Adaptive Multimedia Content Delivery over Wired and Wireless Networks

Dr. Gabriel-Miro Muntean

Performance Engineering Laboratory - PEL

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http://perfenglab.com

PEL - Overview

- **PEL spans two universities in Dublin**
  - Dublin City University (DCU)
  - University College Dublin (UCD)
- **PEL people**
  - 4 academics + 3 postdocs + 2 consultants
  - 20 Postgraduate researchers
  - 3.5+ million euro funding
  - 200+ publications
- **Strong collaboration links**
  - National University of Ireland – Galway (Dr. Hugh Melvin)
  - National College of Ireland – Dublin (Dr. Cristina Muntean)
  - Carlow IT – Carlow (Dave Denieffe)
  - Dublin IT – Dublin (Dr. Nikki Cranley)
  - Athlone IT – Athlone (Enda Fallon)
- **International collaboration**
  - UCLA (USA), UC@Irvine (USA), **Warwick Univ. (UK)**, Brunel Univ. (UK)
  - Charles Univ. Prague (Cz), Politehnica Univ. Timisoara (Ro)

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PEL@DCU - People

- **Directors**
  - Dr. Gabriel-Miro Muntean
  - Dr. Jennifer McManis
- **Multimedia Networking**
  - Janet Adams
  - Edward Casey
  - Seung-Bum Lee
- **Mobile and Wireless Comms.**
  - Olga Ormond
  - Tim Casey
  - Kevin Collins
- **Adaptive Hypermedia Systems**
  - Lejla Rovcanin

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Dr. Gabriel-Miro Muntean

- **Research interests**
  - Quality-aware adaptive multimedia delivery
  - Performance-based mobile and wireless communications systems
  - Performance-aware adaptive e-learning systems
- **Achievements**
  - Over 60 publications (1 Book, 2 book chapters, 12 journal papers)
  - 4 Best Paper awards at top international conferences
  - TPC chair and TPC member for 20+ conferences, IEEE member
  - Research funding from:
    - Enterprise Ireland
    - Science Foundation Ireland
    - Irish Research Council for Science, Engineering and Technology
    - Samsung and Microsoft
  - Supervision of 7 postgraduate students

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Overview

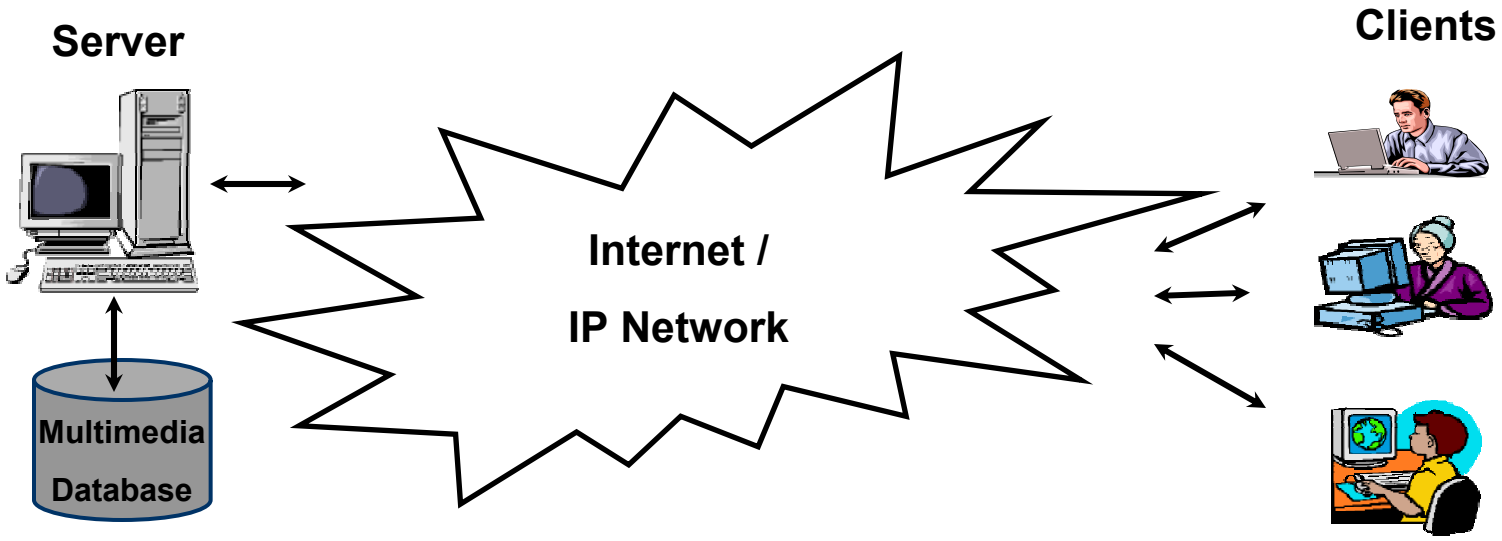
- **Streaming multimedia content**
  - Trends
  - Delivery infrastructure
  - Challenges
- **1) Quality-Oriented Adaptive Scheme (QOAS)**
- **2) Prioritised Adaptive Multimedia Content Delivery Scheme (PAM)**
- **3) Battery Power Adaptive Wireless Multimedia Streaming (BAM)**
- **Conclusions**

Multimedia Streaming - Trends

- **Current Status**
  - High popularity of streamed multimedia-based services
    - e.g. digital TV, Video on Demand, videoconferencing
  - Definite trend from analogue broadcast to on demand digital content delivery
  - Wireless technologies enable multimedia delivery anywhere with low cost
  - Mobile devices are becoming increasingly popular

1) Multimedia Streaming Evolution - Step One

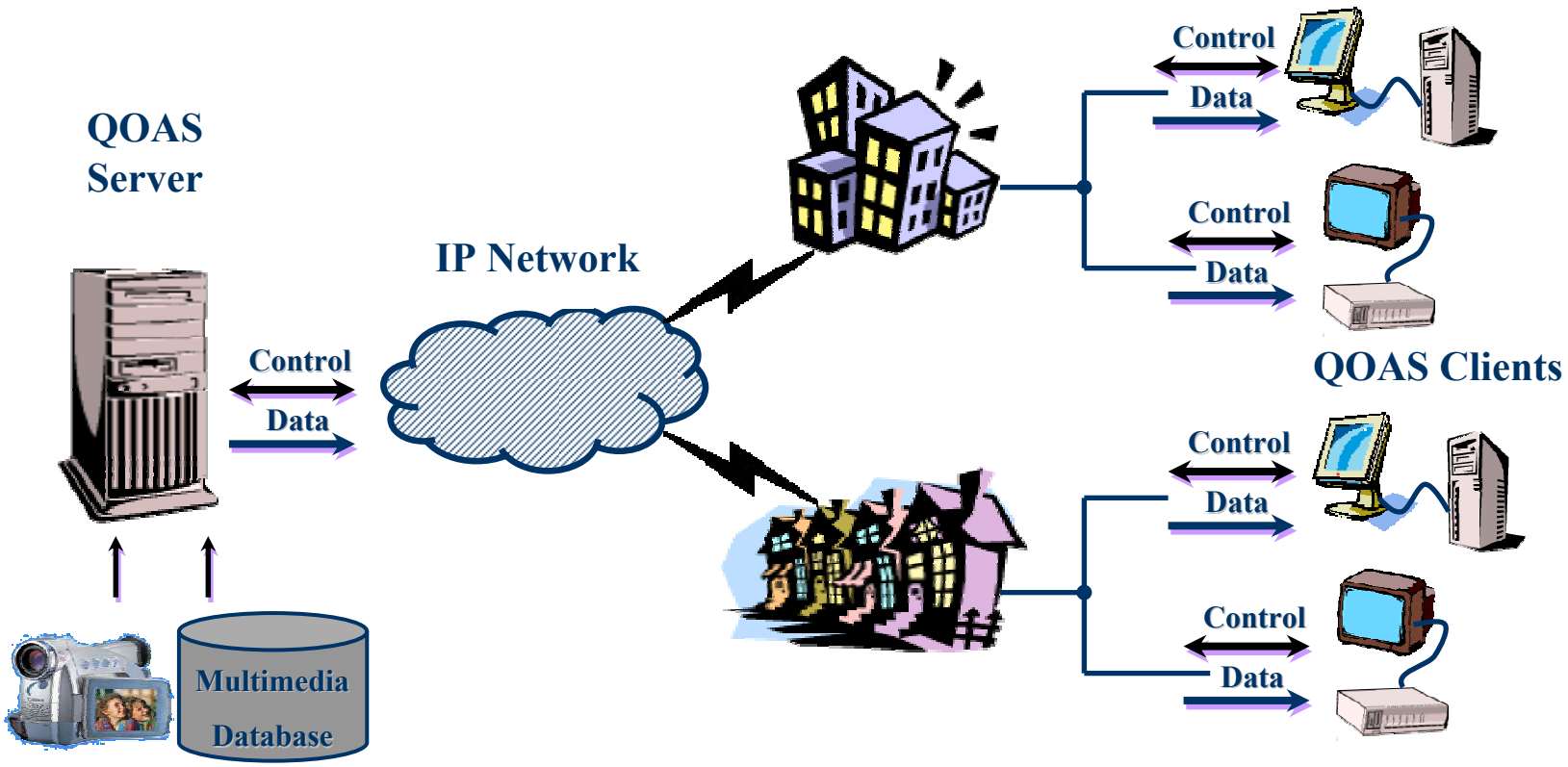
- **Approach**
  - Centralised multimedia server
  - Distributed multimedia users
  - Direct streaming across Internet or IP network



Quality-Oriented Multimedia Streaming

- **Issues**
  - **Network operators and service providers** want more customers simultaneously served and ***high infrastructure utilization*** to maximise their benefit
    - This reduces average bitrate per customer and increases loss
    - **=>** ***decrease in quality***
  - **Viewers** have ***high quality expectations***
    - This requires multimedia streaming with high bitrate and low loss
    - **=>** ***decrease in utilization (and income)***
- **Solutions**
  - **Adaptive streaming**
    - Adjusts multimedia content (bitrate) to fit available bandwidth

Multimedia Streaming – Architecture

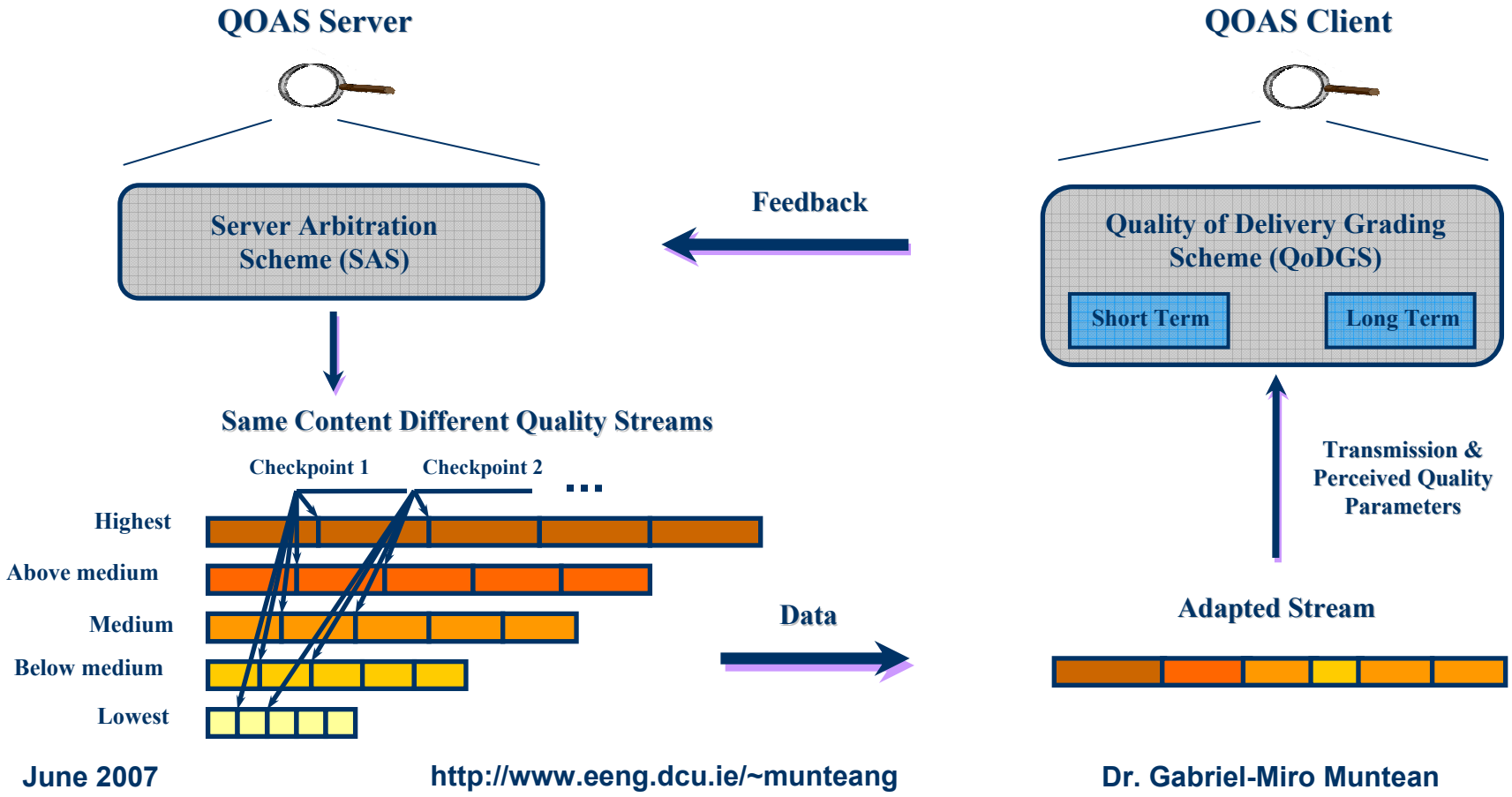


Quality-Oriented Adaptive Scheme (QOAS)

- **QOAS = application-level multimedia streaming solution**
- **QOAS dynamically optimises:**
  - *high infrastructure utilization and more customers* as desired by network operators and service providers
  - *high user perceived quality* as preferred by the viewers
- **QOAS employs a client-server feedback scheme*:**
  - Client monitors QoS and QoE parameters
  - Client regularly informs server in terms of overall grades
  - Server performs bitrate adaptations to increase user perceived quality
- **Note**
  - Users prefer controlled reduction in multimedia quality to random losses

*** IEEE Transactions on Broadcasting, vol. 52, no. 2, June 2006, pp. 230-235**

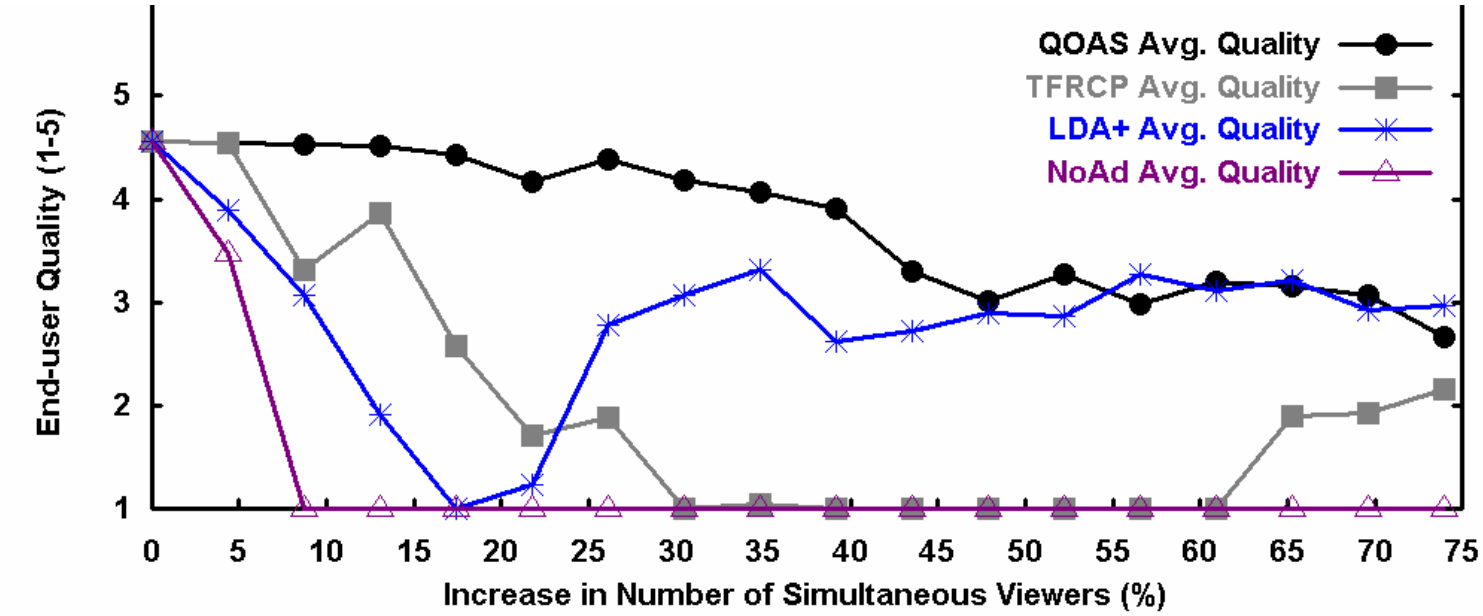
QOAS Principle Illustration



QOAS Testing - Summary

- **Objective Tests**
  - A simulation model, written in C++ and OTCL, was built and tested using Network Simulator 2
  - Simulations tested QOAS performance with various multimedia content in different delivery conditions
  - The results were very good stand-alone and in comparison with two other solutions
    - end-user perceived quality, loss rate, link utilization and
    - number of customers simultaneously served
- **Subjective Tests**
  - The prototype system was built using Microsoft Visual C++ 6.0
  - End-user perceived quality was assessed with human subjects while streaming various clips in different delivery conditions
  - The results showed very good perceived quality and confirmed the simulation results

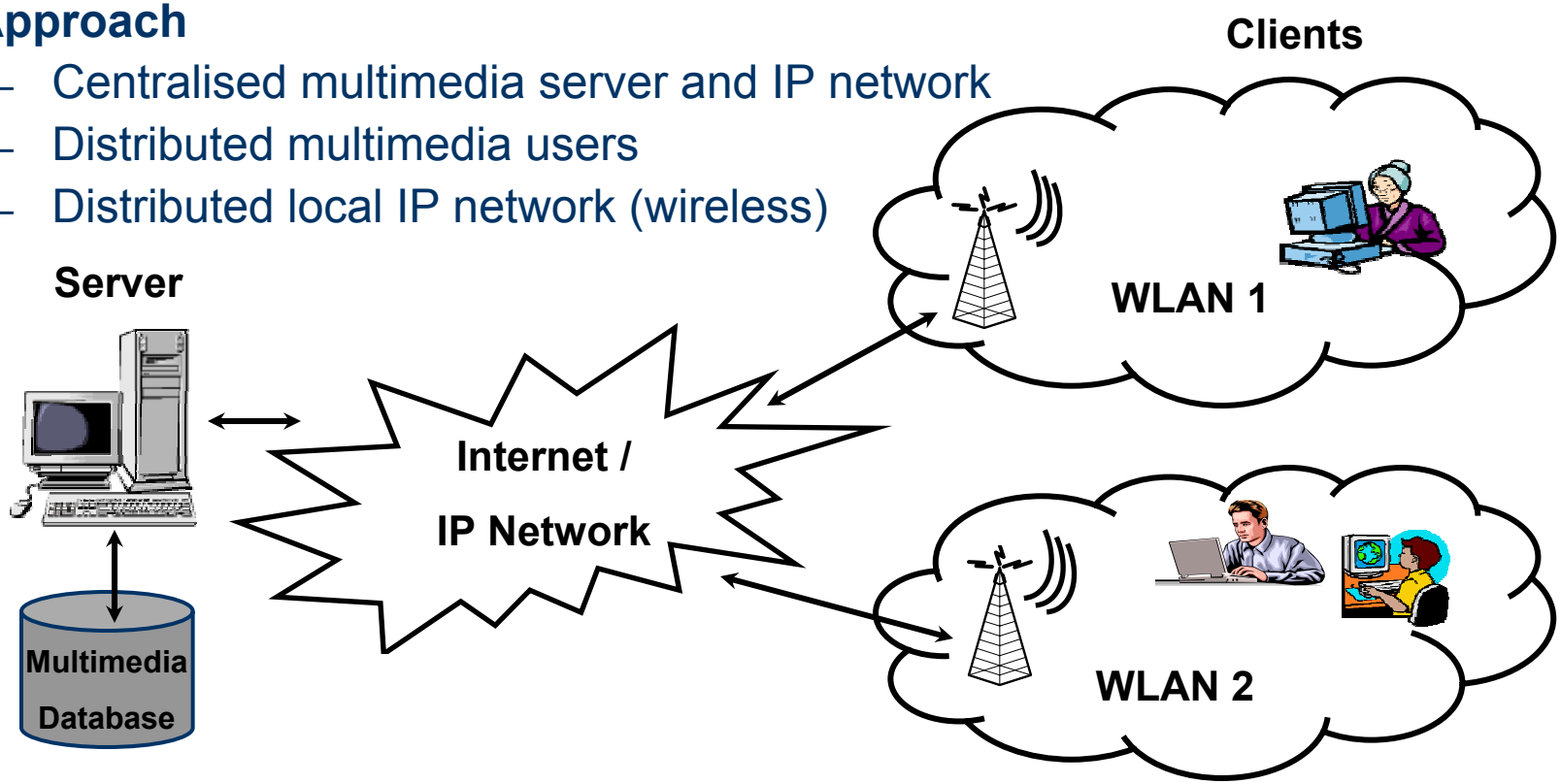
QOAS Testing - Selected Results



* IEEE Transactions on Broadcasting, vol. 53, no. 1, part 1, March 2007, pp. 92-102

2) Multimedia Streaming Evolution - Step Two

- **Approach**
  - Centralised multimedia server and IP network
  - Distributed multimedia users
  - Distributed local IP network (wireless)

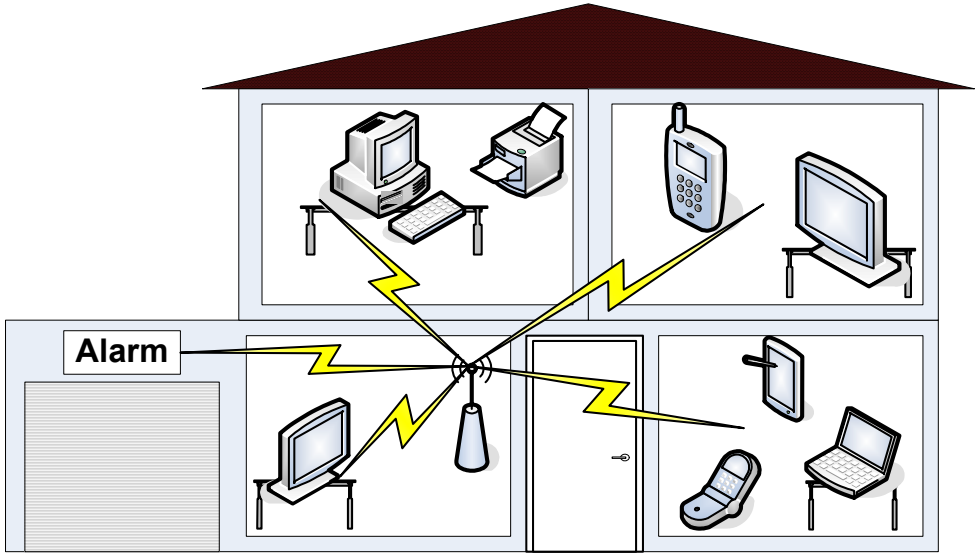


High Quality Multimedia Streaming

- **Issues**
  - **Large diversity of devices**
    - They have different requirements (average bitrate, display size, power)
  - **Wireless network solutions**
    - Lower delivery rates
    - Affected by collisions, signal attenuation with distance and interference
  - **User subjective assessment**
    - Users have different expectations in relation to application, device, etc.
- **Solutions**
  - **Differentiated adaptive streaming**
    - Prioritised adjustment of multimedia content (bitrate)

Wireless Distribution of Multimedia Services - Architecture

- Idea:



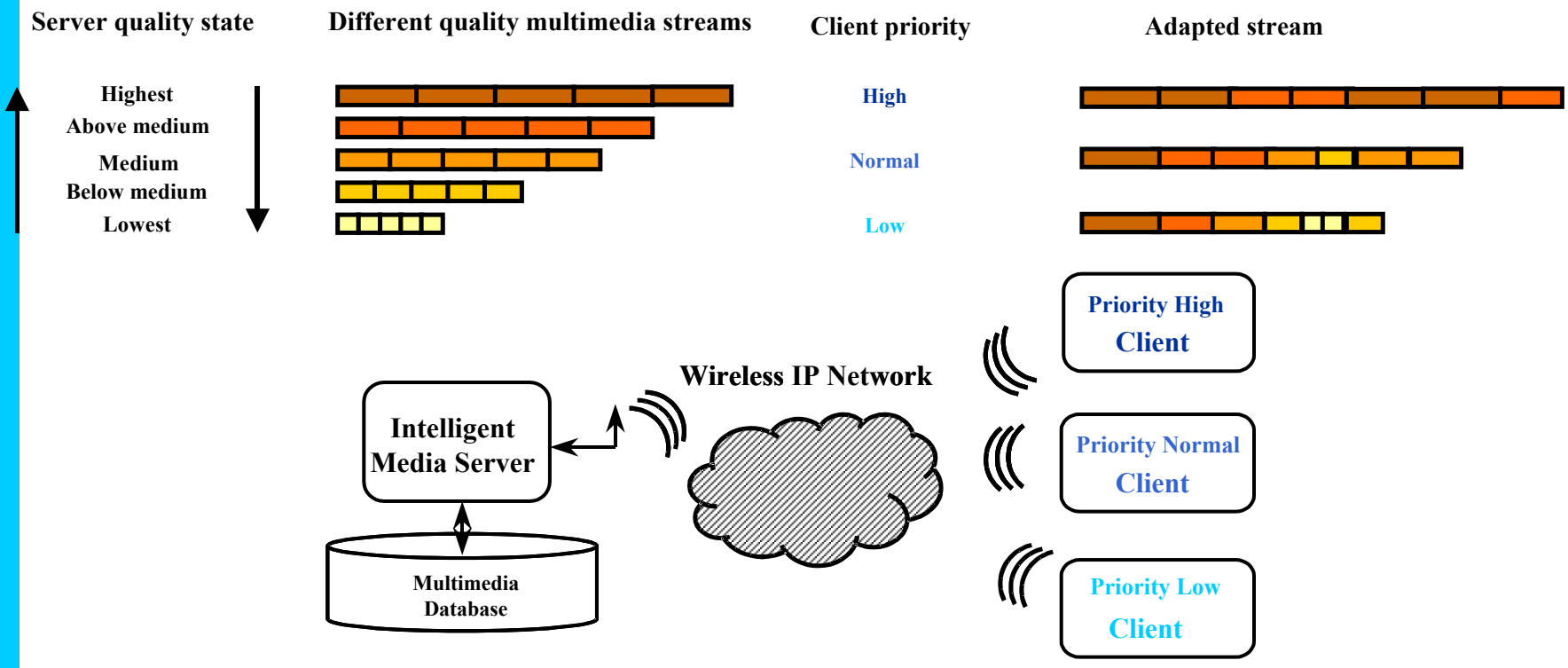
  - Distribution of multimedia-based services
  - Single wireless multimedia gateway (server+wireless access point)
  - Multiple wireless-enabled heterogeneous devices (clients)

Prioritised Adaptive Multimedia Content Delivery Scheme (PAM)

- **Principle*:**
  - Maintains high end-user perceived quality in spite of variations in the characteristics of the wireless network
  - Enables an increased number of streams to be served anytime, anywhere, and to various devices
    - E.g. desktops, laptops, PDAs, smart phones, wide screen TVs, game consoles, etc.
  - Allows differentiated treatment per view-point based on priorities assigned either by users, based on their subjective assessment or automatically detected from the device characteristics (e.g. living room home theatre has higher priority than game consoles)

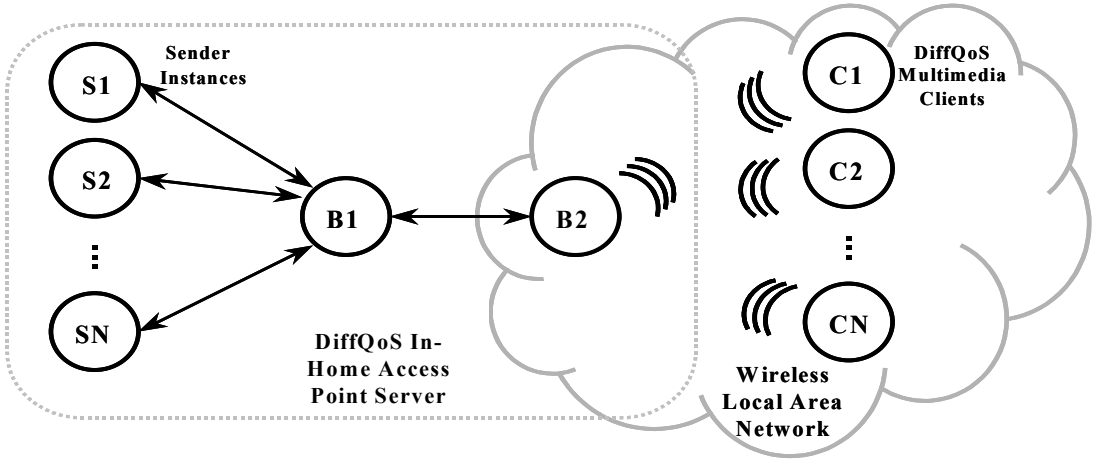
*** IEEE International Conference on Telecommunications, Funchal, Portugal, May 2006**

PAM Principle Illustration



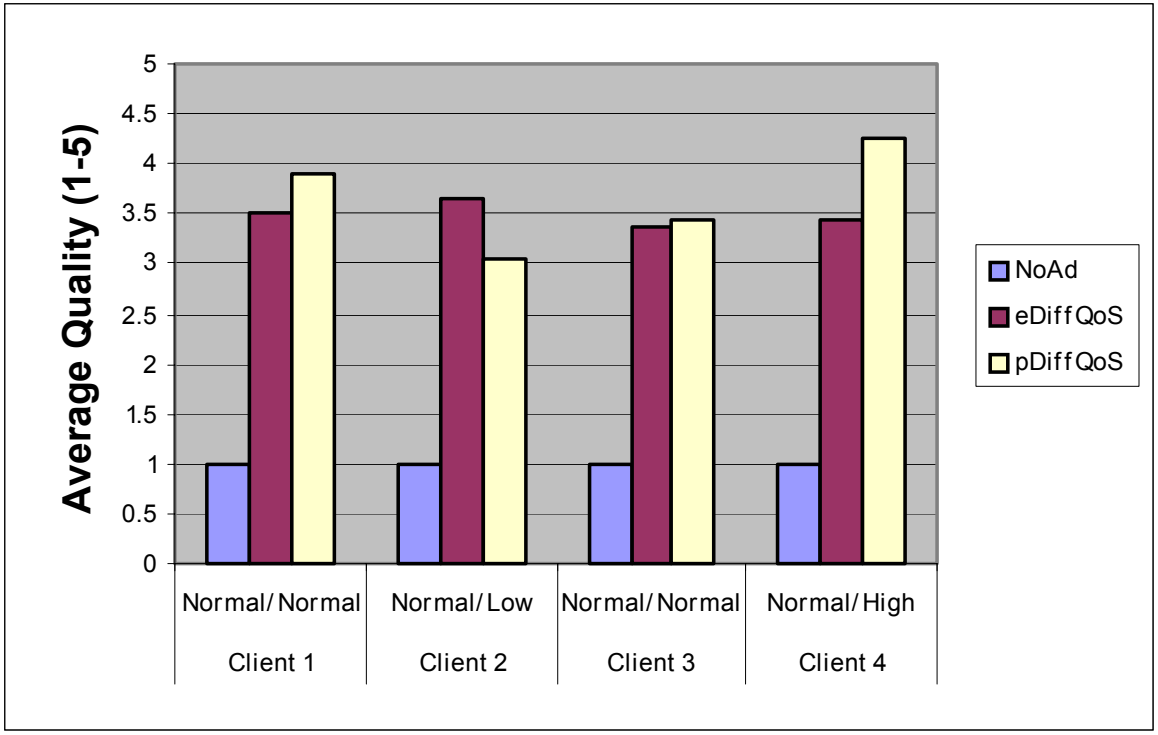
PAM Testing

- **Setup**
  - Network Simulator 2 + wireless extension
  - "Dumbbell" topology (N senders, 1 bottleneck link, N receivers)
  - Comparison between non-adaptive, equal-priority and PAM streaming
  - Assessment in terms of user perceived quality
    - On ITU-T P.910 subjective 1-5 scale: 5 - "excellent"; 1 - "bad"



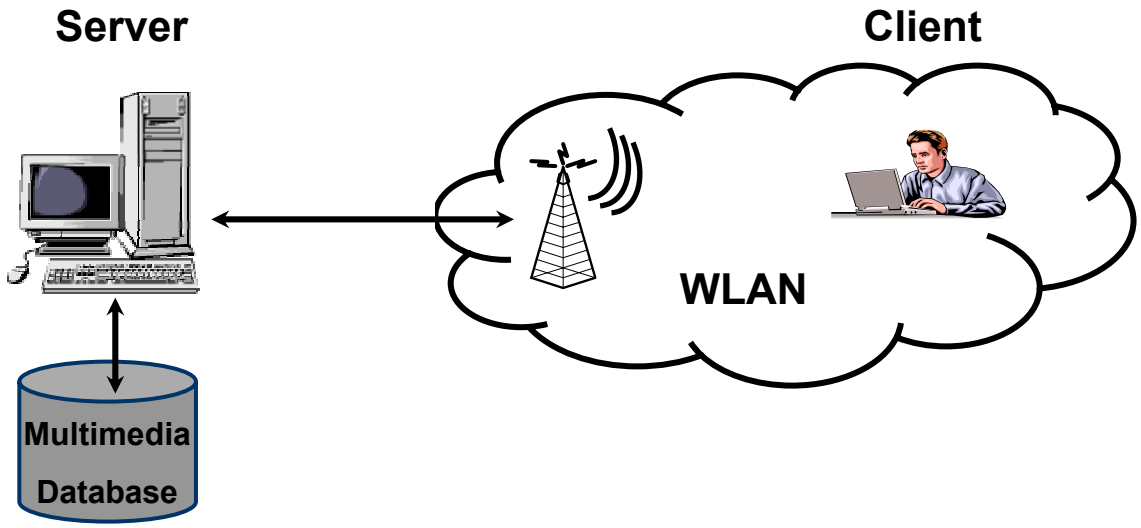
PAM Testing - Selected Results

- **Results**



3) Multimedia Streaming Evolution - Step Three

- **Approach**
  - Local multimedia server
  - Distributed battery-powered devices
  - Wireless local IP network

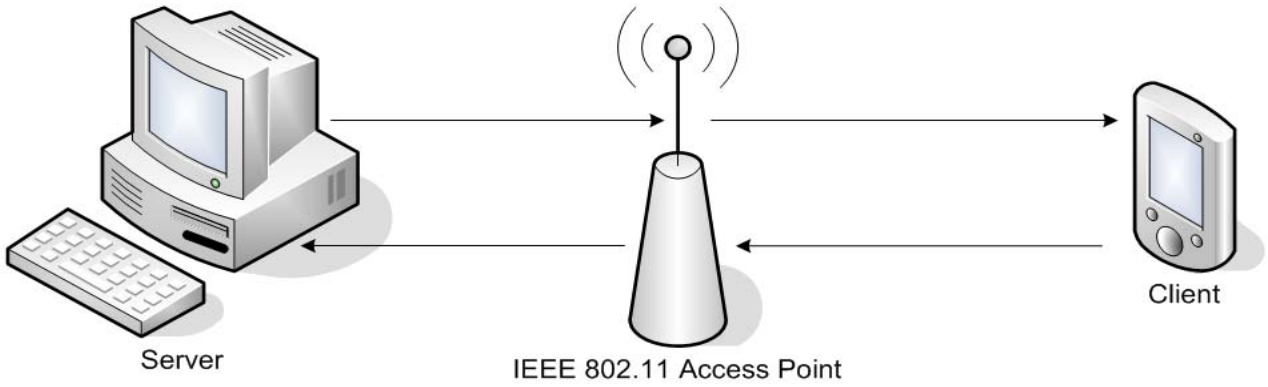


Multimedia Streaming to Battery-powered Devices

- **Issues**
  - **Large diversity of devices**
    - They have different specs, including battery characteristics
  - **Wireless data delivery**
    - High power consumption
    - Dependent on solution
  - **User preference**
    - Users prefer to have their tasks completed
- **Solutions**
  - **Battery-power-aware adaptive streaming**
    - Client device power-based adjustment of multimedia content (bitrate)

Multimedia Streaming to Battery-powered Devices - Architecture

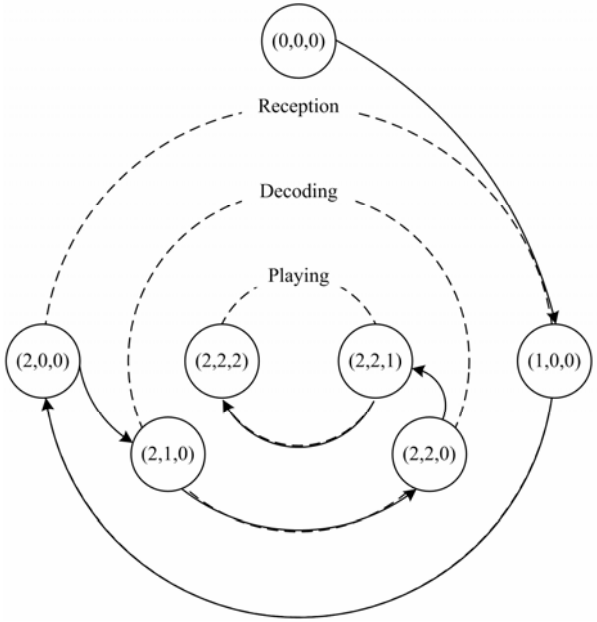
- Idea:



  - Distribution of multimedia-based services
  - Wireless multimedia gateway (server + wireless access point)
  - Battery-powered wireless-enabled devices (clients)

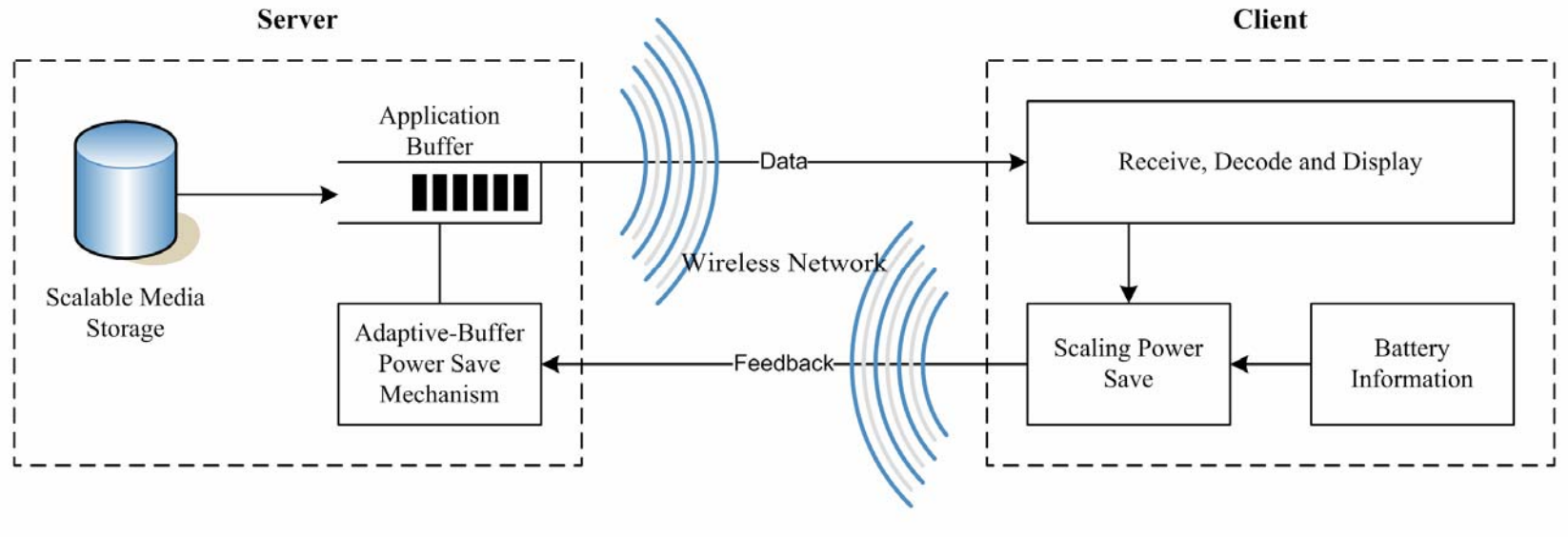
Battery Power Aware Adaptive Wireless Multimedia Streaming (BAM)

- **Principle*:**
  - Applies incremental power saving solutions in all multimedia streaming stages
  - Maintain acceptable user perceived quality
  - Reception
    - modify the process of wireless packet transmission in order to allow the device to sleep for longer
  - Decoding
    - Adapt multimedia bitrate to adjust power required for decoding
  - Playing
    - Adjust volume and brightness levels



* IEEE International Conference on Communications, Glasgow, UK, June 2007

BAM Principle Illustration



BAM Testing

- **Summary**
  - Real-life BAM implementation in the reception stage only
    - Adaptive Buffer Power Save Scheme (AB-PSM)
  - Comparison between **no-power save, IEEE 802.11 legacy PSM and two versions of AB-PSM**
  - Multimedia content is continuously streamed from a server to a PDA via an WLAN until device battery depleted
  - Assessment in terms of total playout time
    - Increase **~ 230%** in comparison with the no-PSM
    - Increase **~ 50%** in comparison with legacy PSM
  - End-user perceived quality was not affected

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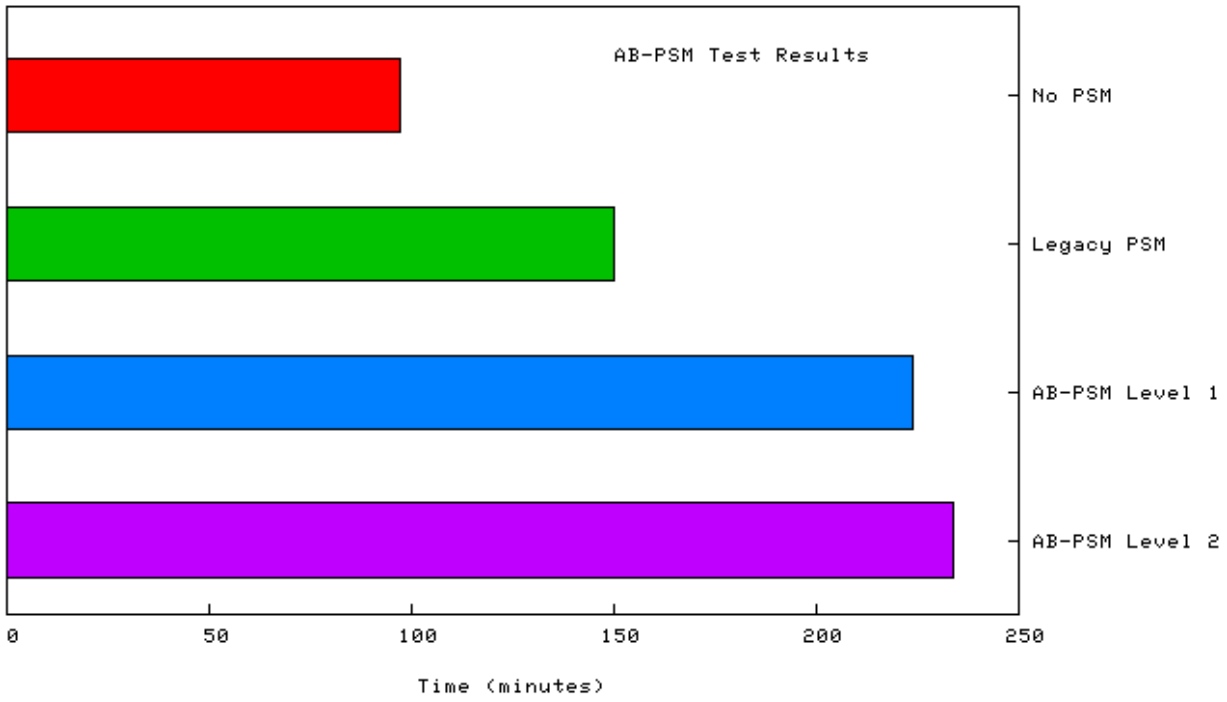
BAM Testing - Selected Results

- **Results**



Questions?

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