An IMS-based Middleware Solution for Energy-Efficient and Cost-Effective Mobile Multimedia Services

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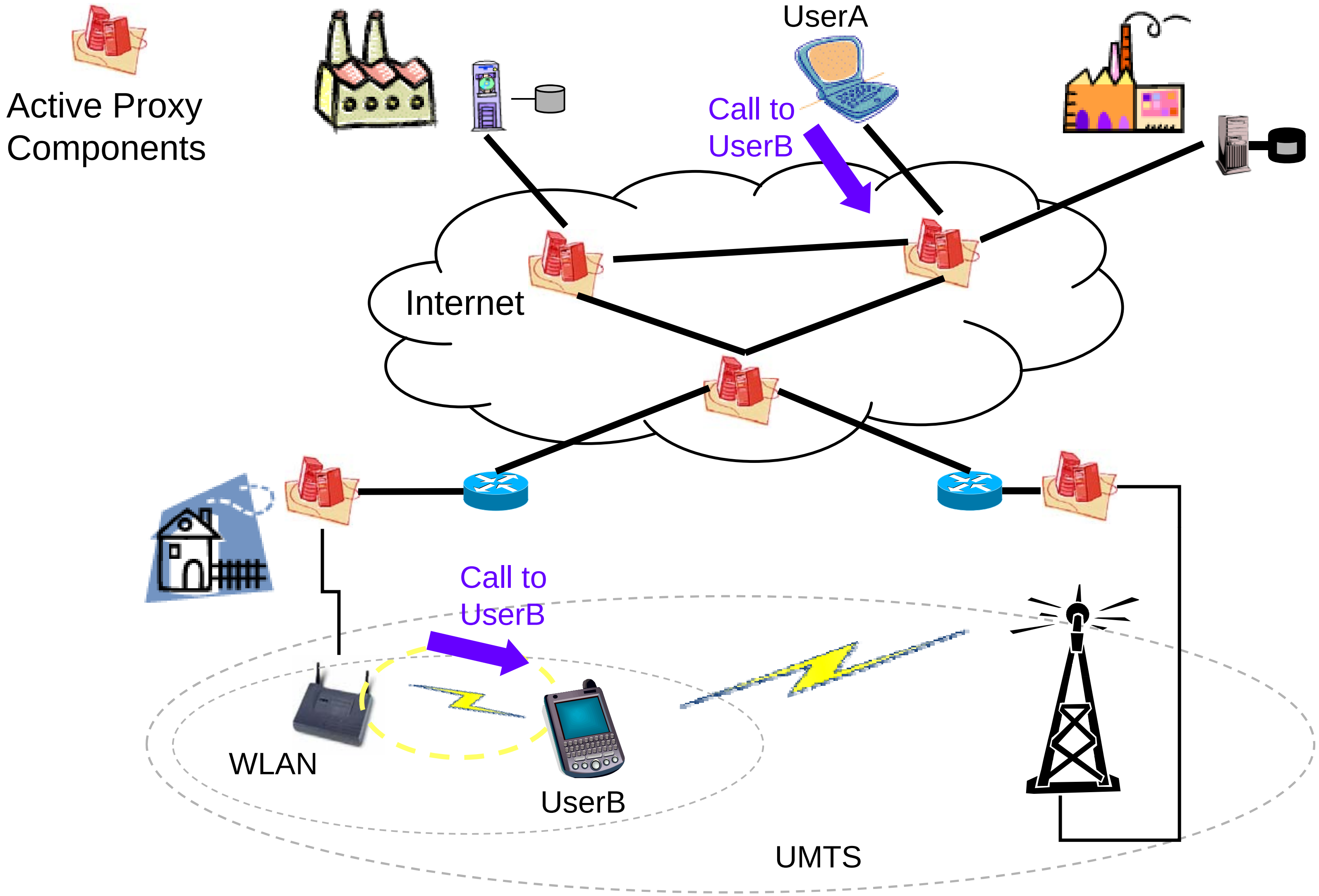
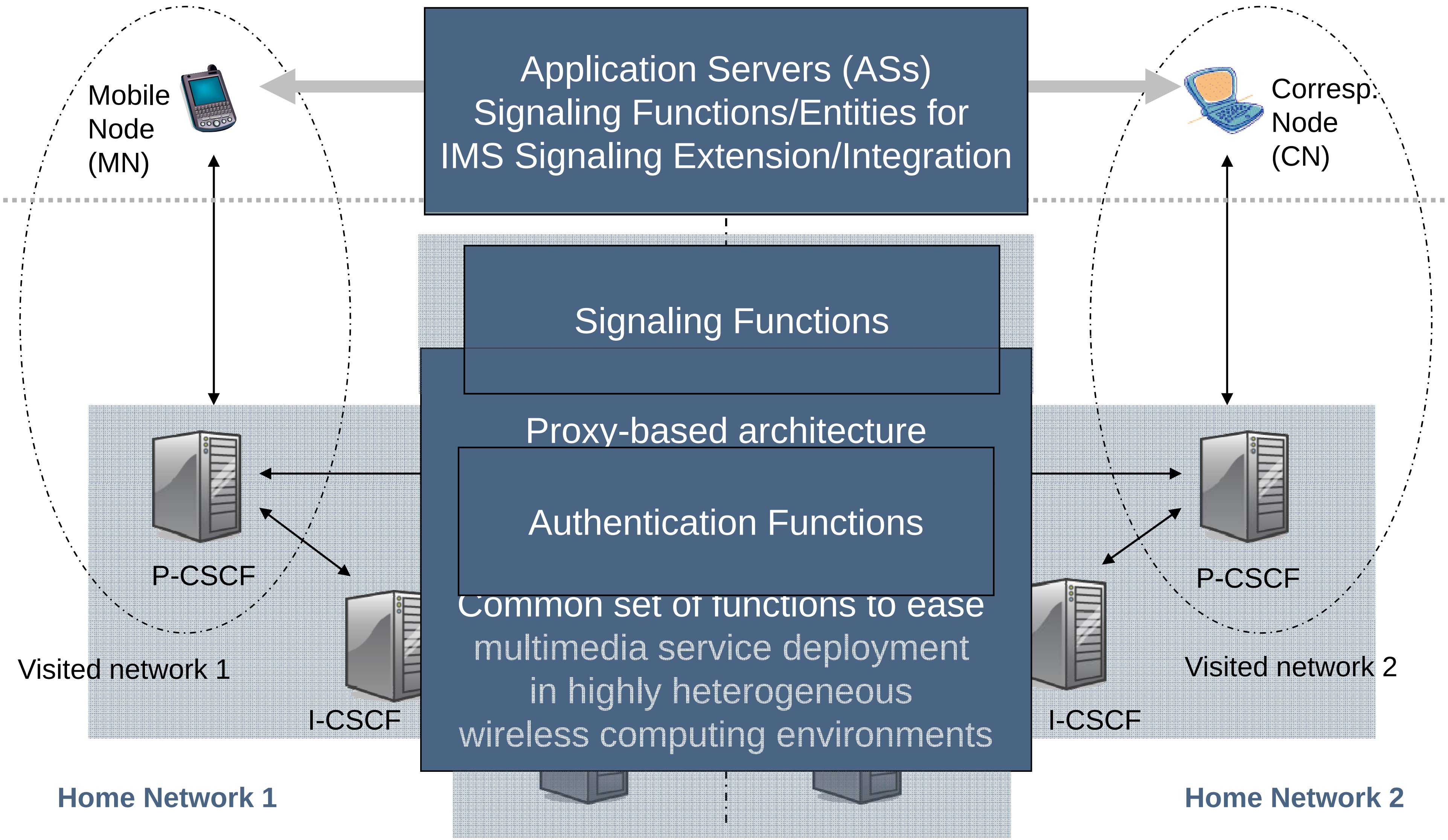
Agenda

- ***Multimedia service delivery*** for the ***wireless Internet***
- ***Middleware*** for ***IMS-based energy-efficient mobile multimedia services***
  - The IMS-compliant Handoff Management Application Server (IHMAS) multimedia middleware solution
  - ***Context-aware, IMS-standard-based, and dynamic switching-on of wireless interfaces only for the duration of multimedia service sessions***
- Implementation insights and experimental evaluation
  - Switch on and session re-direction time evaluation
  - Energy-saving evaluation

Application scenario: multimedia services in the Wireless Internet



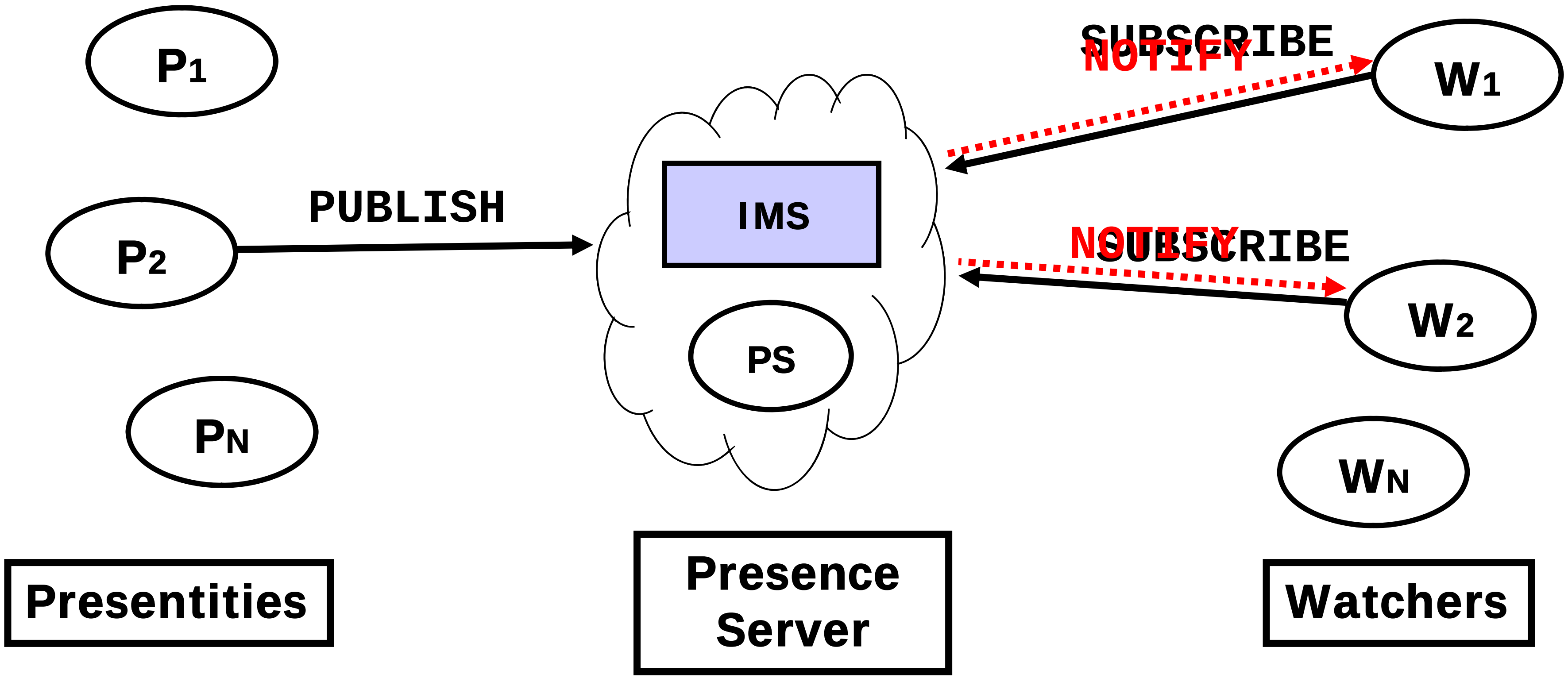
IMS – IP Multimedia Subsystem



IMS Presence Service

Presence Service (PS) permits users and hw/sw components, called ***presentities*** ***(P_i)***, to convey their ability and willingness to communicate with subscribed ***watchers*** ***(W_j)***

IMS standardizes PS as a specific AS → ***IMS PS***



Application-level middleware for multimedia services

- ***Session management*** and ***continuity***

- ***Context-aware*** power management ***middleware***
  - **updates** low level parameters (wireless communications availability, battery level, …)

    → ***wireless access prediction and mobile node energy monitoring***
  - **executes** application-level specific **energy-saving decisions** and **session signaling actions**

    → ***dynamic wireless interface switch on and automatic session re-direction/handoff***
  - **integrates** seamlessly with existing infrastructures

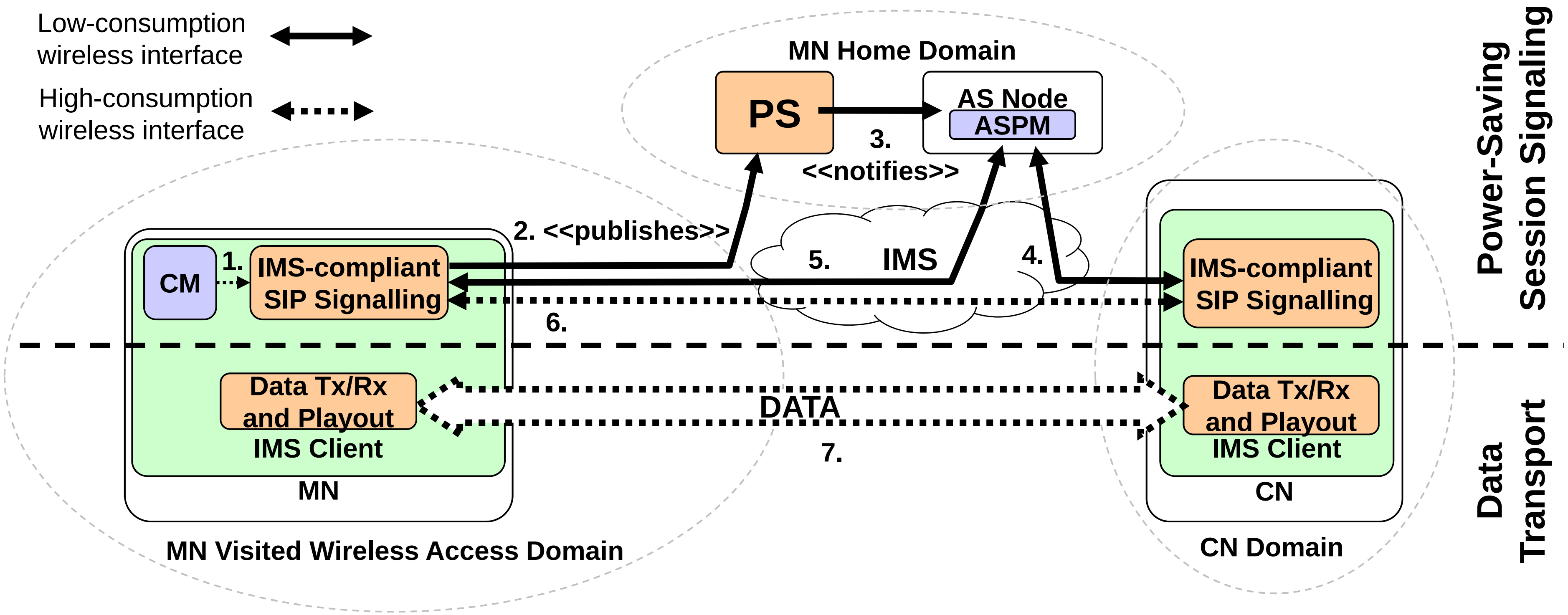
    → ***full compliancy with IMS standard***

IHMAS active middleware

IMS-compliant **H**andoff **M**anagement **A**pplication **S**erver

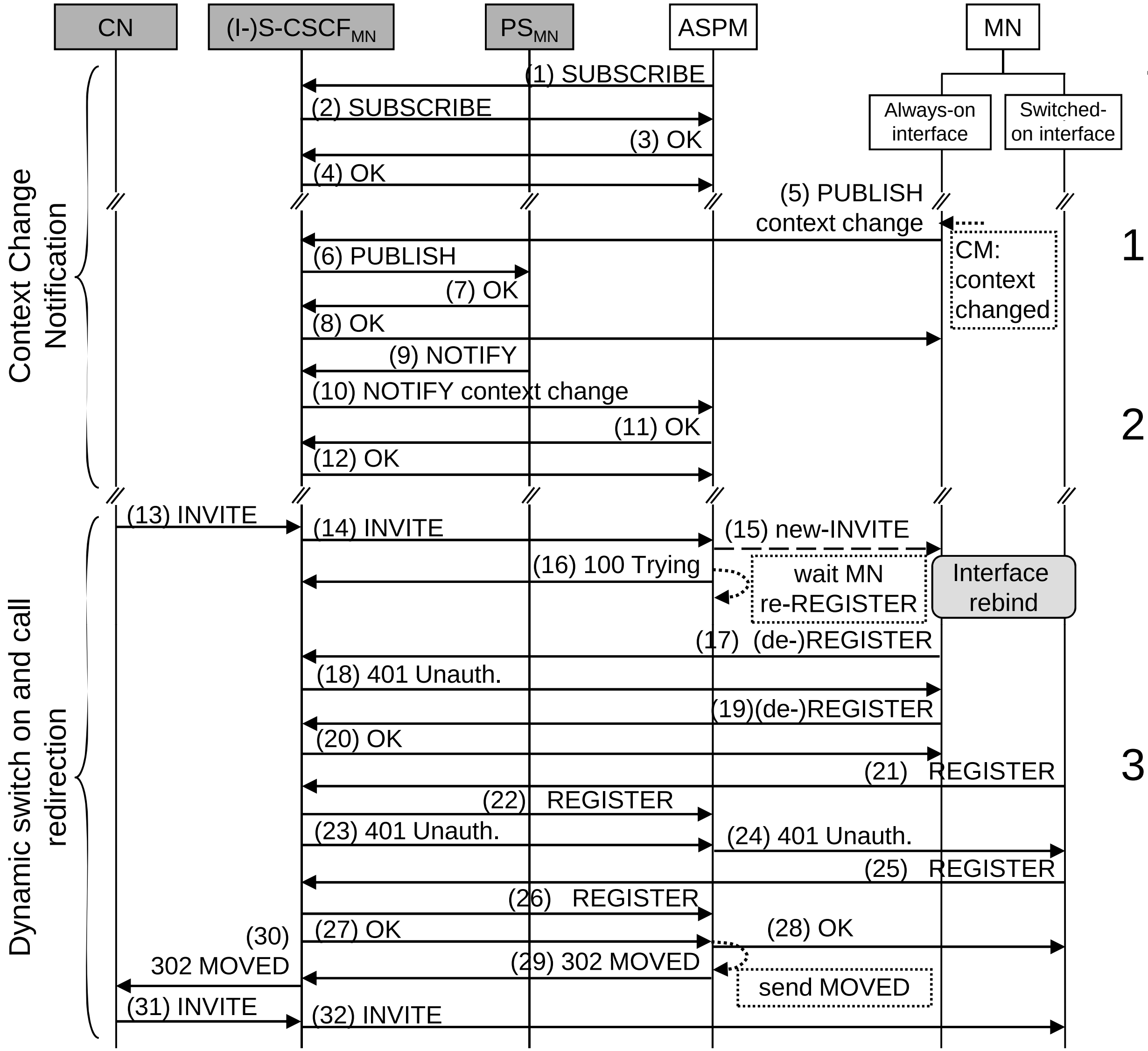
- Multimedia session continuity
  - ***Session signaling enhancements*** for power management
- Active session signaling and media data paths
  - Dynamic session signaling and re-direction ***to exploit high energy-consumption and low transmission-cost wireless interfaces***
- IMS-compliant solution
  - Session management entity realized as a ***novel IMS AS***
  - AS performs management operations
    - ***Context-aware energy-saving decision making and orchestration***
- Application-level approach
  - **Seamless integration** with existing services
    - ***IMS PS*** to deliver ***context updates*** about mobile node

IHMAS Power Management Facility: Distributed Architecture



- Context Monitor – ***CM*** (one for client): implements lightweight and completely decentralized context monitoring via local access to client wireless devices
- AS for Power Management – ***ASPM*** (one for IMS domain): realizes our IMS energy-saving optimization
- IMS PS – ***PS*** (one for access locality): facilitates CM-ASPM interactions

IHMAS Power Management Facility: Modified Invitation Protocol



- - - → IHMAS original message flow extensions

——→ IMS standard messages

1. CM proactively ***notifies context changes*** over the always-on interface
2. ASPM intercepts INVITE from Correspondent Node (CN) and ***activates wireless interface switch-on*** at Mobile Node (MN)
3. MN re-REGISTERs over switched-on interface, and ASPM ***re-directs CN by using a MOVED message***

Implementation Insights: AS for Power Management

```
    private void processInvite(Request request) {
1.    SessionDescription sdp =
        sipUtils.getSessionDescription(request);
      sd=addPowerManagementAttribute(request, sd);
      request.removeContent();
2.    try {
        request.setContent(sd,
        headerFactory.
          createContentTypeHeader("application","sdp"));
      } catch (ParseException e) { e.printStackTrace(); }
      try {
3.      sipProvider.sendRequest(request);
      } catch (SipException e) { e.printStackTrace(); }
    }
```

- ASPM implementation is based on ***JAIN SIP stack***
- On INVITE message, ASPM:
  1. Extracts Session Description Protocol (SDP) part of the message
  2. Adds in the optional field (“a:” field) the MAC of the wireless interface to switch on
  3. Sends it to MN

```
INVITE sip:alice@open-ims.test SIP/2.0
…
Content-Type: application/sdp
Content-Length: 414

v=0
o=- 0 0 IN IP4 192.168.3.11
s=IMS Call
c=IN IP4 192.168.3.11
t=0 0
m=audio 10281 RTP/AVP 3 0 14 101
b=AS:64
a=rtpmap:3 GSM/8000
a=rtpmap:0 PCMU/8000
a=rtpmap:14 MPA/90000
a=rtpmap:101 telephone-event/8000
a=fmtp:101 0-11
a=curr:qos local none
a=curr:qos remote none
a=des:qos mandatory local sendrecv
a=des:qos mandatory remote sendrecv
a=switchoninterface:00:04:23:5E:48:DE 192.168.125.2
```

- ***Modified INVITE*** message
  - SDP part of the INVITE message as modified by ASPM
  - **Note our application parameter a:…** field at the end of the message

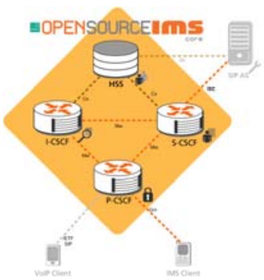
Implementation Insights: IMS Client

```
void ims_process_incoming_invite(eXosip_event *je)
{ …
  sdp_message_t * sdp_message;
  eXosip_lock();
  sdp_message=eXosip_get_sdp_info(je->request);
  eXosip_unlock();
  switchOnAddress=extractPowerManAttribute(sdp_message);
  if(newInvite) ims_send_de_register();
  else { … /* standard session invite management */ }
}

void ims_send_re_register()
{
int port=5060, pid, status;
pid=fork();
if(pid==0) {  // child
  if(!is_bye) { execl("../scripts/switchOnInterface.sh",
                "switchOnInterface.sh", switchOnAddress, (char *)0 ); }
  else { execl("../scripts/switchOffInterface.sh",
         "switchOffInterface.sh", switchOnAddress, (char *)0 );  }
} else {      // parent
  wait(&status);
  if(!is_bye) { while( eXosip_listen_addr(IPPROTO_UDP, switchOnAddress,
                            port, AF_INET, 0) != 0 ) port++; }
  else { while( eXosip_listen_addr(IPPROTO_UDP, alwaysOnAddress,
                            port, AF_INET, 0) != 0 ) port++; }
  ims_send_register();
}
```

- Based on ***UCT IMS Client***
- New-INVITE processing
  - ***Extracts*** from the “a:…” field ***the MAC of the wireless interface to switch on***
  - Sends de-REGISTER
- Re-registration
  - ***Switches on the wireless interface***
  - ***Sends a REGISTER*** over the switched-on wireless interface

Implementation Details



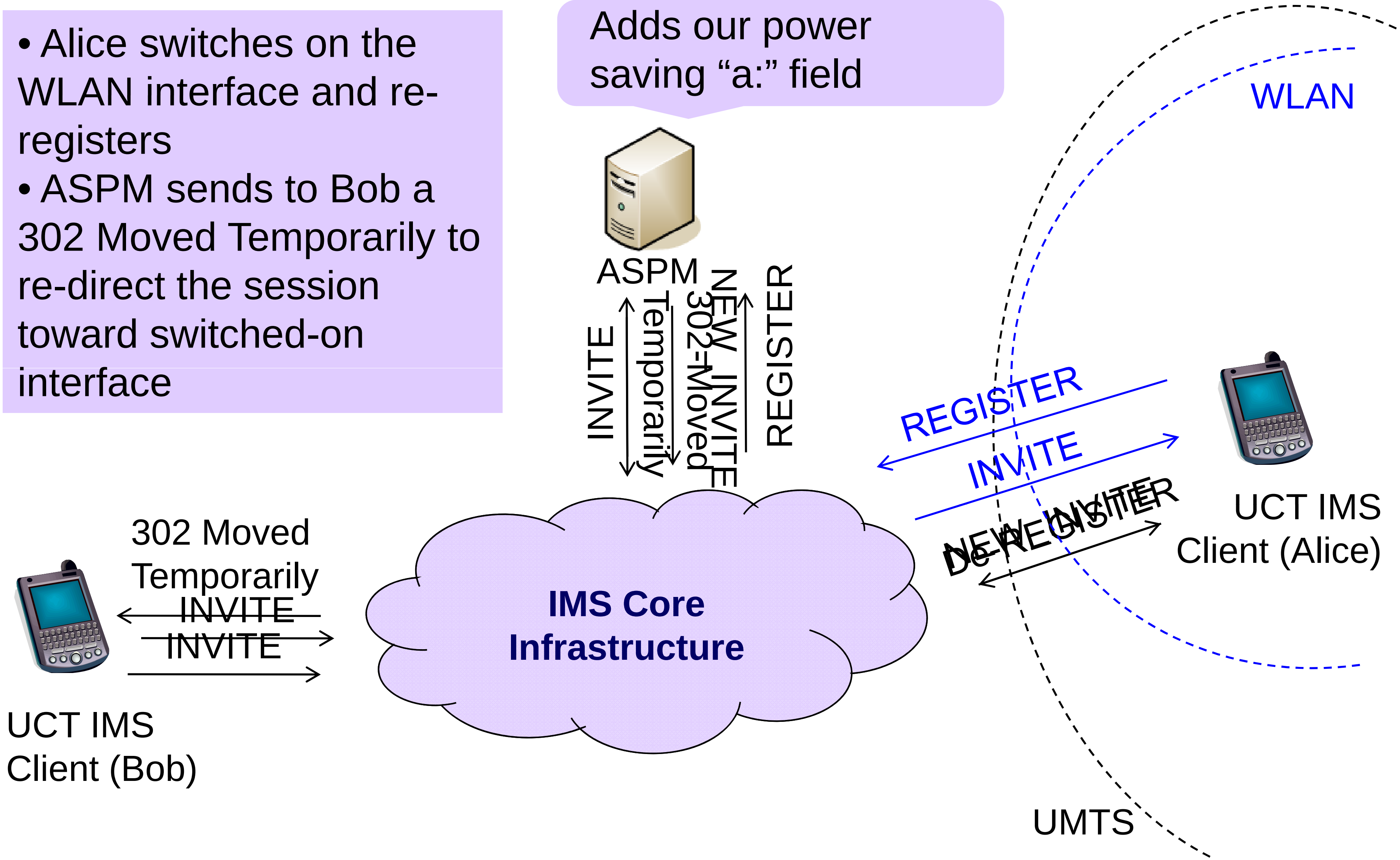
ASPM

UCT IMS Client

- IMS core components
  - OpenIMSCore (Fokus)
  - initial Filter Criteria (iFC) for IMS message re-routing
- ASPM
  - Java NIST JainSIP implementation of the SIP stack
  - OpenIMSCore properly configured to interpose ASPM in the signaling path
- University of Cape Town (UCT) IMS Client
  - CM: **`iwconfig`** and **`hcitool`** (Linux), NDIS (WIN)
  - CM integration with UCT IMS Client
- Deployment environment
  - Client: Linux laptops with 3G UMTS adaptor and IEEE 802.11b Cisco card
  - P-/I-/S-CSCF run on PCs: 2 CPUs 1,80GHz, 2048MB RAM, Linux Ubuntu
  - Wireless infrastructures:
    - Wi-Fi: Cisco Aironet 1100 AP

Experimental testbed

- Alice switches on the WLAN interface and re-registers
- ASPM sends to Bob a 302 Moved Temporarily to re-direct the session toward switched-on interface



Experimental Results (1): some elements about the testbed

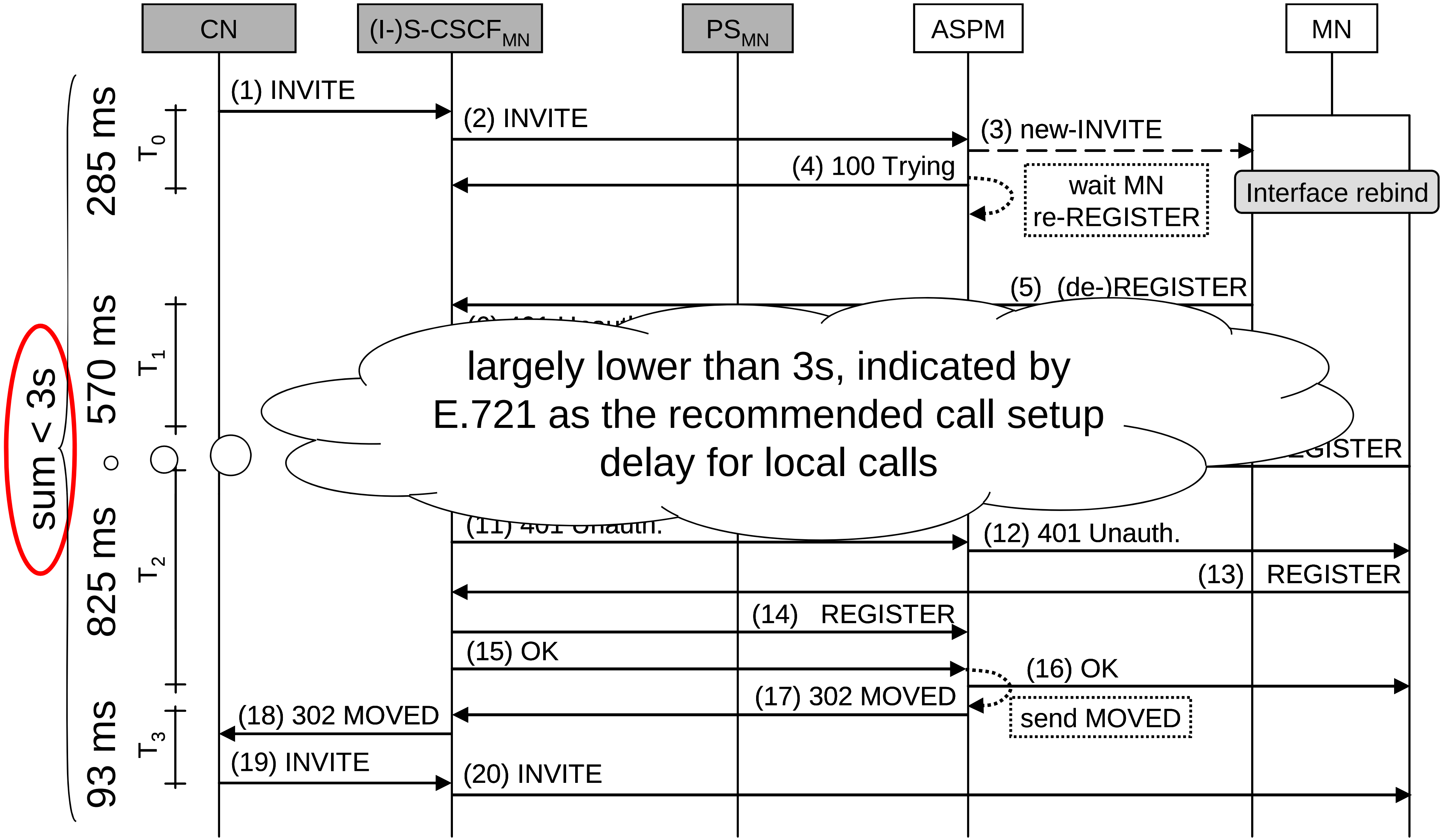
<u>Experimental testbed</u>:

- ❑ Linux boxes for the IMS infrastructure (1.8GHz CPU and 2GB RAM)
- ❑ ***Nokia N95*** as reference client device (one of the first smart phones with WiFi)
- ❑ **VoIP service with GSM-encoded** audio, frame rate = 50 frames/s
- ❑ Reported results are averaged over 1000 session initiation cases

<u>Session Initiation Delay Analysis</u>:

- T0: initiation phase
- T1: mobile node de-registration
- T2: mobile node registration for WiFi
- T3: MOVED notification

Experimental Results (2): session inititation delay

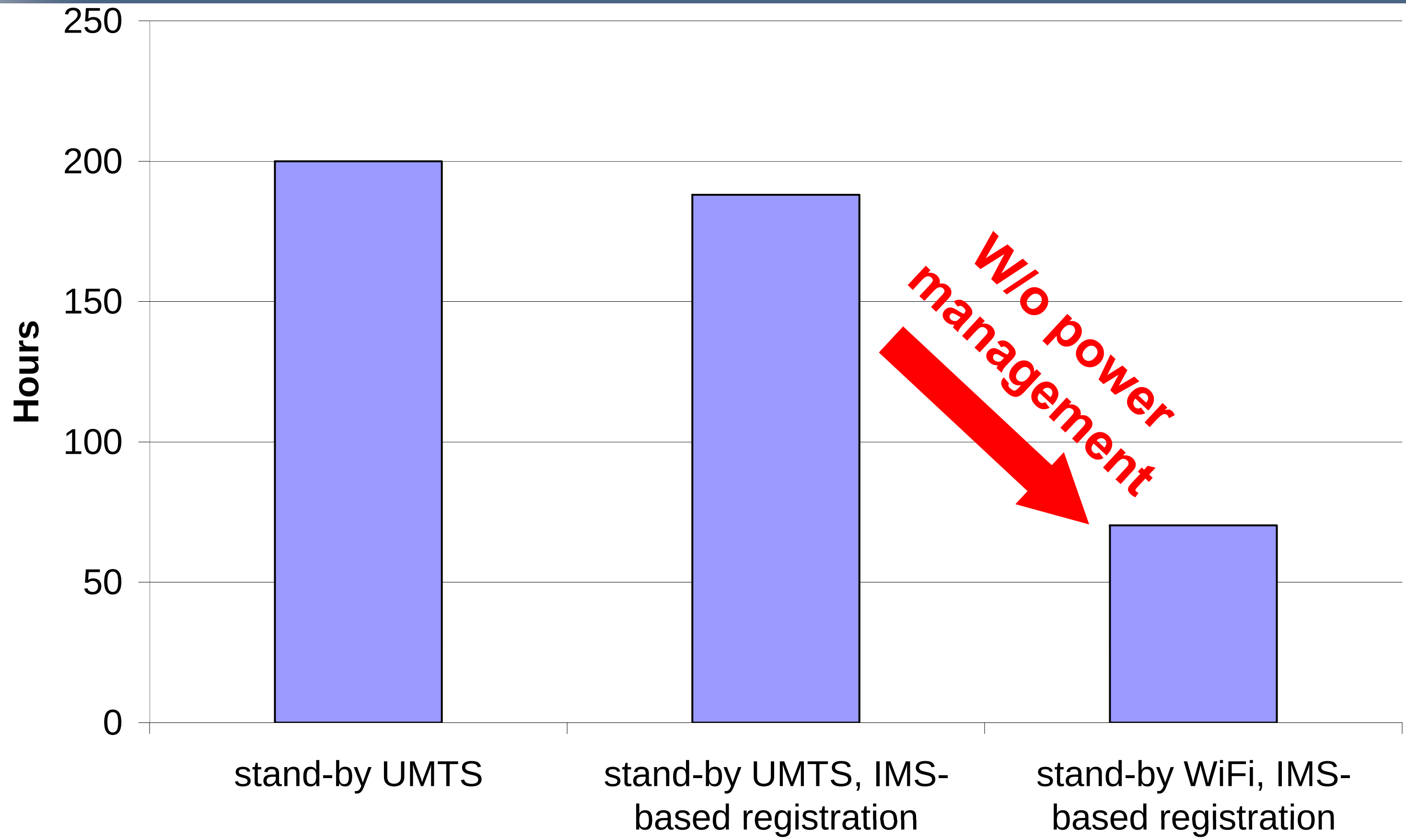


Experimental Results (3): Stand-by time

Nokia N95

WiFi and UMTS standby

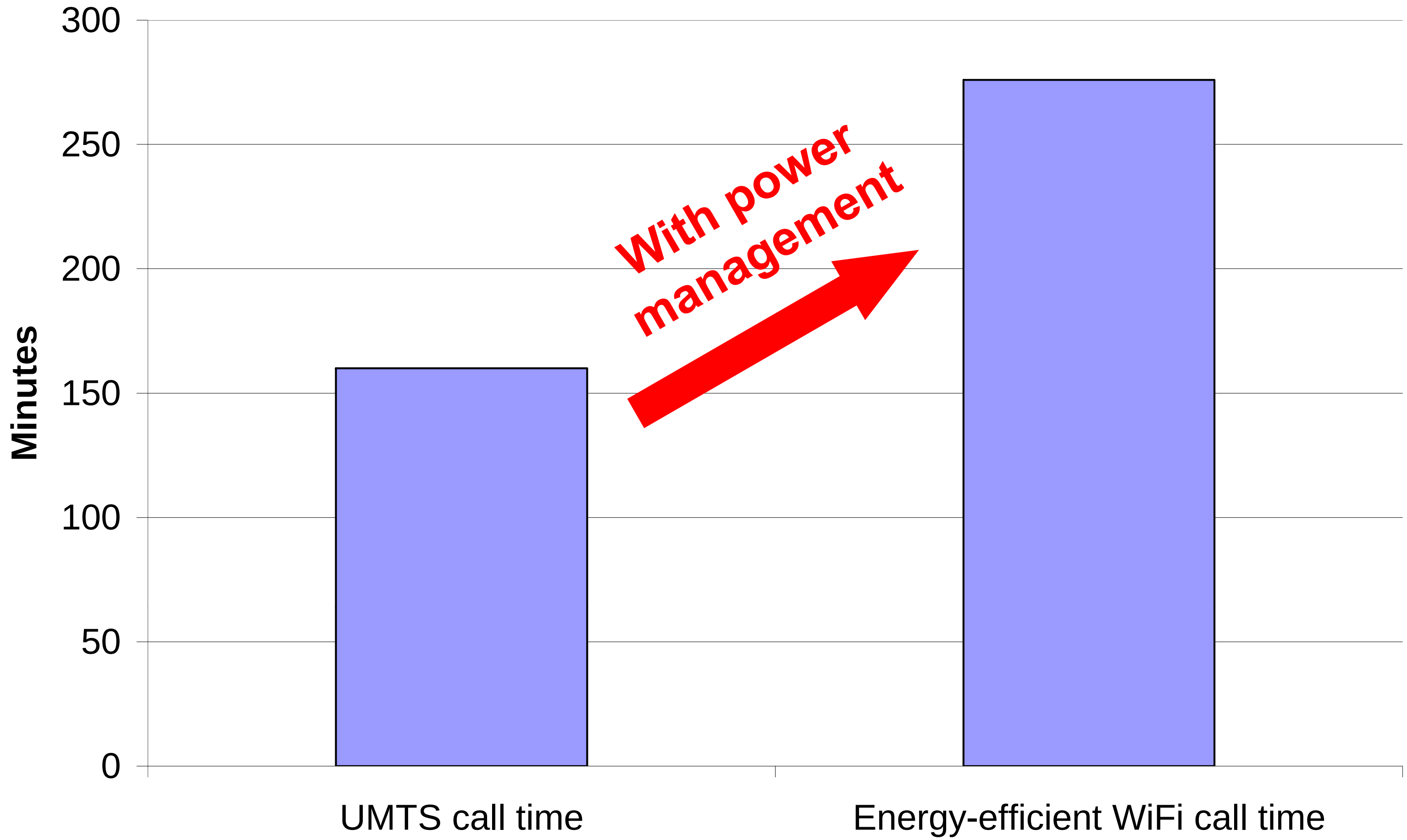
These standby costs are completely eliminated by our IHMAS power management technique



- Analytical results evaluated for N95 (also based on Arjona experience and measurements)
  - Battery: 950mAH and charged at 3.7V
  - WiFi average additional consumption (always-on): 0.05W

Experimental Results (4): Call time

In addition, ***significant advantages on call time***



- Energy-efficient WiFi call time is longer than the talk time duration specified by Nokia for UMTS

Conclusions and ongoing work

- Conclusions
  - ***Feasibility*** of IMS-based standard approaches also for ***context-aware power management***
  - Practical guide on how to exploit IMS ASs to support application-level management functions
  - Energy-saving techniques can ***relevantly increase battery lifetime*** when using high-consumption and low-cost wireless interfaces
  - ***Session invitation delays*** introduced by the IHMAS facility for power management are ***compatible even with strict VoIP reqs***

- Ongoing work
  - Scalability issues of IMS PS (see our article on IEEE Wireless Comm in June)
  - J2ME version of CM and IMS client
  - Extensive measurements of energy consumption in wide-scale deployment environments

IHMAS project Web site and contacts

- Prototype code: **http://lia.deis.unibo.it/Research/IHMAS**

- Contacts: Luca Foschini (lfoschini@deis.unibo.it)

Any questions?

Thanks for your attention!