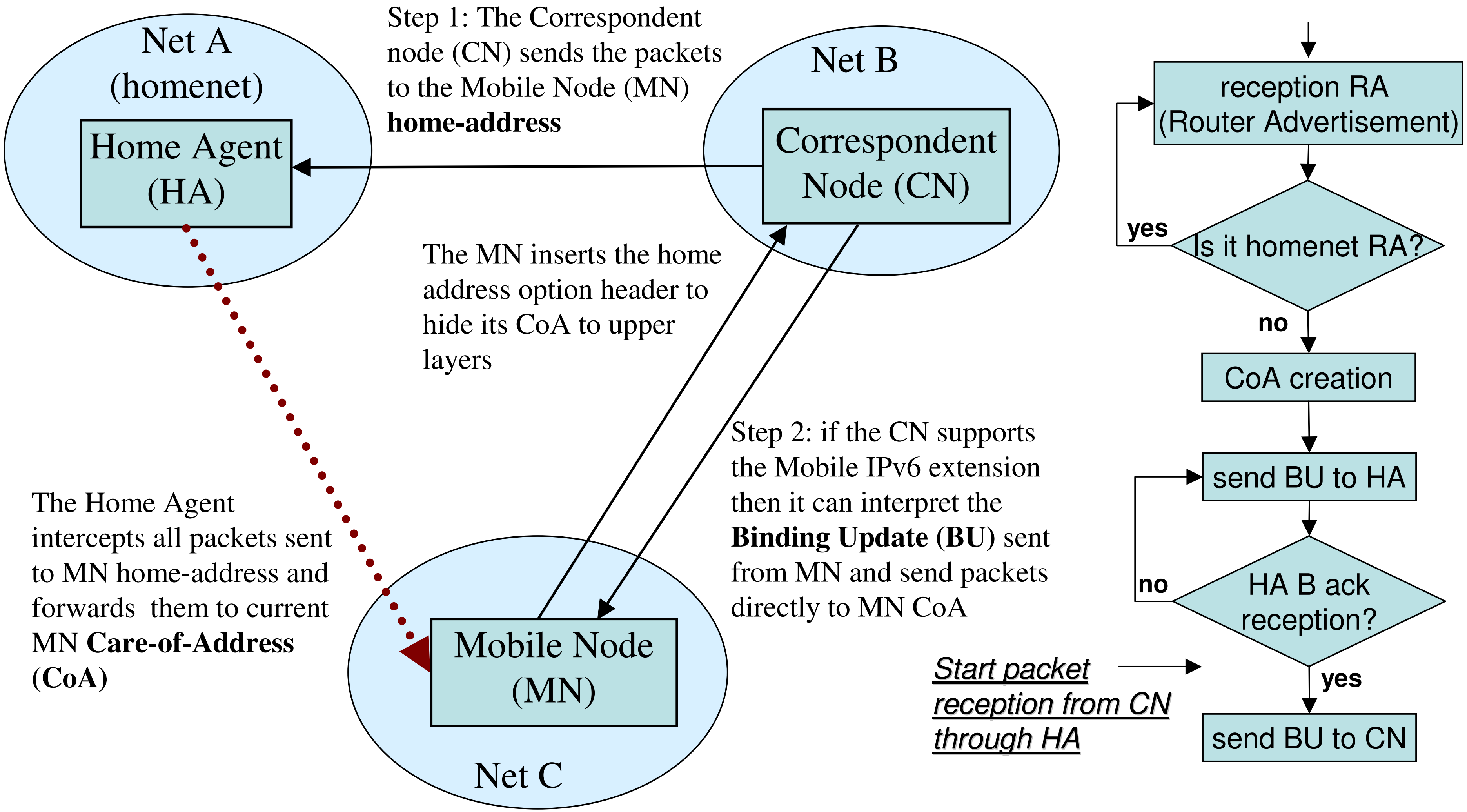
- Service delivery should be **dynamically adapted** to the characteristics of the network (example: image resolution for video streaming, buffering for voice applications, page content for interactive Web applications)

Mobility on Heterogeneous Networks – Scenario



A comprehensive solution to many of these issues is provided
by IPv6

Mobile IPv6


Net A
(homenet)
Home Agent
(HA)
Step 1: The Correspondent node (CN) sends the packets to the Mobile Node (MN) **home-address**
Net B
Correspondent
Node (CN)
The MN inserts the home address option header to hide its CoA to upper layers
The Home Agent intercepts all packets sent to MN home-address and forwards them to current MN **Care-of-Address (CoA)**
Step 2: if the CN supports the Mobile IPv6 extension then it can interpret the **Binding Update (BU)** sent from MN and send packets directly to MN CoA
Mobile Node
(MN)
Net C
reception RA
(Router Advertisement)
yes
Is it homenet RA?
no
CoA creation
send BU to HA
no
HA B ack
reception?
yes
send BU to CN
Start packet reception from CN through HA

Vertical Handoff

Handoffs can be classified into:

- *Horizontal handoff:* the migration is between homogeneous networks (*e.g.,* WLAN 802.11b)
- *Vertical handoff:* the migration is between heterogeneous networks (*e.g.,* Ethernet to WLAN 802.11b or WLAN 802.11b to 2.5/3G networks)

Vertical Handoff Performance

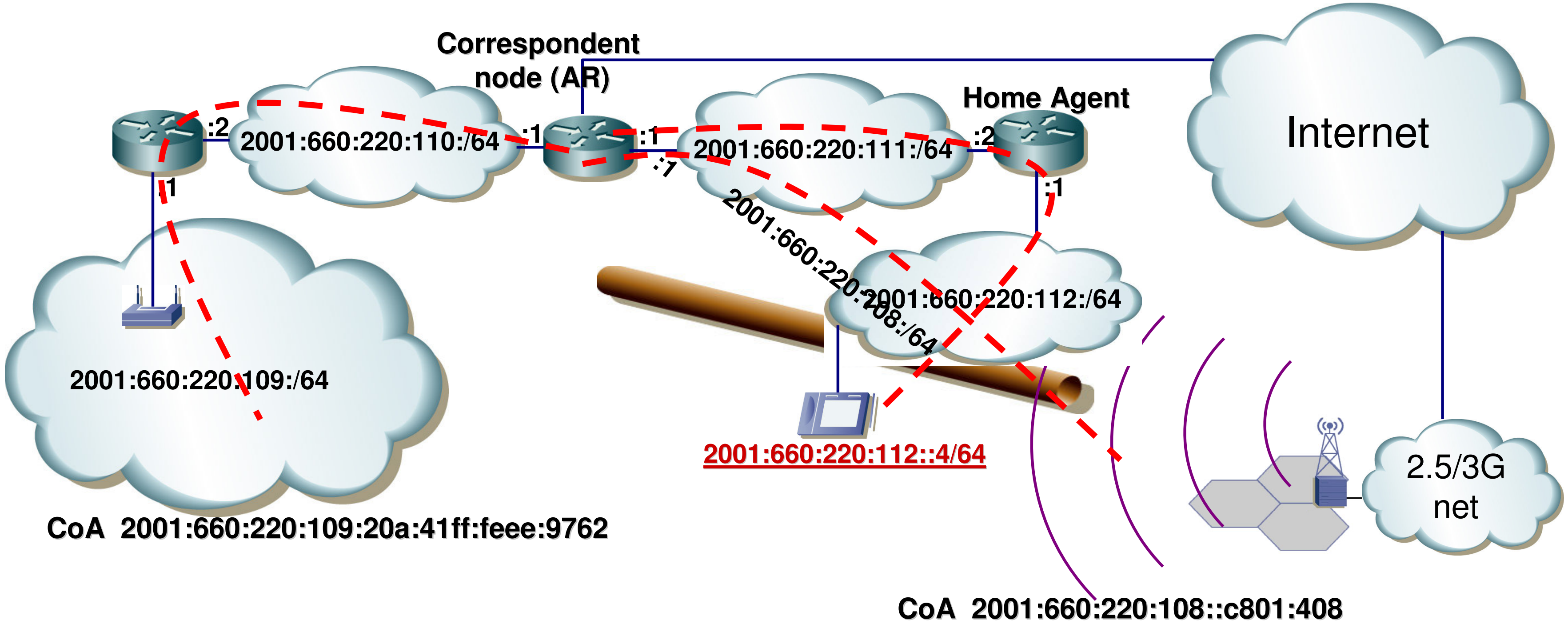
- At the same time, a node could be connected to an *Ethernet LAN* and under the coverage of a *Wireless LAN* or a *cellular data connection*.
- A vertical handoff can be initiated for convenience, rather than connectivity reasons.
- It is often possible to have handoffs with no packet loss by performing the configuration and signaling steps on the new network before leaving the old one.

Vertical Handoff Performance

Handoff latency is composed of the following delays:

1. delay D_t for detecting lower layer events eventually leading to the handoff;
2. delay D_n for configuring an IP address on the new subnet;
3. delay D_s for handoff execution (i.e. due to signaling between MN and HA).

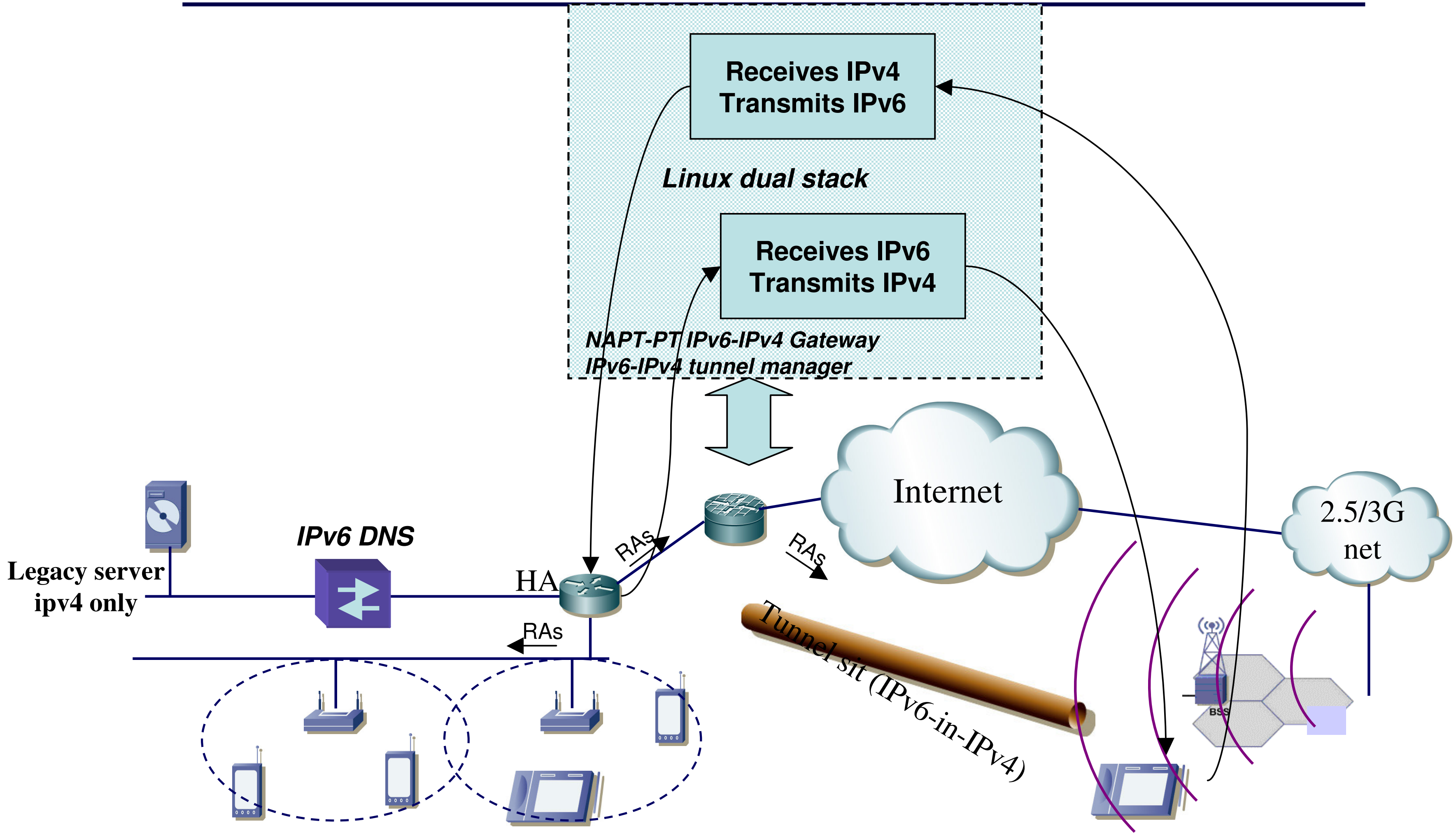
Vertical Handoff Performance



Handoff	*LATENCY (D_t +D_n +D_s)*
WLAN-GPRS	2552 ms ±433.
WLAN-UMTS	1657 ms ± 272.
GPRS-WLAN	1960 ms ± 210
UMTS-WLAN	1640 ms ± 130

The latency is too high

IPv6-IPv4 interoperability

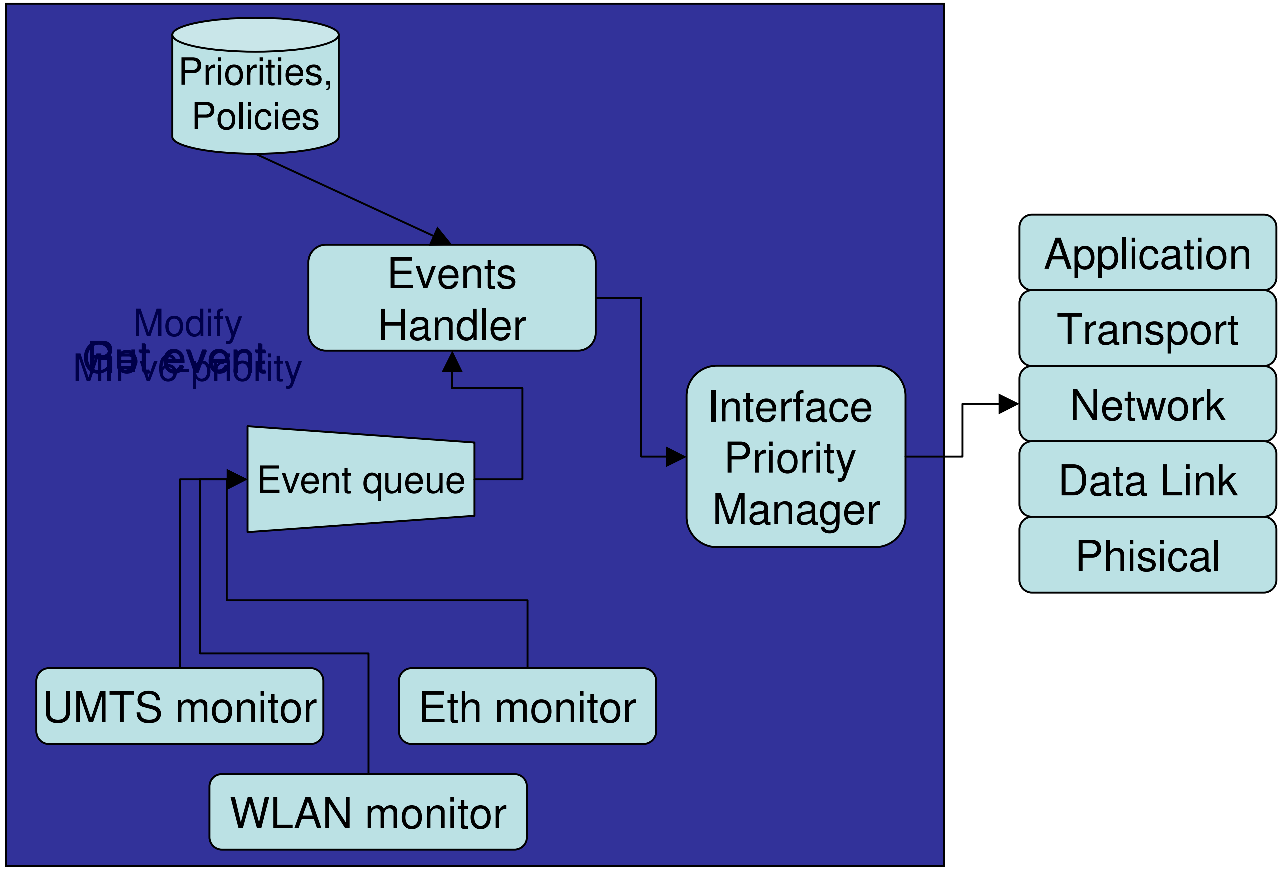


Lower layer triggering

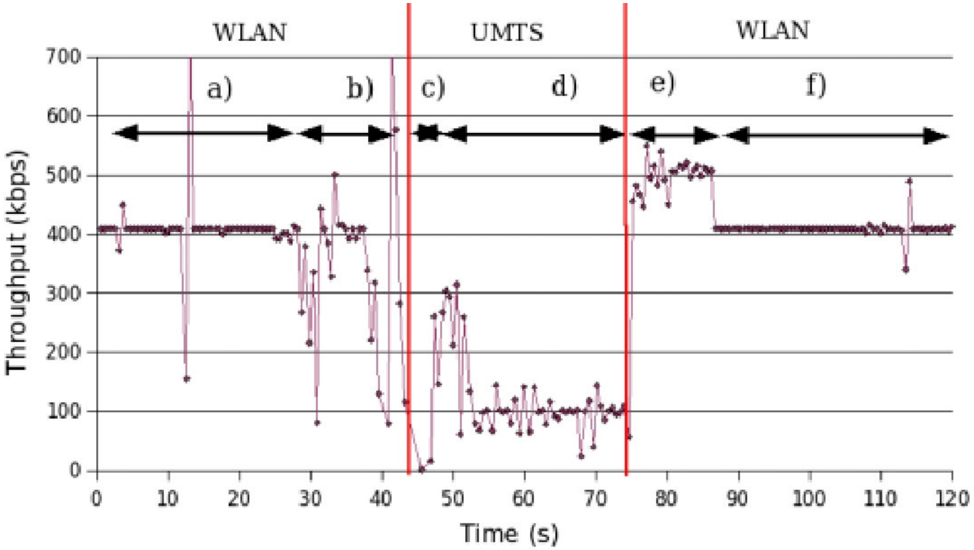
The basic idea is to use low level information provided by the devices to determine the most suitable interface according to a predefined policy.

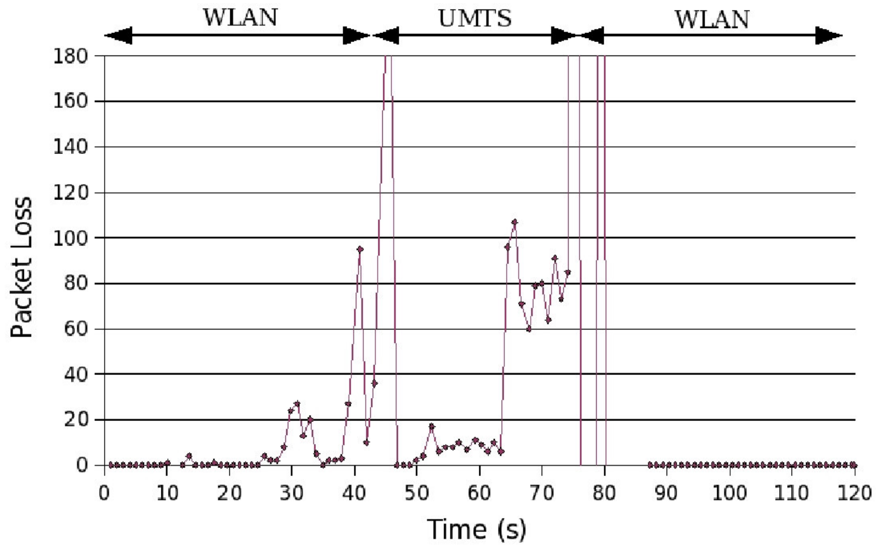
Features:

1. *Modular application*: the architecture can be easily extended by adding handlers for other network interfaces
2. Better handoff performance *with no changes to the network protocol.*



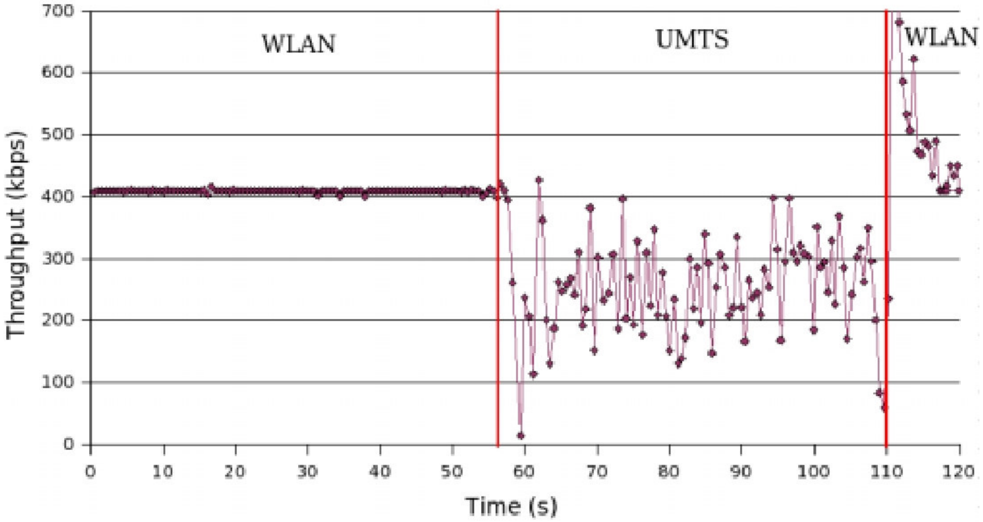
UDP Performance: throughput and packet loss

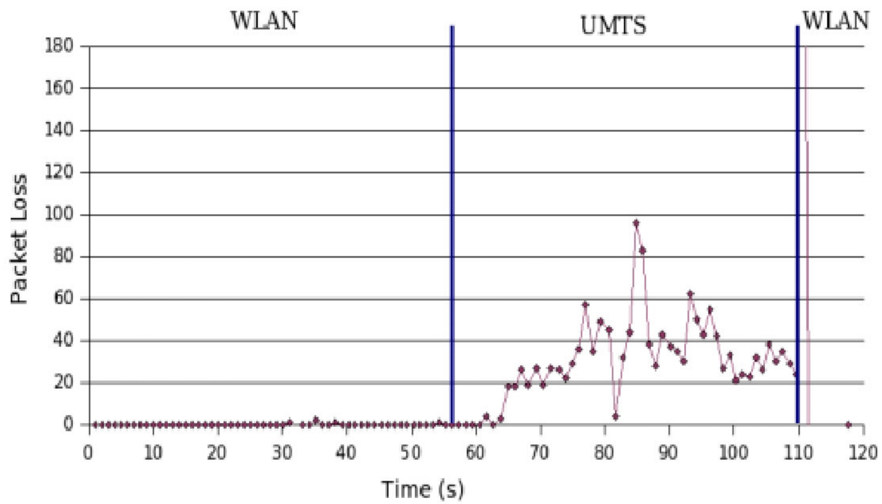




UDP flow at about 410 kbps, with 2 handoffs and **network-layer handoff triggering**: (a) wlan (b) wlan signal weakening; (c) handoff; (d) flow on UMTS link; (e) handoff: flow from both interfaces; (f) wlan

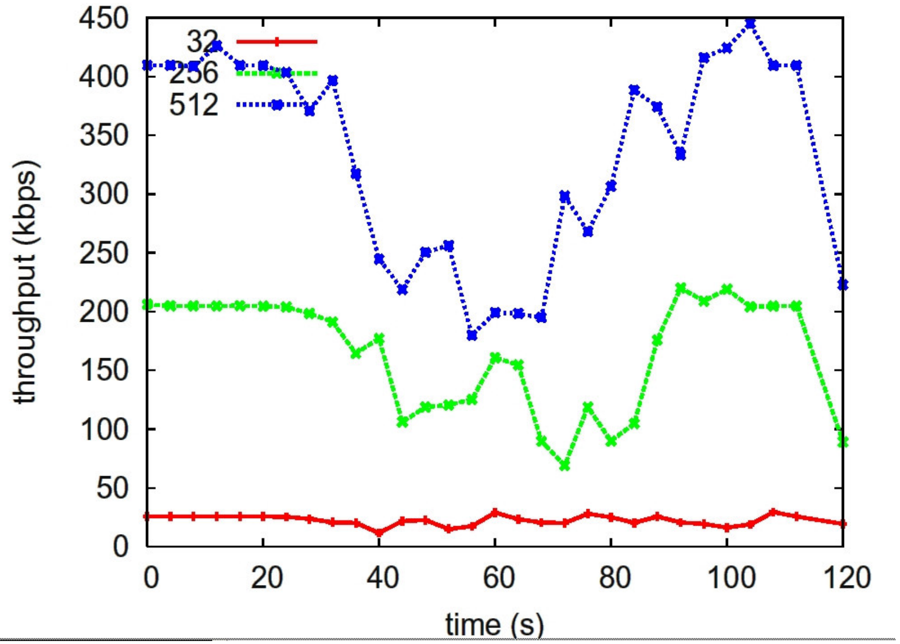
UDP performance: L2 triggering packet loss and throughput

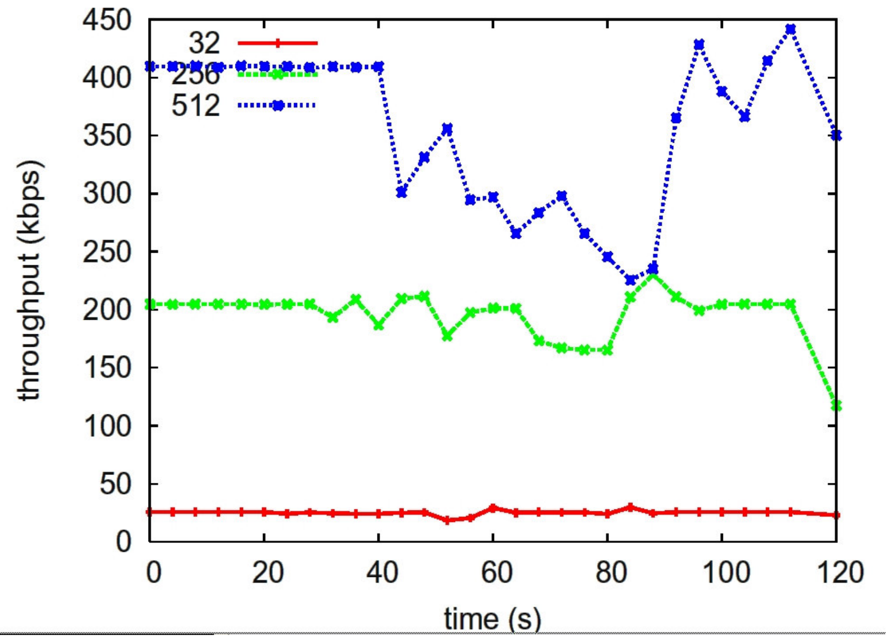




UDP flow at about 410 bkps, with 2 handoffs and **link-layer handoff.**

UDP Performance: comparison L3/L2 triggering



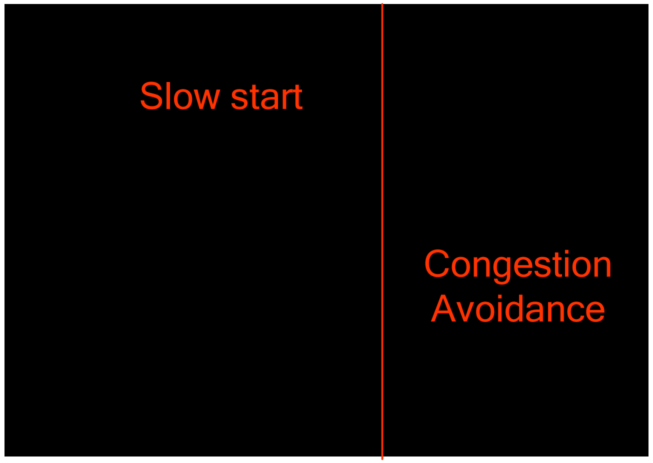


Better performance of L2 triggering stems from:
- lower handoff delay (no NUD);
- handoff before the signal is lost;
- less ping-pong effect

TCP Performance

TCP implements a congestion control by using:

- Slow start
- Congestion avoidance



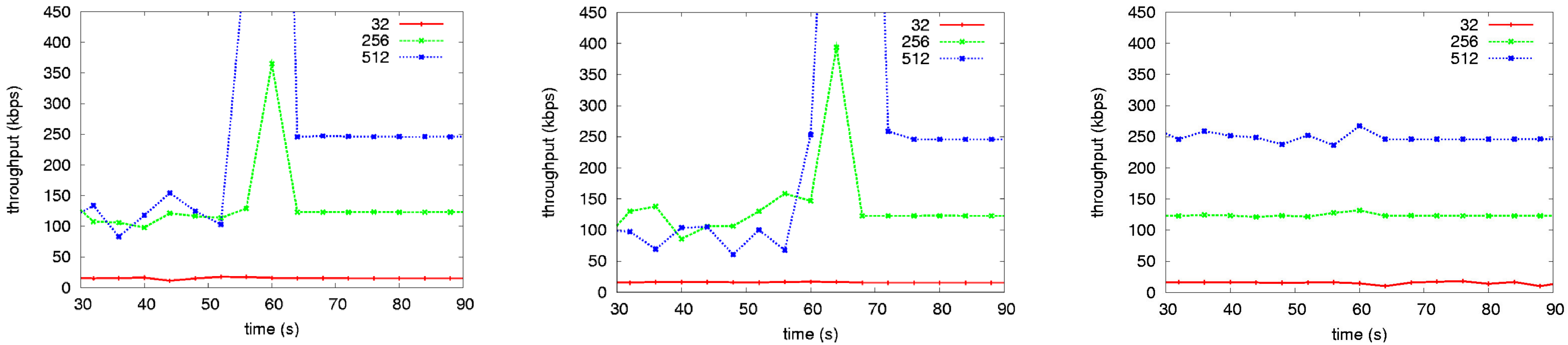
TCP improvements (NewReno 1999):

- Selective Acks (SACK): it allows to selectively acknowledge packets;
- Timestamp: to measure accurately the *round trip time* (RTT) and the *retransmission timeout* (RTO).

TCP Performance

- D-ITG can be configured to generate CBR traffic by tuning two parameters:
  - packet size (PS) and interdeparture time (IDT).
- In our tests the D-ITG sender is the CN, whereas the D-ITG receiver is the MN.
- To take into account the declared bit rate of the cellular network technologies
- in use, we introduced the following *traffic load* classes:
  - *Low*: PS = 32 bytes and IDT = 1/50 s, corresponding to a bit rate of 12.8 kbps
  - *Medium*: PS = 256 bytes and IDT = 1/50 s, corresponding to a bit rate of 102.4 kbps
  - *High*: PS = 512 bytes and IDT = 1/50 s, corresponding to a bit rate of 204.8 kb/s

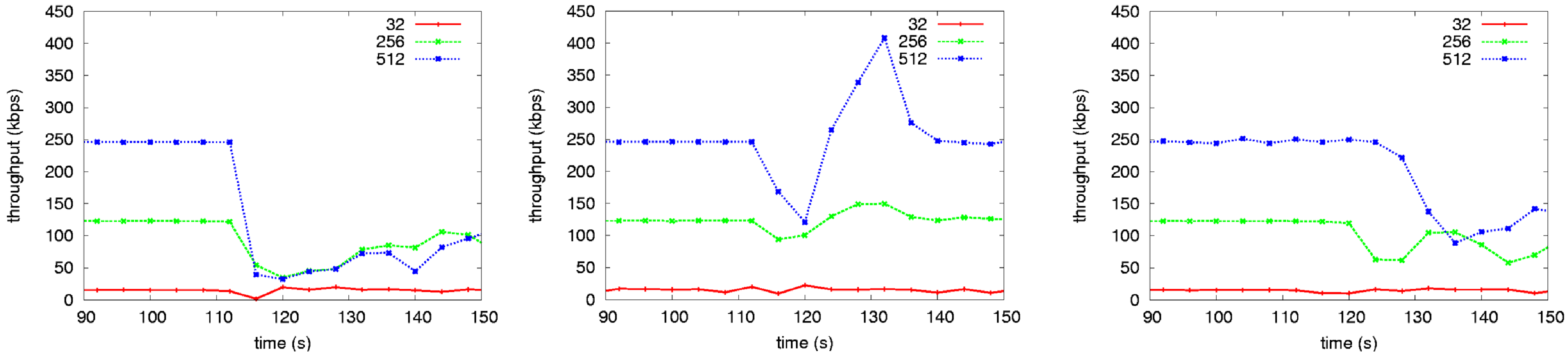
TCP Performance



TCP throughput for handoff from cellular network to WLAN 802.11b:

- *a) GPRS;*
- *b) 100 kb/s UMTS;*
- *c) 384 kb/s UMTS.*

TCP Performance

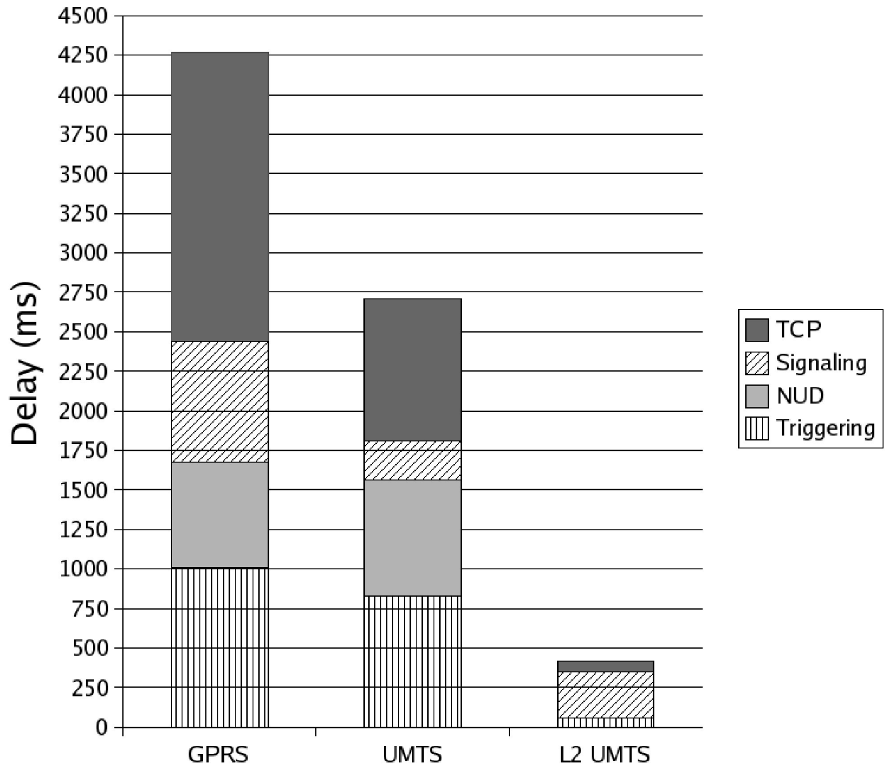


TCP throughput for handoff from WLAN 802.11b to cellular network:

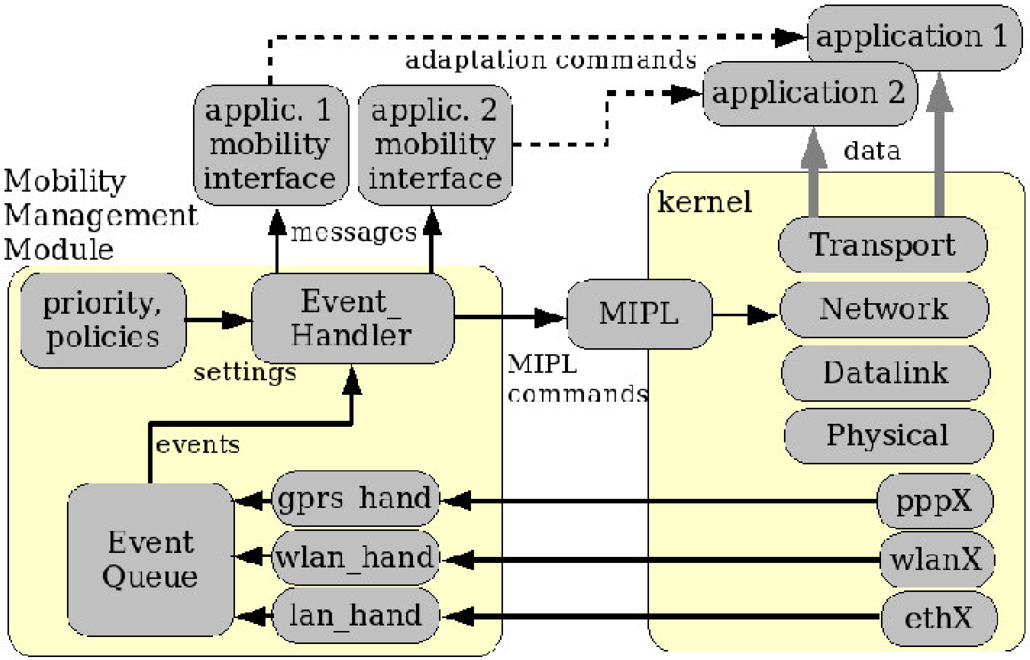
- *a) GPRS;*
- *b) 383 kb/s;*
- *c) 100 kb/s UMTS with L2 triggering.*

TCP Performance

- The delay of TCP packets is proportional to the network level delay.
- The decreasing of the delay at network level allows to achieve better performance in TCP handoff.



Mobile Applications Support

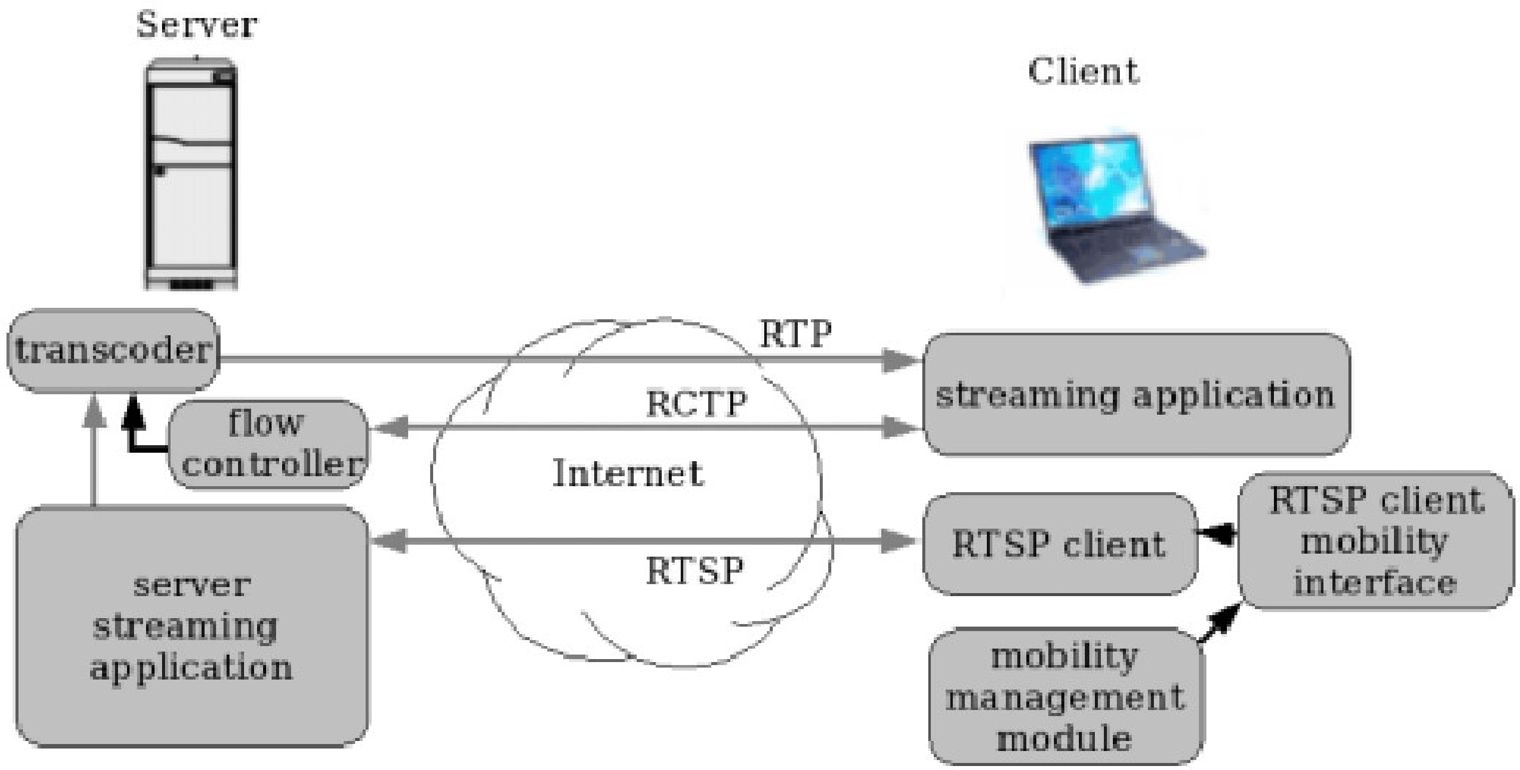


Mobility: through MMM cross-layer approach (network and lower layers)
Adaptation: through Application Mobility Interfaces (AMIs) at session and application layer.

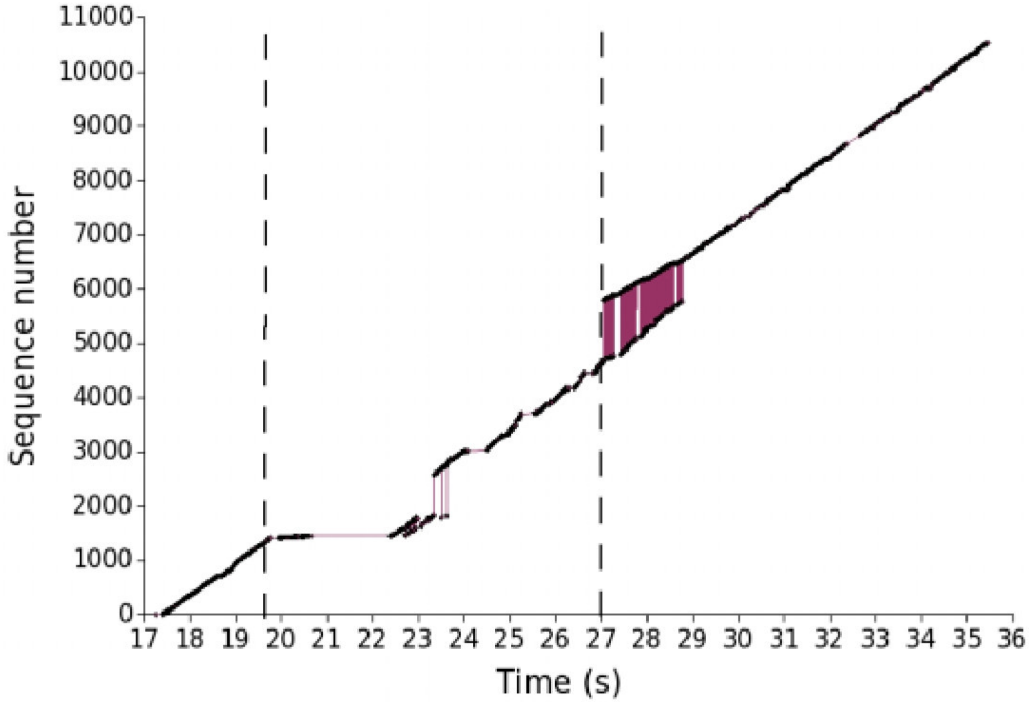
Mobile Applications Support

- Interface between MMM and AMIs:
  - handoff warning and/or notification;
  - periodic update about link performance;
  - notification content: bit-rate, delay, jitter, packet-loss, IP address of the interface
- How to obtain link parameters:
  - from network technology (static)
  - from link model (SNR, signal level, etc.)(dynamic)
  - from probing module (dynamic)
  - from QoS agreements (if available)

Adaptive Streaming

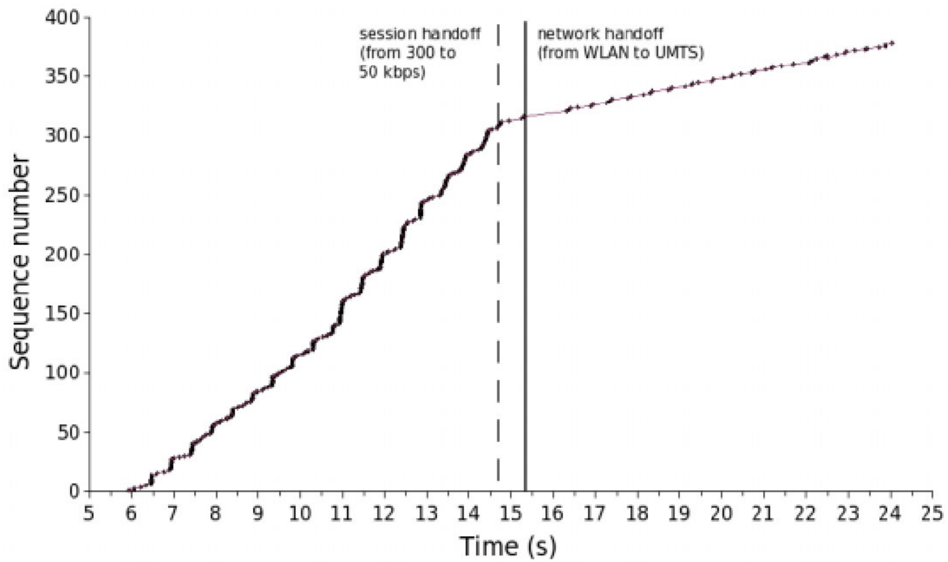


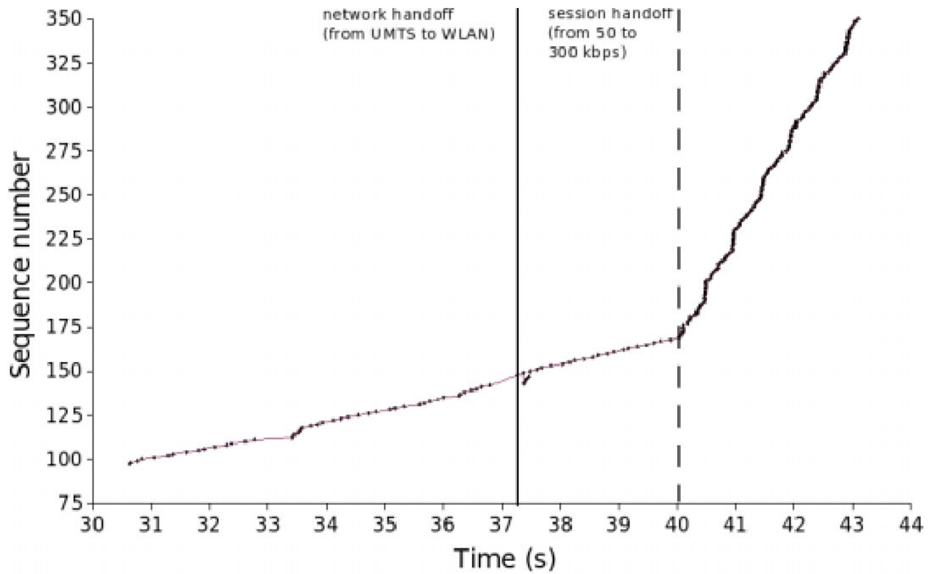
Adaptive Streaming



Streaming of a 300 kbps video clip with two handoff (WLAN-UMTS-WLAN)

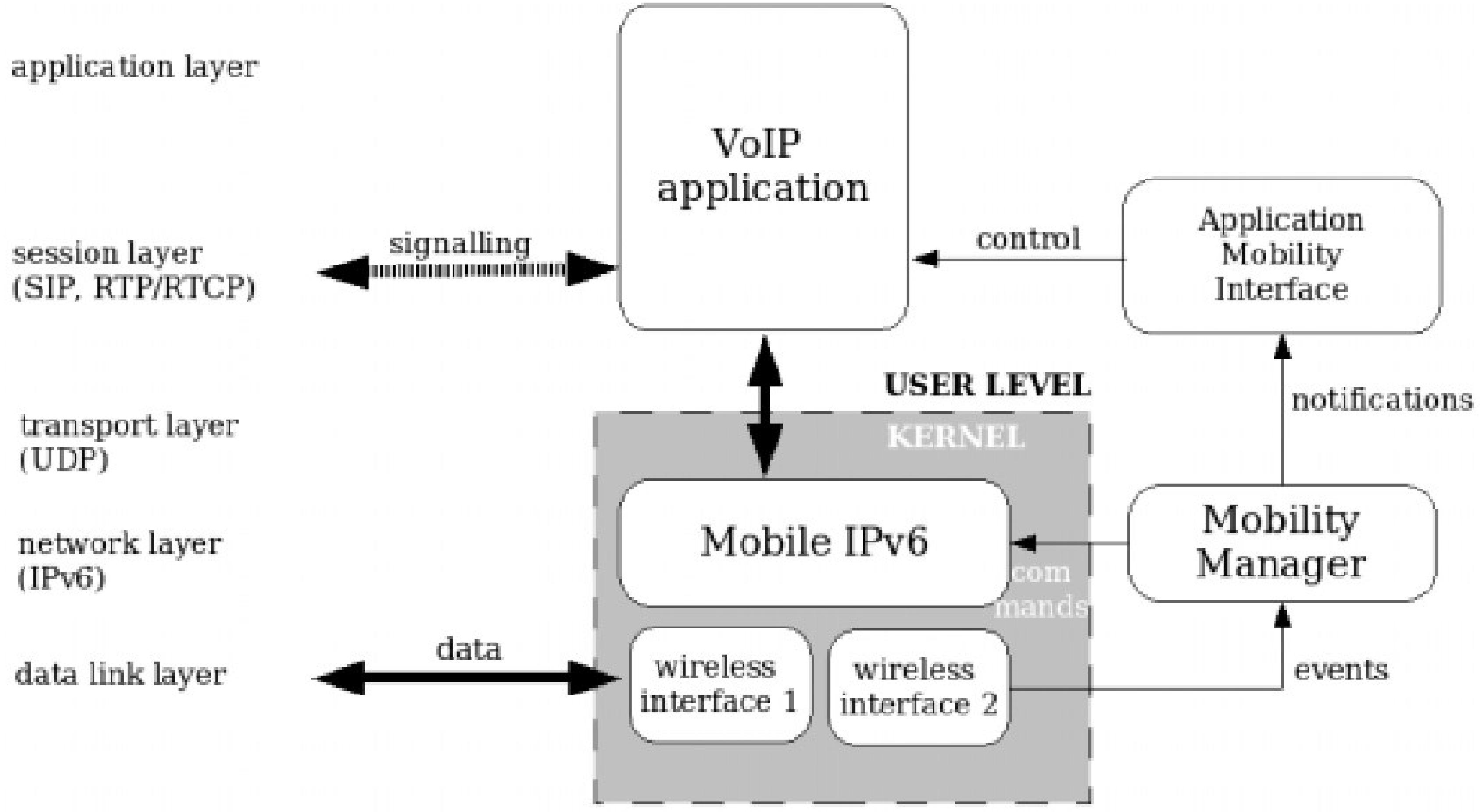
Adaptive Streaming





Handoff UP (from WLAN to UMTS): session handoff (from a stream at 300 kbps to a stream at 100 kbps) is performed before the network handoff by means of a 'handoff warning' notification subscription issued by the RTSP client to te MM module.
Handoff DOWN: session handoff follows network handoff. 'handoff notification' is used.

Adaptive VoIP



Adaptive VoIP

- Adaptation at the session layer:
  - dynamic change of codec
  - turn on/off video subsession
  - update location at the SIP registrar
- Adaptation at the application layer:
  - change buffer dimension to avoid packet discarding due to jitter