ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

Ασύρματα Δίκτυα και Κινητοί Υπολογισμοί

Μαρία Παπαδοπούλη
Τμήμα Επιστήμης Υπολογιστών
Πανεπιστήμιο Κρήτης

Χρηματοδότηση

- Το παρόν εκπαιδευτικό υλικό έχει αναπτυχθεί στα πλαίσια του εκπαιδευτικού έργου του διδάσκοντα.
- Το έργο «**Ανοικτά Ακαδημαϊκά Μαθήματα στο Πανεπιστήμιο Κρήτης**» έχει χρηματοδοτήσει μόνο τη αναδιαμόρφωση του εκπαιδευτικού υλικού.
- Το έργο υλοποιείται στο πλαίσιο του Επιχειρησιακού Προγράμματος «Εκπαίδευση και Δια Βίου Μάθηση» και συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση (Ευρωπαϊκό Κοινωνικό Ταμείο) και από εθνικούς πόρους.

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Σημείωμα αδειοδότησης

Agenda

- Introduction on Mobile Computing & Wireless Networks
- Wireless Networks - Physical Layer
- IEEE 802.11 MAC
- Wireless Network Measurements & Modeling
- Location Sensing
- **Performance of VoIP over wireless networks**
- Mobile Peer-to-Peer computing

This presentation is based on two recent research papers that were done with my students:

Ilias Tsompanidis, Giorgos Fortestanakis, and Toni Hirvonen, a postdoc at FORTH (now with Dolby):

- Analyzing the impact of various wireless network conditions on the perceived quality of VoIP (***IEEE LANMAN'10***)
- A comparative analysis of the perceived quality of VoIP under various wireless network conditions **(*WWIC'10*)**

Roadmap

- ➔ **Introduction**
- Objectives
- Methodology
  - Network conditions
  - Metrics
  - Codecs
- Performance analysis
- Conclusions & future work plan

Wireless landscape

☞ Wireless networks experience periods of severe impairments due to various reasons, such as **contention, handovers, channel impairment, outages, congestion**

Important observations:

- **Handoffs result to packet losses**
- **Queue overflows at APs lead to poor VoIP quality**
- Average delay does **not capture well the VoIP quality due to packet loss burstiness**

☞ **No comparative analysis** of the **impact of various conditions on the perceived quality of experience** (**QoE**)

Objectives

Long-term objectives

☞ Characterize the **perceived quality of experience (QoE)**

Reliability of ‘rule of thumbs’ such as an 150 ms end-to-end delay

☞ Improve the **adaptation mechanisms** to **enhance QoE**

Shorter-term objectives

- Analyze the impact of **codecs** & various **network conditions** on QoE
- Analyze the performance of various **QoE metrics**

Performance analysis methodology

- Important parameters:
  - **network conditions**: handover, heavy TCP traffic & heavy UDP traffic
  - **codecs**: **G711, AMR 6.7kb/s, AMR 12.2kb/s**
  - **metrics**: subjective (**auditory tests**), objective (**PESQ** and **E-model**)
- Set testbeds that manifest the above network conditions
- Collect data using the above network conditions, codecs, and metrics
- Statistical analysis using ***Student's T-Test, ANOVA & HSD***

Testbed

- 2 VoIP users: a **wireless** and a **wired one**
- VoIP users use **H323** with **G.711 codec (64kbps)**
- The **wireless VoIP client captures packets in promiscuous mode using tcpdump**

- Recording of a female voice in English, 1:30 min long
- “Replayed” various network conditions in the testbed
- For each condition, specific traffic was generated to emulate the network condition

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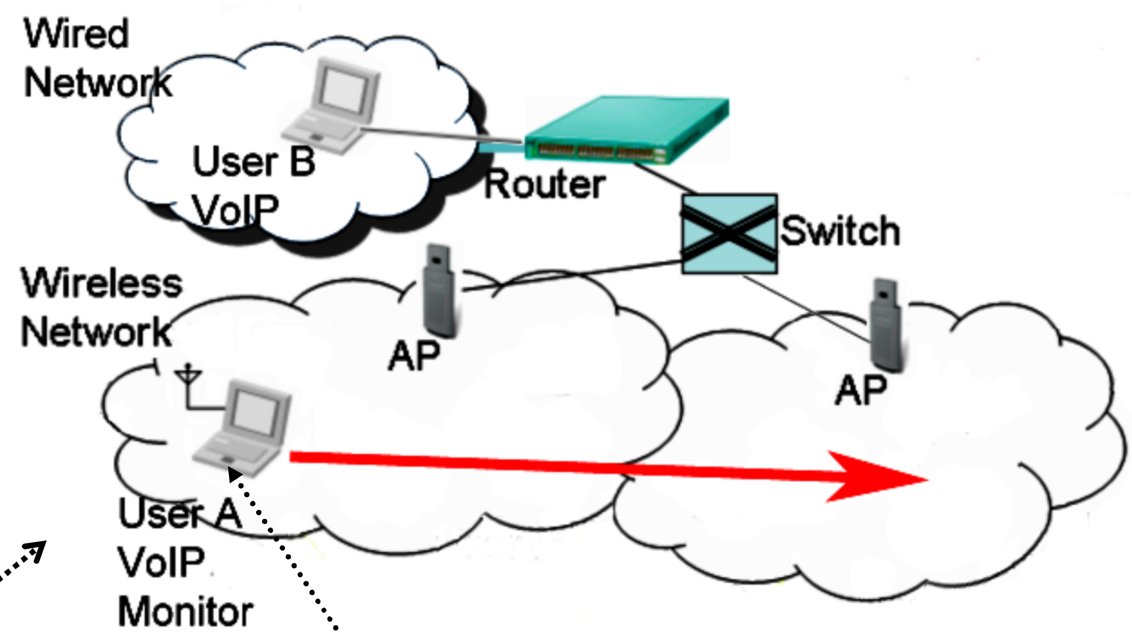
Handover scenario

- No background traffic
- User A roams in the premise of FORTH
- **Handovers between two APs**
- **Lasts 1 to multiple seconds**
- Consist of:

active scanning
acquisition of new IP addr
reassociation

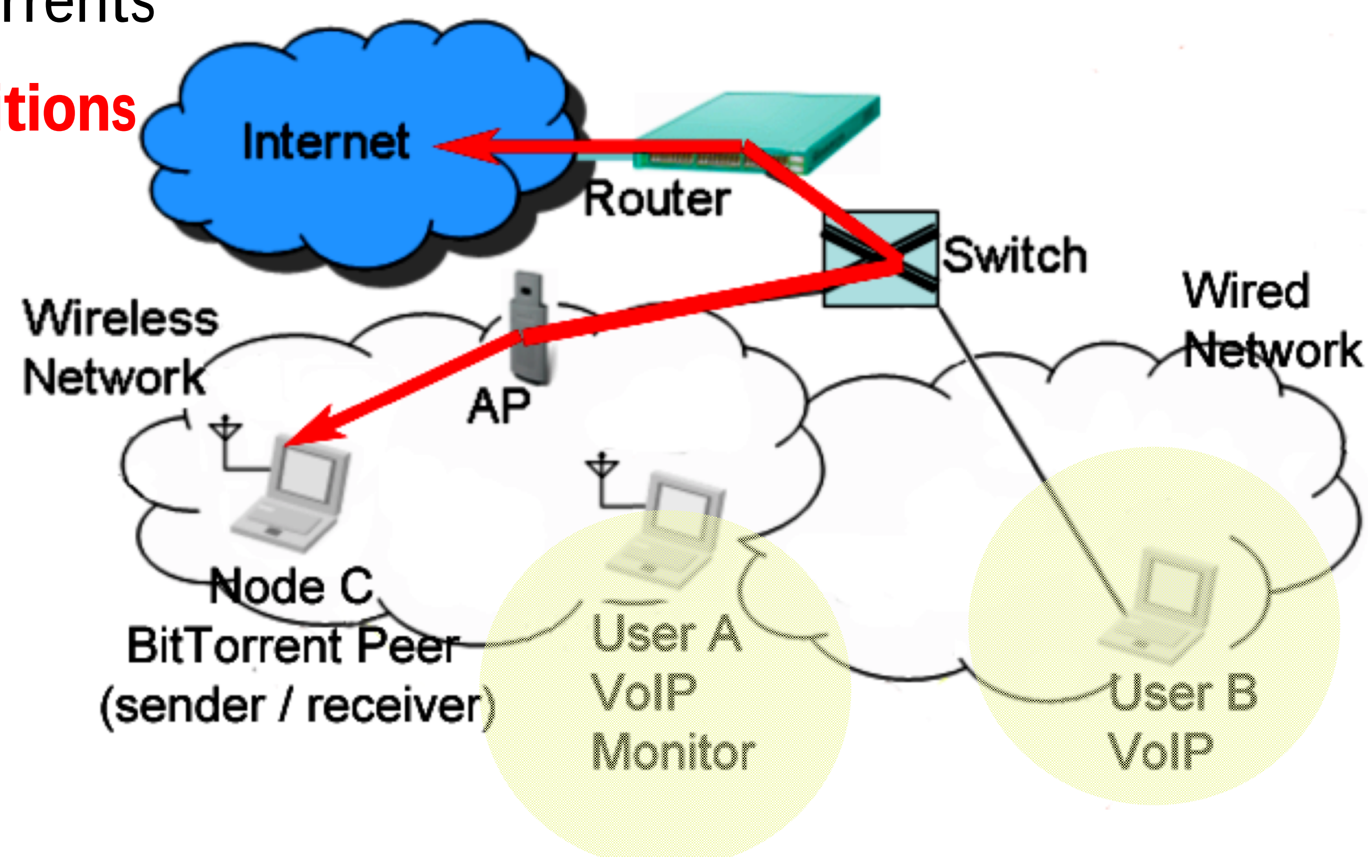


Use H323 & G711

captures packets in promiscuous mode

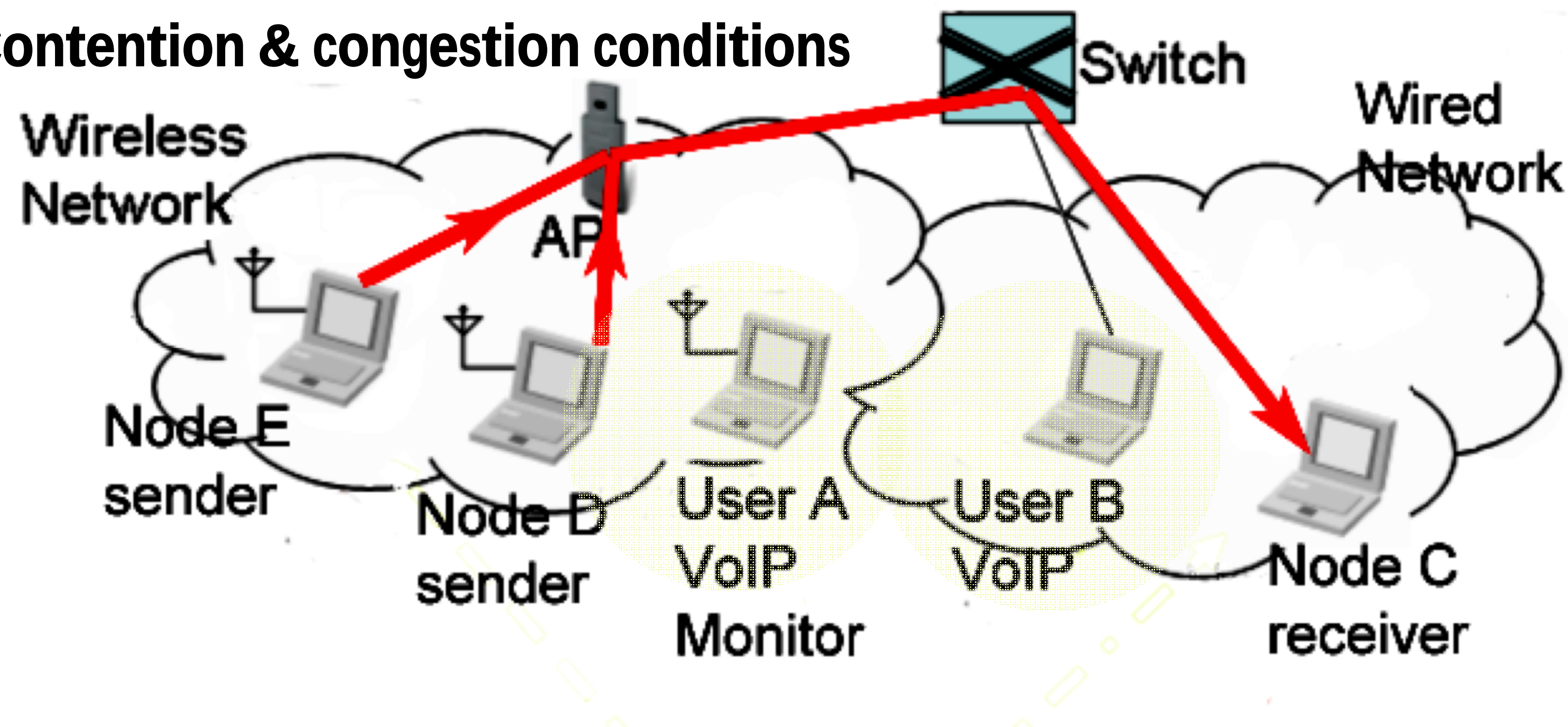
Heavy TCP traffic scenario

- No user mobility
- Background traffic: BitTorrent
- Highly seeded torrents
- **Saturation conditions**



Heavy UDP traffic scenario

- **No** user mobility
- Background UDP traffic
- 4 clients, each generates 2 Mbps
- **Contention & congestion conditions**



Roadmap

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  - Network conditions
  - ➔ **Metrics**
  - Codecs
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E-model

Takes into account:

- Average delay
- Packet losses
- Packet loss burstiness

E-model

Takes into account:

- Voice specific impairments
- Delay and echo impairments
- Equipment impairment
- Packetization distortion
- Codec robustness
- Voice loudness
- Background noise

default values set according to ITU recommendation

PESQ

- Compares **two audio signals**
- ☞ Estimates the **perceptual difference** between them

PESQ

- <u>Our approach:</u>

Subjective Tests

- Ten subjects, members of FORTH-ICS, of age between 22-35 years old, without hearing impairments
- A recording of a female voice in English, around 1.30 min
- Three calls, each corresponding to a network condition
- Each subject listened to these three calls, and reported an opinion score for each of them

Roadmap

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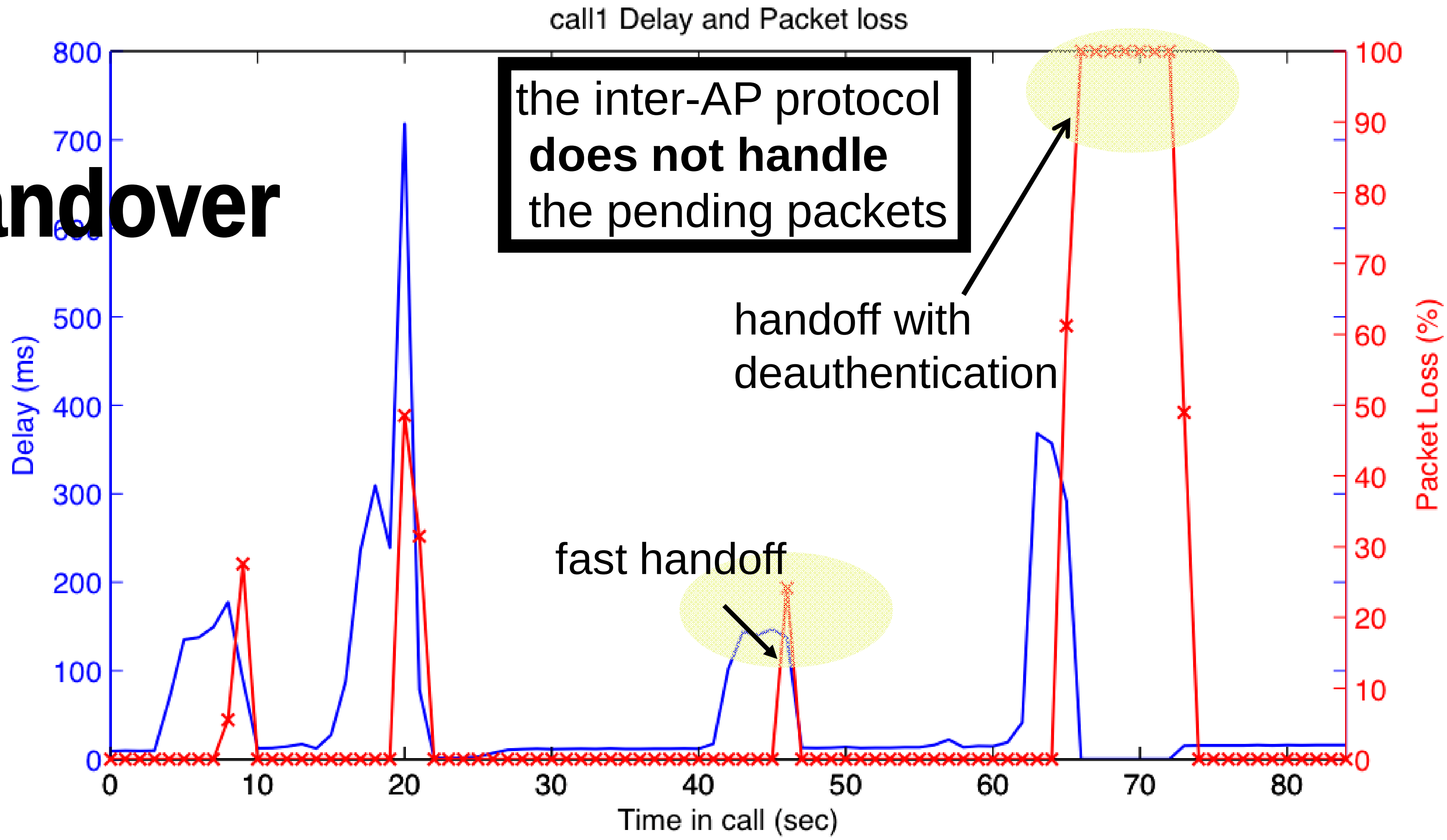
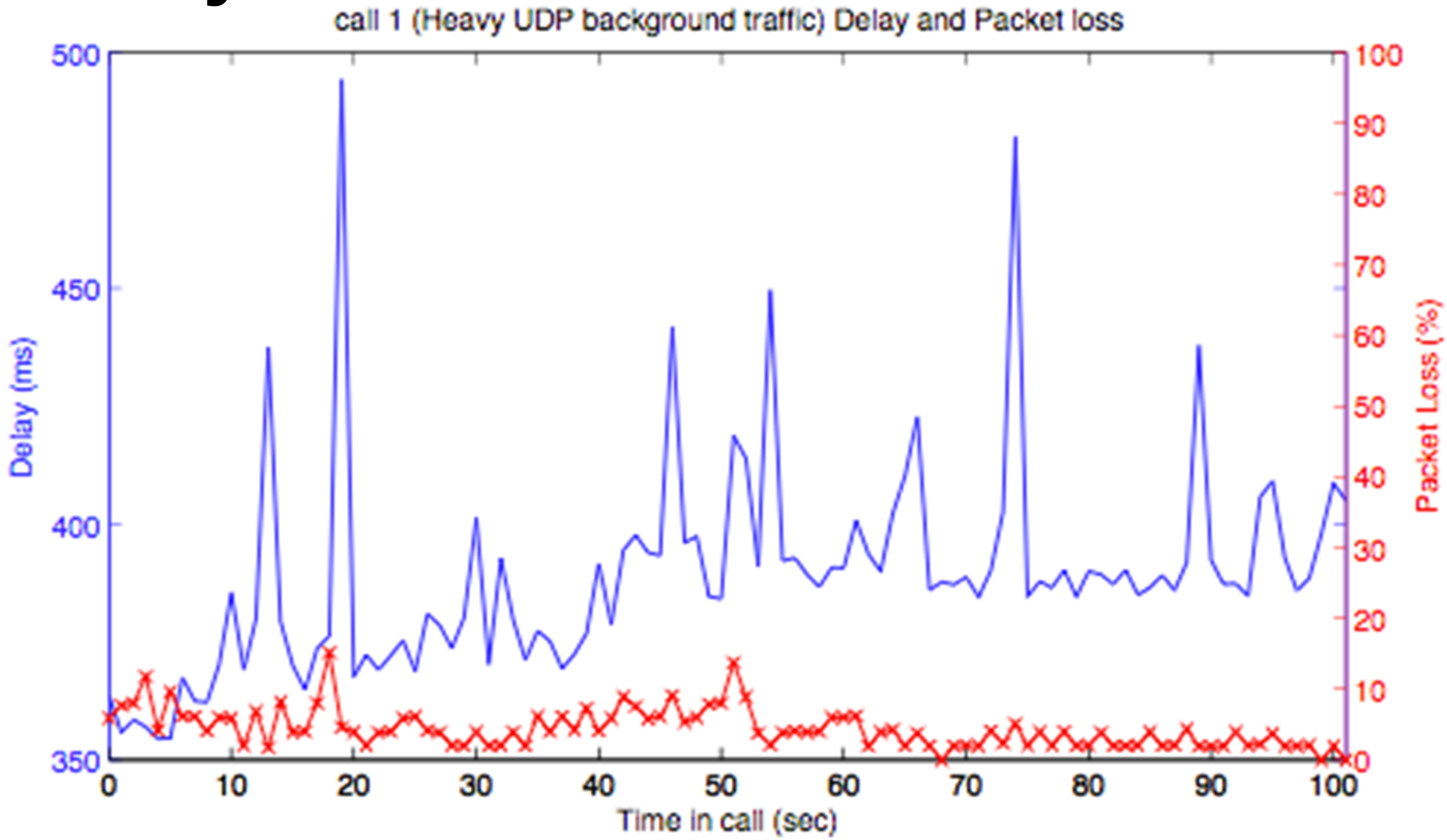
  - Metrics
  - ➔ **Codecs**
- Performance analysis
- Conclusions & future work plan

Handover



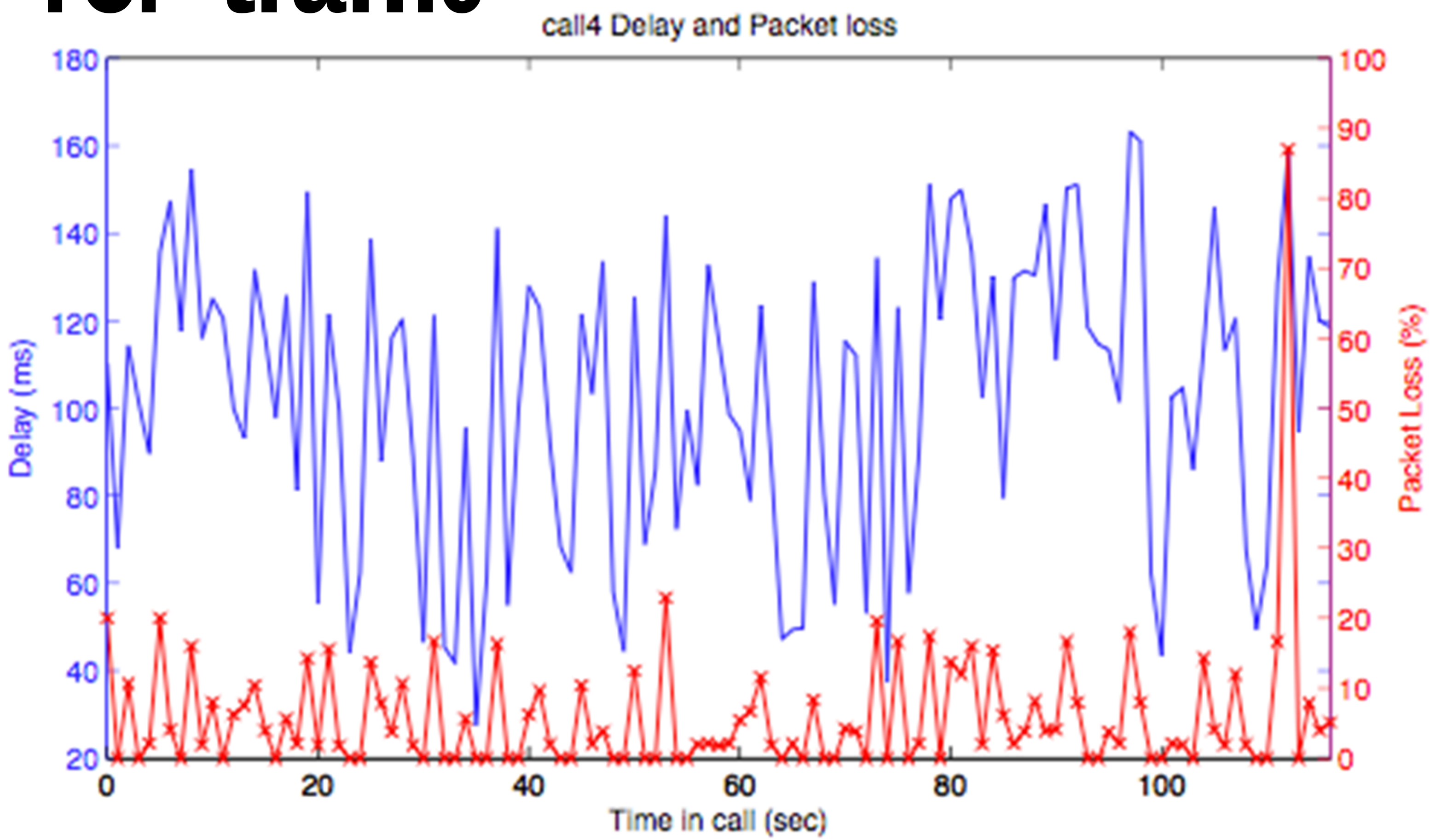
- Relatively low delays (except during scanning & handovers)
- No packet losses (except during scanning, handover, deauthentication)

Heavy UDP traffic



- Constantly large delays
- Low packet losses

Heavy TCP traffic



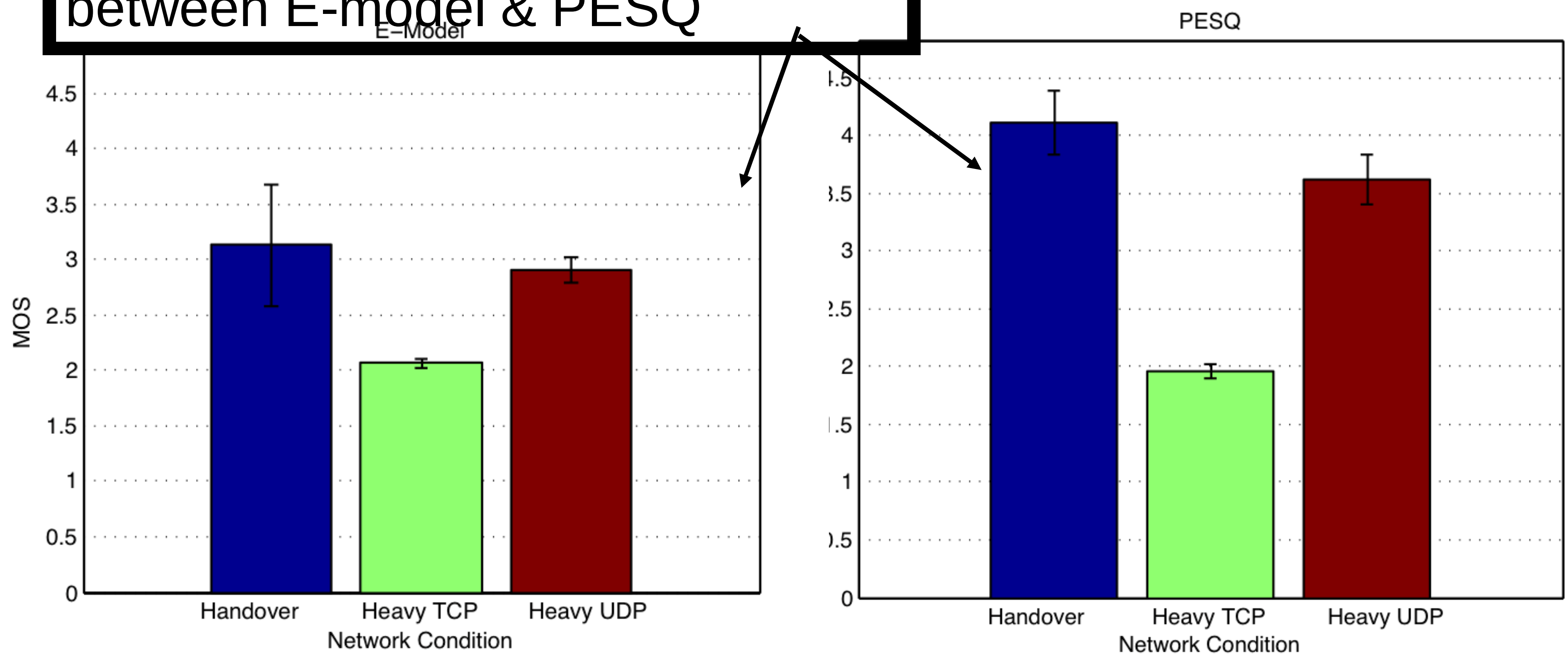
- Significant packet losses
- Noticeable delays

Saturated network with full buffers → need for a **prioritization scheme** **for different classes (IEEE802.11e)**

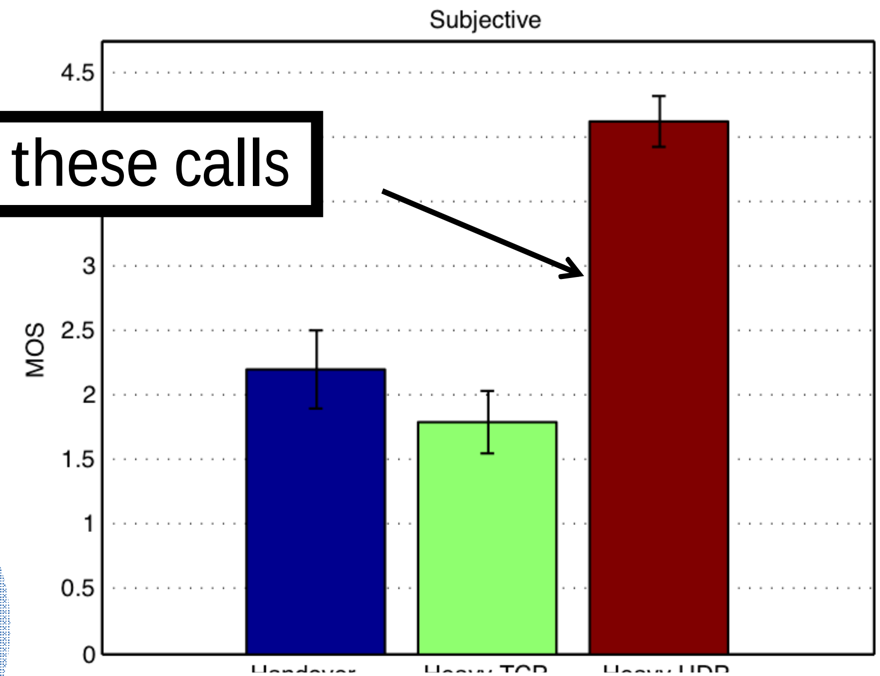
TABLE I
EXAMPLES OF VOIP CALLS UNDER VARIOUS SCENARIOS.

Scenario/Network conditions	Mean delay (ms)	Std delay (ms)	Packet loss (%)	Std packet loss (%)	BurstR	E-model MOS
Handover	24.23	40.43	8.66	26.61	201.40	3.07
Handover	55.99	72.20	8.12	25.53	131.35	3.14
Handover	32.25	81.67	8.51	26.97	198.55	3.09
Handover	58.91	71.66	8.22	26.90	394.68	3.11
Heavy UDP traffic (*UDP-8*)	499.23	11.4	2.57	2.09	1.78	2.57
Heavy TCP traffic	96.28	104.10	11.24	15.42	2.11	2.86

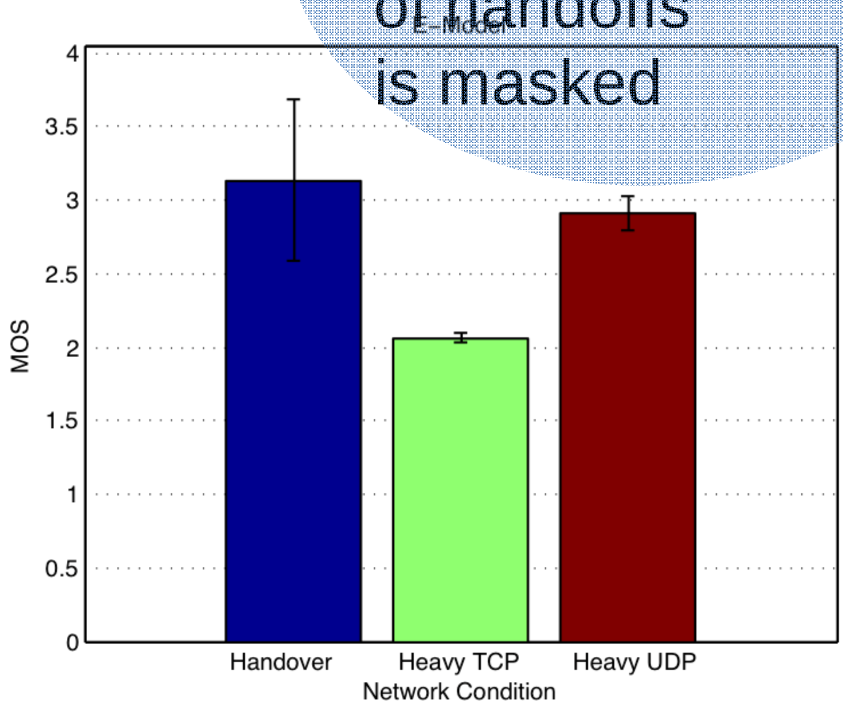
statistically significant differences between E-model & PESQ

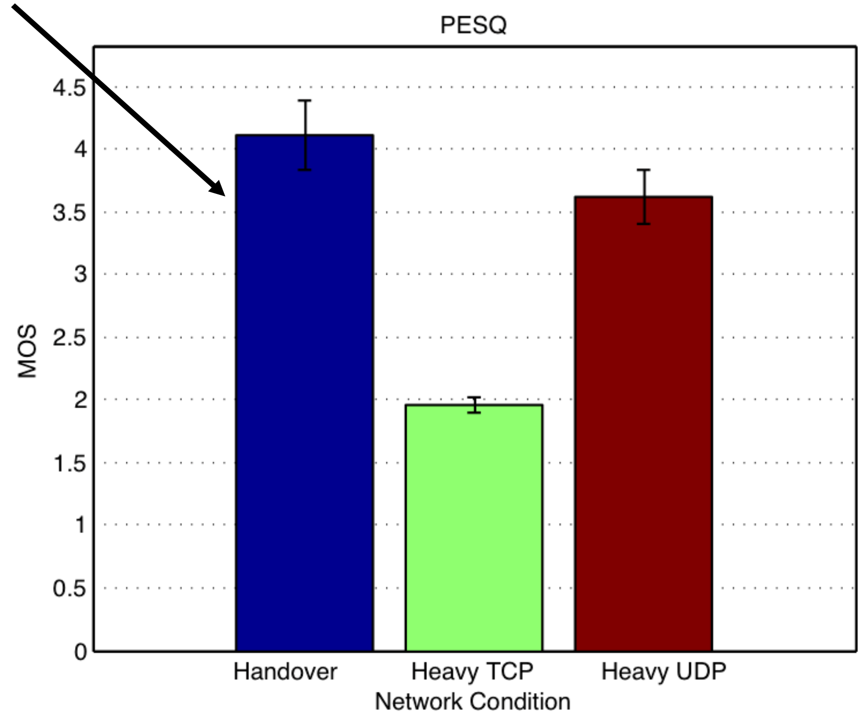


due to the non-interactive nature of these calls



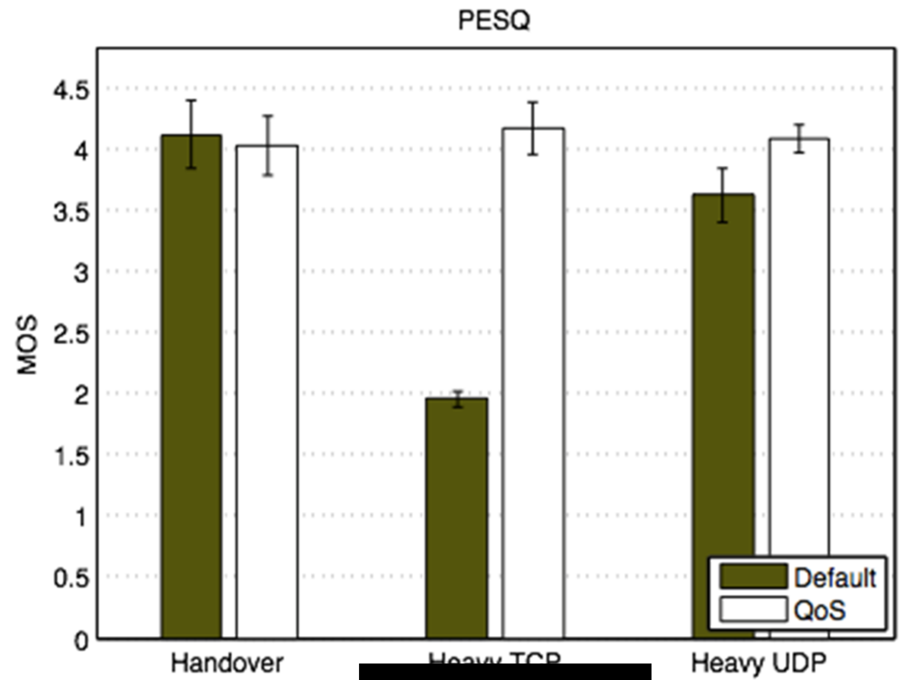
due to its averaging the negative impact of the large delays of handoffs is masked

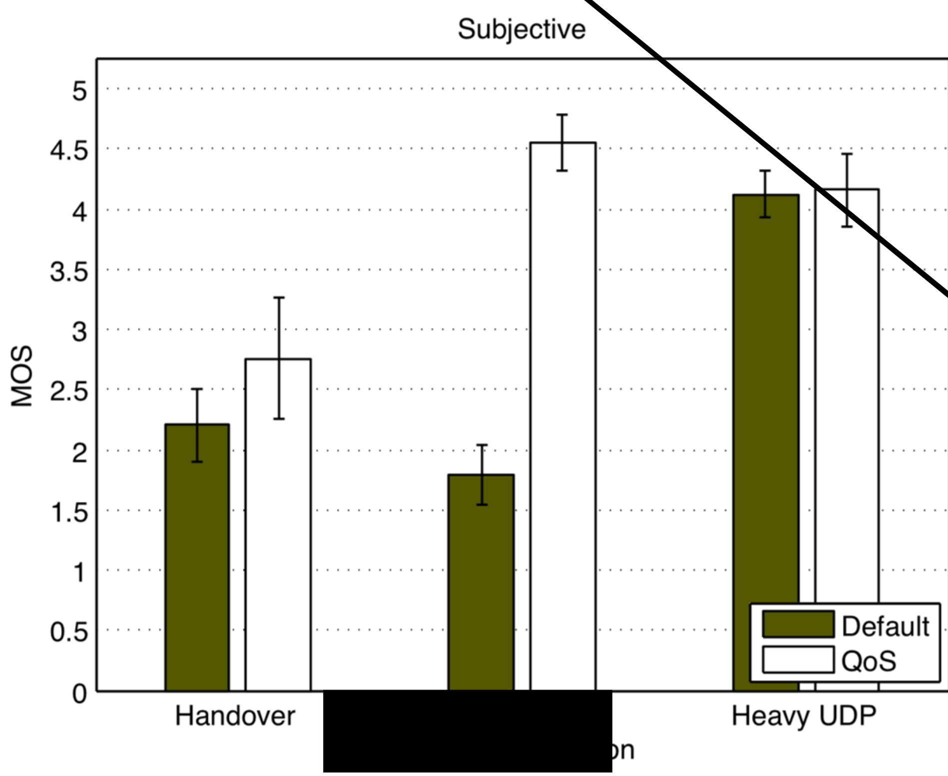


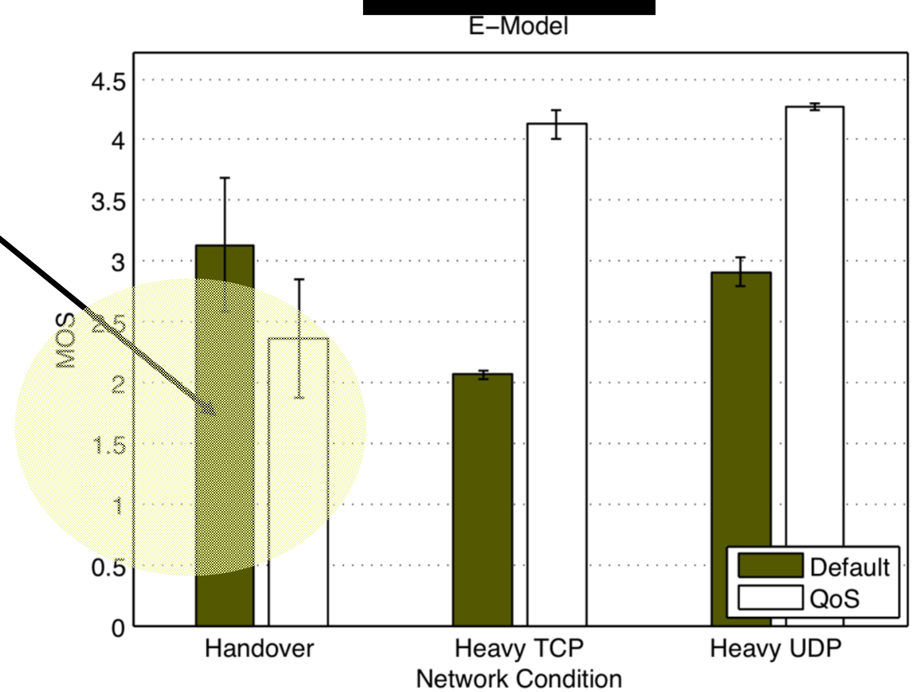


Impact of QoS

of long handovers when QoS was enabled was increased

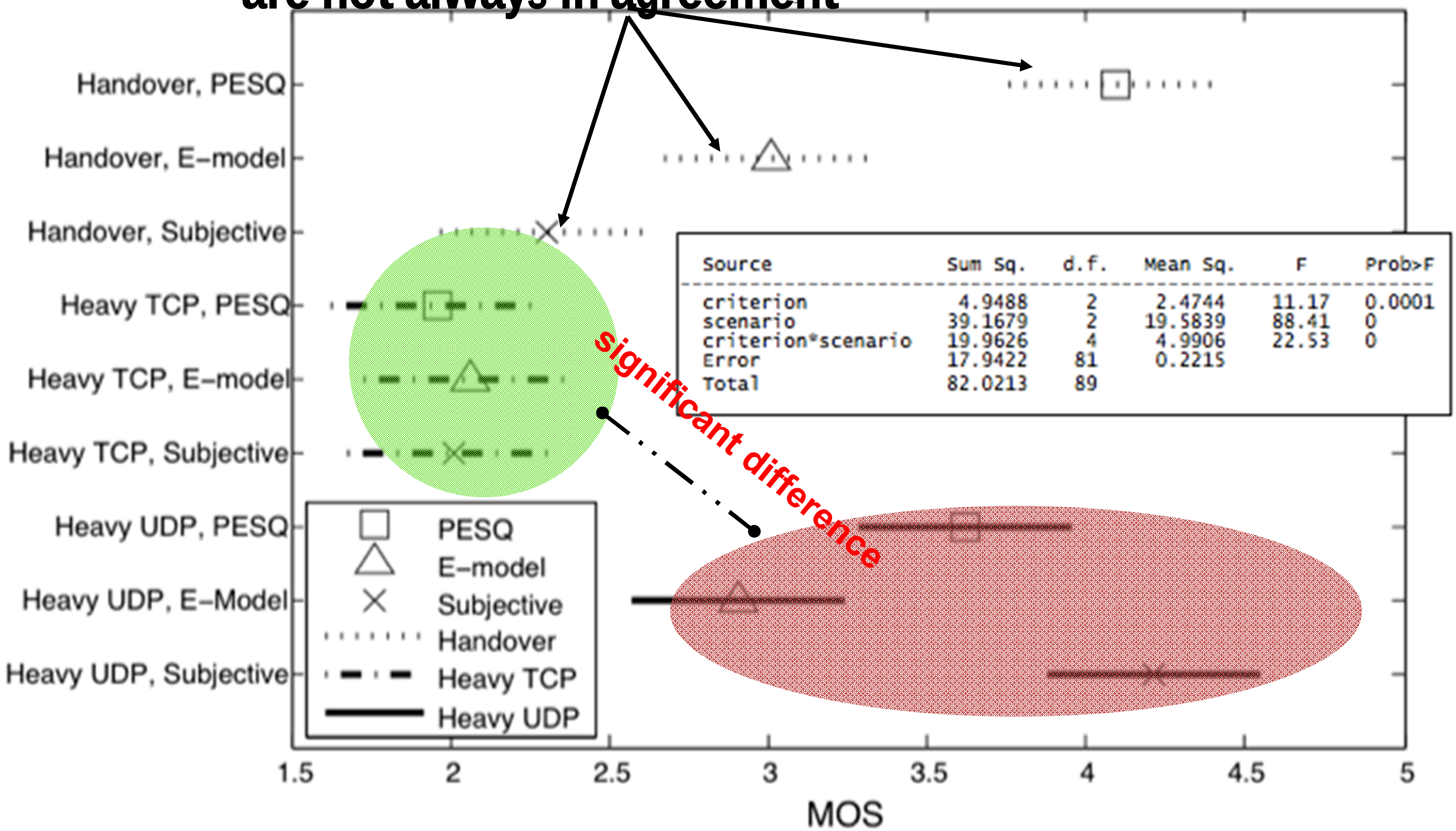






Analysis using ANOVA & HSD

Results from different perception metrics are not always in agreement



Source	Sum Sq.	d.f.	Mean Sq.	F	Prob>F
criterion	4.9488	2	2.4744	11.17	0.0001
scenario	39.1679	2	19.5839	88.41	0
criterion*scenario	19.9626	4	4.9906	22.53	0
Error	17.9422	81	0.2215		
Total	82.0213	89			

Conclusions

- Inability of PESQ & E-model to capture the user experience

  ☞ PESQ due to its *averaging* masks the negative impact of handoff delays

- **Statistically significant differences** based on the **metric, scenario & their interplay**
- Packet concealment of **AMR 12.2kb/s & QoS are beneficial**
- G.711 64kb/s vs. AMR 6.7kb/s perform similarly

☞ **Performance degradation** when handoff with de-authentication occurs **even** when **QoS is enabled**

Future work

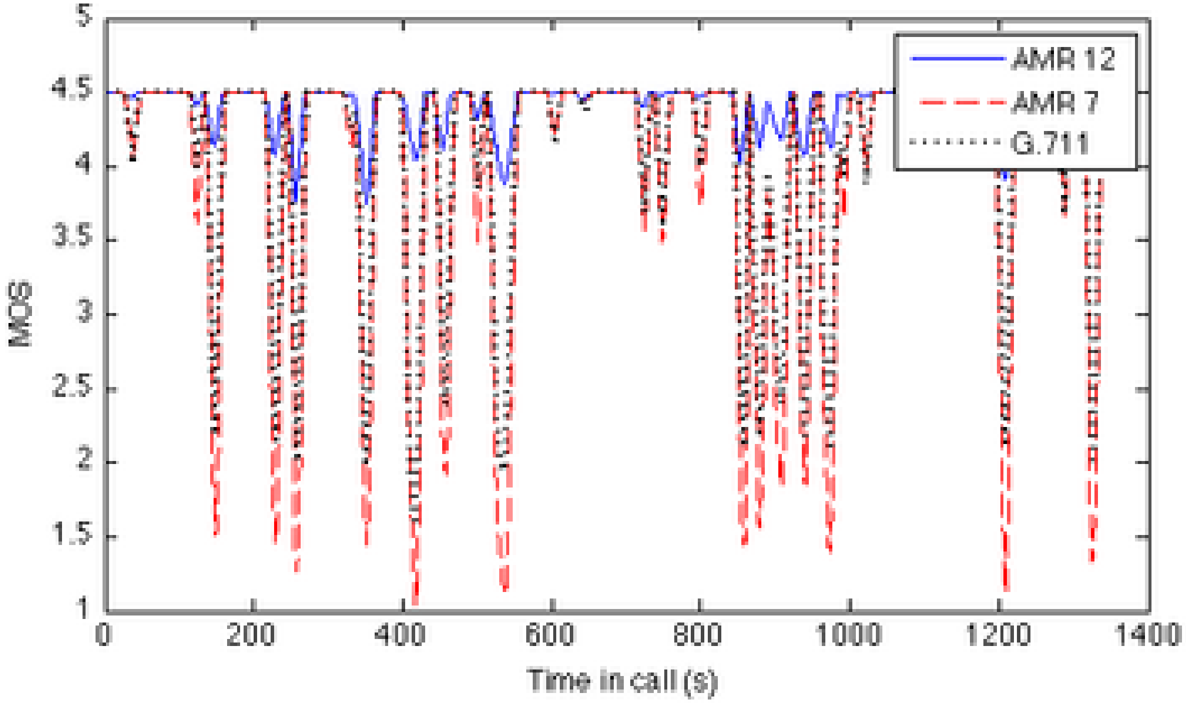
- Improve the auditory tests/user study
  - Shorter recordings
  - Different samples
  - Impact of the **relative position** & **duration** of long pauces
- Further experiments with other ***testbeds & apps***
  - IEEE802.11 QoS-enabled
  - WiMAX
  - **home/airport/hotel networks**

Future work

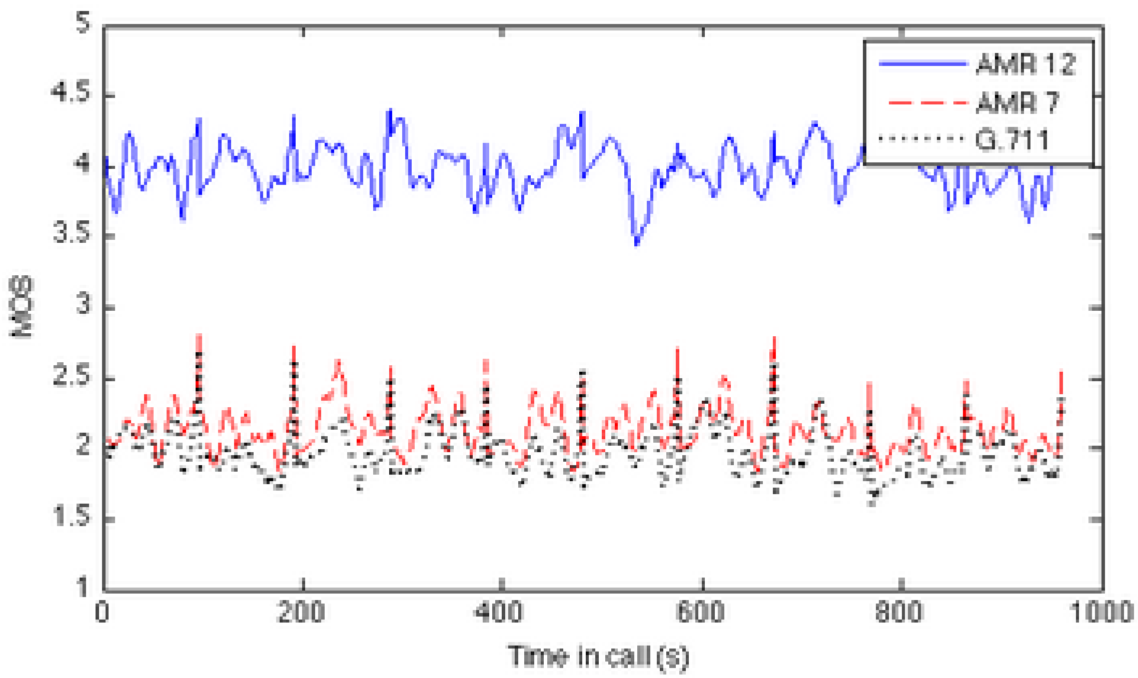
- **Cross-layer measurements to predict network conditions**
  – Hard to prediction transitions
  – Evaluate the performance gains

More info at http://www.ics.forth.gr/mobile

Codecs

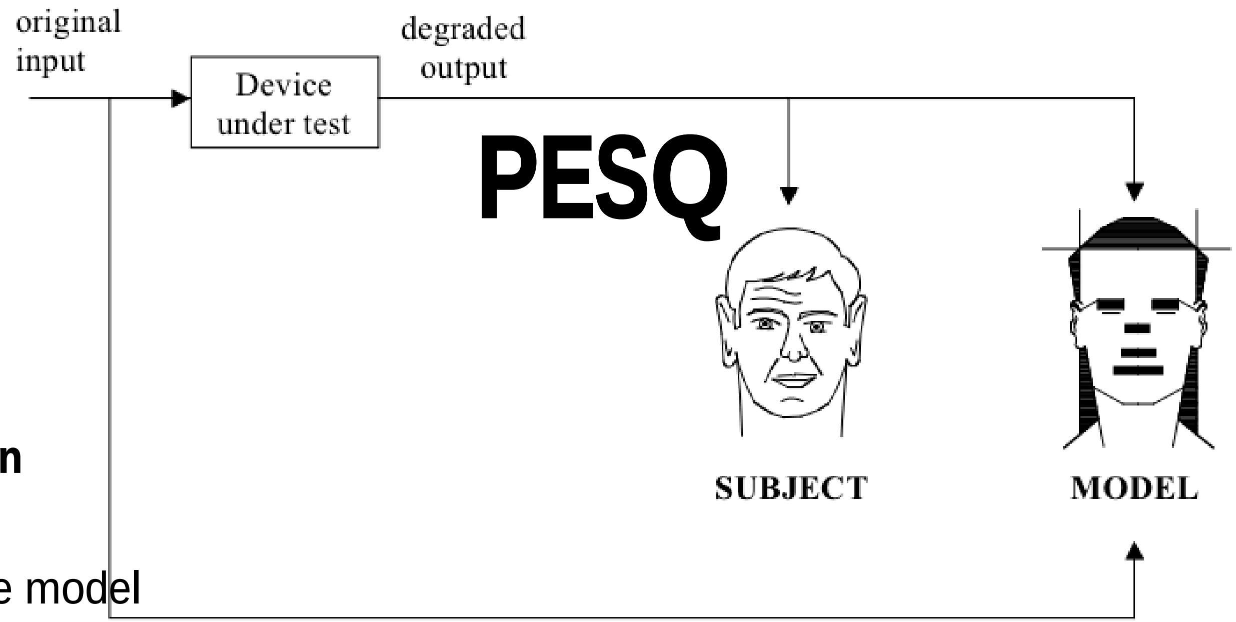


Handover (no QoS)

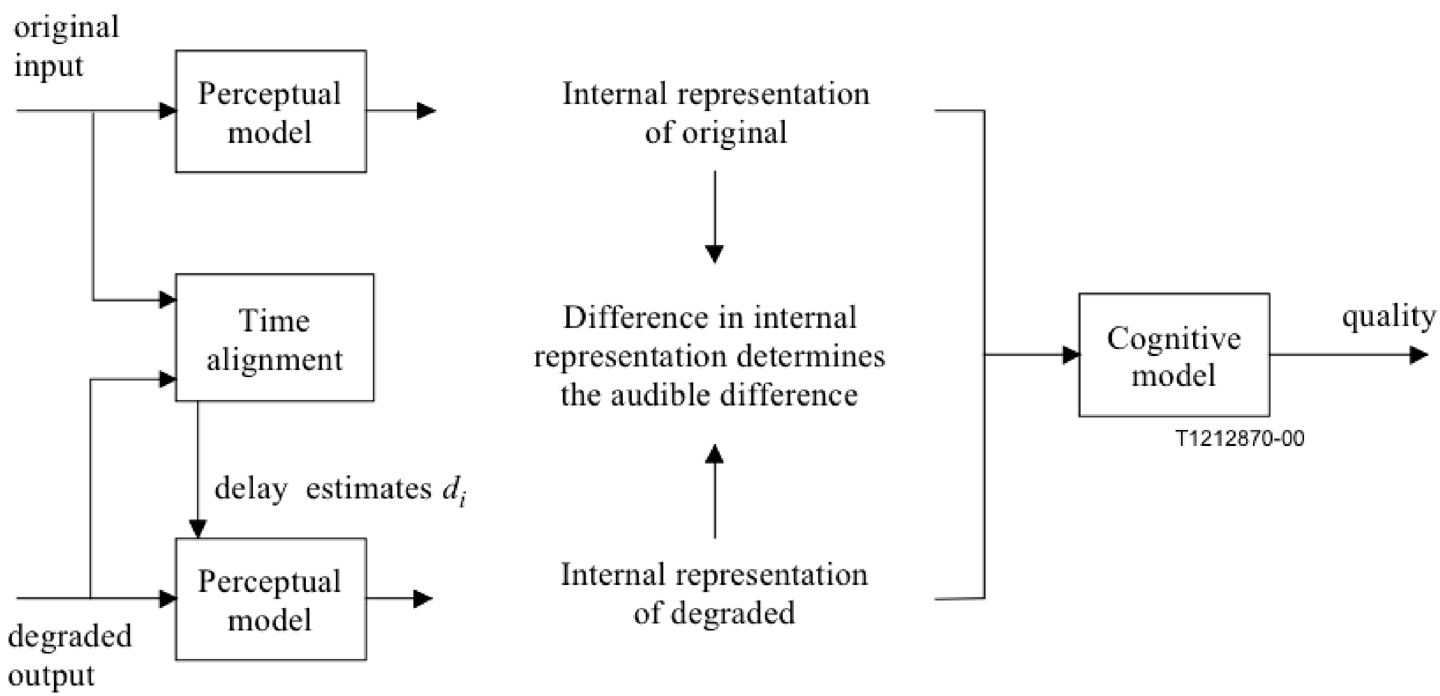


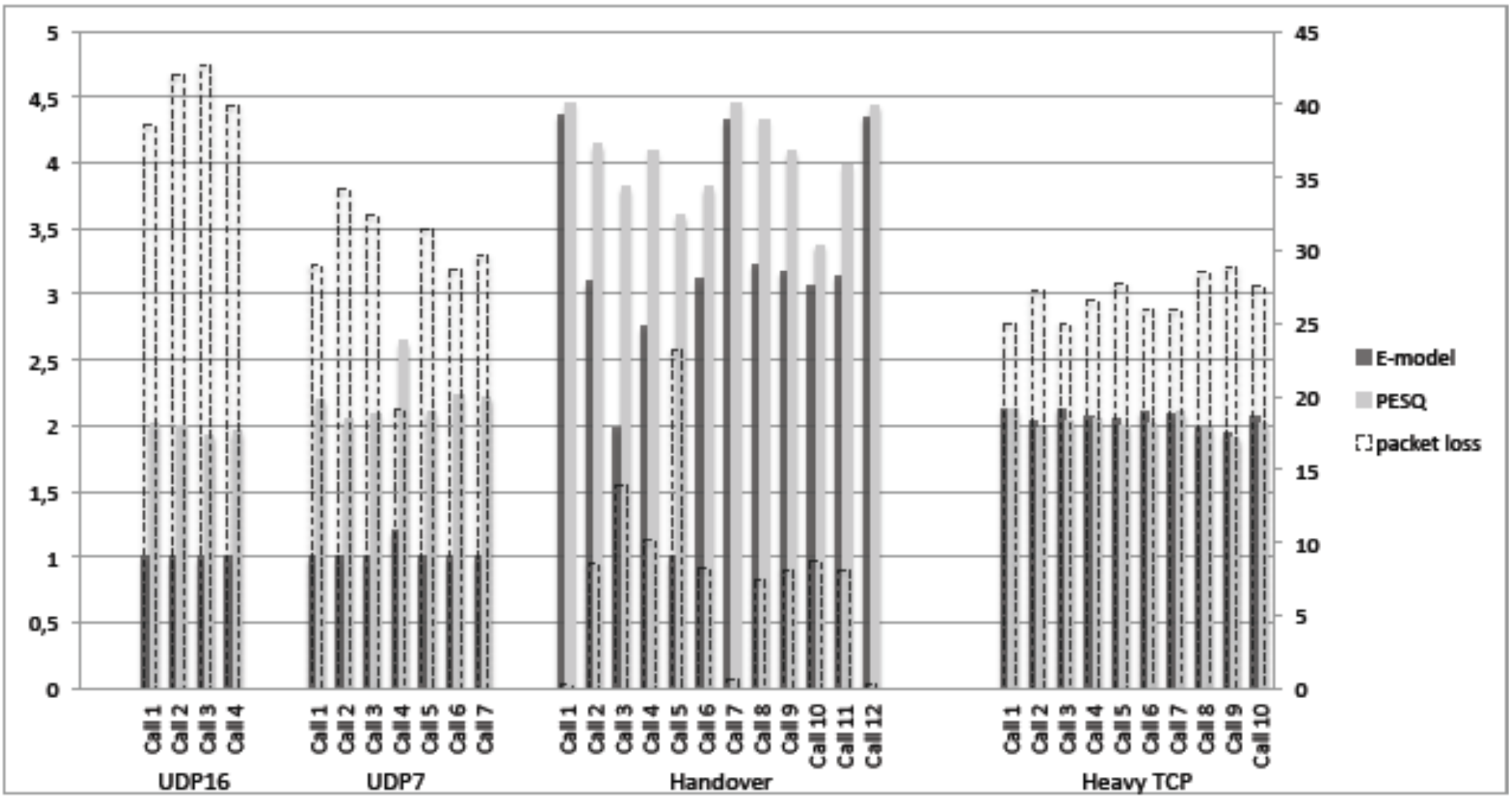
Heavy TCP (no QoS)

PESQ



- **Audio signal comparison**
- Regressive algorithm
- Perceptual and cognitive model





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Call 1
Call 2
Call 3
Call 4
Call 5
Call 6
Call 7
Call 8
Call 9
Call 10
Call 11
Call 12
UDP16
UDP7
Handover
Heavy TCP
E-model
PESQ
packet loss

Related work

- SyncScan : Synchronize scanning phase with AP beacons.
- Forte et al.: the impact of a handover on a SIP call, reduce overhead by acquiring a temporal address
- Pentikousis et al. : capacity of WiMAX as num of VoIP calls
- Ganguly et al. impact of packet aggregation, header compression, adaptive routing, fast handoff techniques
- Anjum et al. benefits of priority queuing at the AP
- Shin et al. : capacity of IEEE802.11 as num of VoIP calls (preamble size, ARF, RSSI, packet loss, scanning)
- Deutsche Telecom Labs: quality of VoIP and real-time video over heterogeneous networks, codec change
- Chen et al.: user satisfaction in Skype over wired networks (call duration as quality benchmark)
- Hoene et al. : call quality in adaptive VoIP applications and codecs
- Markopoulou et al.: impact of ISP network problems on real-time applications

Τέλος Ενότητας

Ευρωπαϊκή Ένωση
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ΕΣΠΑ 2007-2013
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